Review Article

Ureteral endometriosis: A systematic literature review

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ABSTRACT

Introduction: Ureteral endometriosis is a rare disease affecting women of childbearing age which presents with nonspecific symptoms and it may result in severe morbidity. The aim of this study was to review evidence about incidence, pathogenesis, clinical presentation, diagnosis, and management of ureteral endometriosis.

Materials and Methods: PubMed Central database was searched to identify studies reporting cases of ureteral endometriosis. "Ureter" or "Ureteral" and "Endometriosis" were used as key words. Database was searched for articles published since 1996, in English without restrictions regarding the study design.

Results: From 420 studies obtained through database search, 104 articles were finally included in this review, including a total of 1384 patients with ureteral endometriosis. Data regarding age, location, pathological findings, and interventions were extracted. Mean patients' age was 38.6 years, whereas the therapeutic arsenal included hormonal, endoscopic, and/or surgical treatment.

Conclusions: Ureteral endometriosis represents a diagnostic and therapeutic challenge for the clinicians and high clinical suspicion is needed to identify it.

INTRODUCTION

Endometriosis is an important gynecologic clinical disorder characterized by the ectopic presence and growth of functional endometrial tissue, glands, and stroma, outside the uterus, clinically associated with pelvic pain and infertility.[1] While the true incidence of this clinical entity cannot be exactly known since a large proportion of the affected women are asymptomatic, it is estimated to be about 5%–20%. The organs most commonly involved include the ovaries, the uterosacral ligaments, the fallopian tubes, the cervix, and the cul-de-sac.[2] Endometriosis can be classified as ovarian, peritoneal, or deep infiltraring endometriosis, with the latter defined as the presence of a lesion infiltrating 5 mm or more into the peritoneum.[3] Another classification based on the number, size, and superficial and/or deep location of endometrial implants, plaques, endometriomas and/or adhesions has been established by the American Society for Endometriosis and is as follows: stage I (minimal-points 1–5), stage II (mild-points 6–15), stage III (moderate– points 16–40), and stage IV (severe– points >40).[4] The endometriotic cells may originate from retrograde menstruation, blood and lymphatic dissemination, stem cells, and metaplasia of coelomic epithelium.[4] We present the clinical appearance of endometriosis in the ureter(s), the steps to diagnosis and treatment options through a review of the literature.

MATERIALS AND METHODS

Data collection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used for this

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systematic review. Medline was systematically searched, and thereafter, we performed a snowball process in the reference lists of the eligible articles for additional titles.

Search methodology

A thorough search of the English language literature published from 1996 until August 2017 was performed to identify studies relative to ureteral endometriosis. The search strategy explored medical subject heading terms in all possible combinations: "Endometriosis" and "ureteral" or "ureter." Each title and abstract of studies were evaluated and selected according to relevance and inclusion criteria. The electronic search was supplemented and expanded using the "related articles" function of the search engine and with manual search of the relevant articles. The study selection and data extraction were performed by two investigators (VP, GK), and the full texts of the studies were retrieved. Discrepancies were rechecked, and consensus was achieved by discussion. After locating and reading 420 abstracts online, relevant articles were printed to permit thorough reading. After full-texts analysis, 235 articles were excluded because they met exclusion criteria while 185 were selected for inclusion [Figure 1].

One hundred and four articles were finally included in this review: 5 prospective studies and 99 retrospective, of which 62 were case reports. A total of 1384 patients (mean age 38.6 years) with ureteral endometriosis were evaluated and data on age, side affected, histological type, and management are included in Supplementary Table 1 (available online only at www.indianjurol.com).

Inclusion and exclusion criteria

Eligibility for inclusion was limited to papers referring specifically to patients having ureteral endometriosis, and including data regarding age, side affected, histology, and intervention. Articles were excluded if they referred only to endometriosis located in other organs or when the referable data were mixed. Furthermore, reviews and letters were also excluded.

RESULTS

Epidemiology

Ureteral endometriosis is a rare disease first described by Cullen in 1917, constituting 0.1%–0.4% of genitourinary tract endometriosis.[5,6] Ureters are the second most common site of the urinary tract affected by endometriosis with a ratio of bladder/ureter/kidney/urethral endometriosis of 40:5:1:1, whereas an increase in incidence is observed over the years probably because of the increased diagnosis.[7,8] On the other hand, the fact that the disease can also run asymptomatically or present with nonspecific symptoms may lead to an underestimation of the prevalence of this clinical entity.

Pathogenesis and histopathology

The pathogenesis of endometriosis and more specifically of ureteral involvement has been widely investigated; however no single theory explains the clinical entity. The most common theory is that of retrograde menstruation,[9,10] which also explains the asymmetrical localization of ureteral endometriosis. The sigmoid colon contributes to the creation of an isolated microenvironment around the left adnexa. Macrophages, the first line of the immune system cannot reach the endometrial cells coming from the left fallopian tube into the peritoneal environment. On the right side, the cecum cannot provide such protection because of its more cranial anatomical position. The above-mentioned asymmetry has also been correlated with the presence of ovarian endometriosis indicating a common pathogenesis of ovarian and ureteral endometriosis or the development of ureteral lesions as a subsequent implantation arising from the ovaries. In addition, the propensity for endometriotic lesions to affect the distal ureter more frequently than the proximal ureter could also be explained by the retrograde menstruation theory, explaining the implantation of endometriotic cells under the influence of gravity.[11]

The second theory is the embryonal one. According to this, endometriosis may develop primarily in the retroperitoneum from the embryonic remains of the Mullerian duct. A further spread of the disease up to and around the ureter may be explained by the proliferation of smooth muscle surrounding the ureteral wall.[8,9]

Benign metastasis could also potentially provide a theory for some cases of endometriosis, wherein endometrial cells

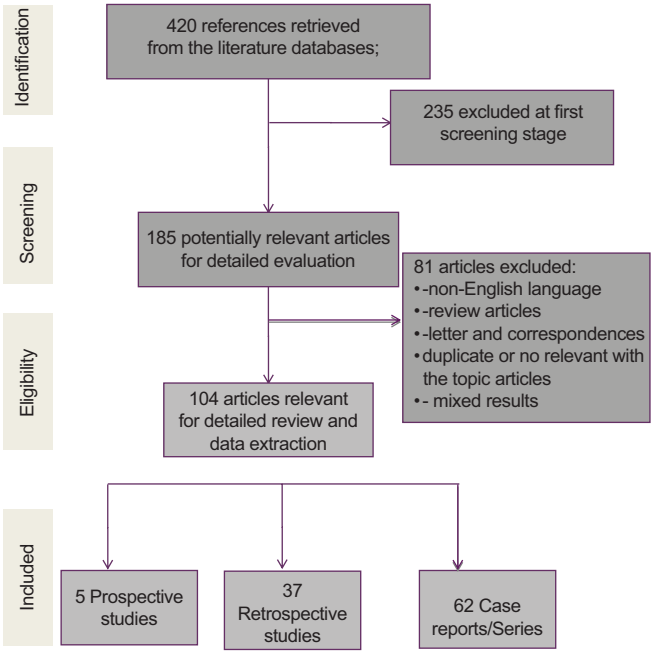

Figure 1: Summarizing literature search results

from within the uterus circulate through the lymphatic or blood vessels and spread to distant parts of the body.[12]

In addition, other hormonal and molecular pathways play an important and complicated role in the pathophysiology of deep endometriotic lesions in the ureters. The presence and survival of ectopic endometrial tissue in deep endometriotic lesions require a type of immunotolerance. Sphingosine-1-phosphate receptor 1 axis plays a particular role in this process, receiving several stimuli such as growth factors (EGFR, VEGFR, and NGFR), hormones, chemokines, cytokines, and reactive oxygen species and inducing interleukin (IL) 1b, tumor necrosis factor-alpha (TNF-α). Cytokines such as IL-1b or IL-33, which are elevated in deep infiltraring endometriosis (DIE), have further immunomoderative effects. In addition, DIE lesions demonstrate an overexpression of prostaglandin endoperoxide synthase 2 (PTGS2), which in turn leads to an increase in the production of PGF2a and PGE2 from endometrial cells. This fact, in combination with the upregulation of prostaglandin receptors leads to the presence of high concentrations of prostaglandins in DIE.[13-16]

The hormonal background is also different in DIE lesions, which show an increased estrogen biosynthesis and a decreased inactivation through the following mechanisms; upregulation of aromatase (converts androgens to estradiol E2), downregulation of 17b-hydrosteroid dehydrogenase type 2 (HSD17B2) (converts E2 to the less active metabolite estrone), increase of 17b-hydrosteroid dehydrogenase type 1 (HSD17B1) messenger RNA (E2 with increased tissue concentration), and upregulation of the expression of estrogen receptor (ER) β (suppression of ERa expression and consequently E2 inhibition of progesterone expression dominates against its stimulation).

On the other hand, DIE tissues show progesterone resistance, which in turn leads to decreased expression of HSD17B2 and downregulation of estrogen metabolism. In addition, estradiol in combination with TNF-a (Tumor necrosis factor-alpha) induces while progesterone inhibits the activation of NF-kB, which has antiapoptotic functions.

The hormonal milieu of DIE lesions is responsible for their resistance to progesterone's antiproliferative effects and subsequently for survival of the endometriotic cells.

A favorable invasion microenvironment is also created by the upregulation of matrix metalloproteinase MMP-3, TGF-b, and other cytokines. Oxidative stress and neuroangiogenetic mechanisms were also found to be involved in the pathogenesis of DIE increased proliferative (reactive oxygen species), extracellular regulated kinase, and advanced oxidation protein product, and increased expression of neurangiogenesis genes including nerve growth factor, vascular endothelial growth factor, and intercellular adhesion molecule activity of oxidative stress of NF-kB, reactive oxygen species.[4]

Histopathologically, two major types of endometriosis are recognized according to the grade of infiltration of the ureteral wall: intrinsic and extrinsic.[7] In the extrinsic type, the endometrial tissue invades the ureteral adventitia and/or the surrounding connective tissue. As a result, ureteral obstruction and hydronephrosis are common. In the intrinsic type, the ectopic endometrial tissue, apparently through lymphatic or venous metastasis, is found in the muscularis mucosa and the uroepithelium. Nevertheless, the two types may occur simultaneously.[7,17-19]

Diagnosis

Ureteral endometriosis presents a diagnostic challenge. Many medical specialties may be involved since the patients complain of non-specific symptoms. Most patients present with incapacitating dysmenorrhea, dyspareunia, pelvic pain, symptoms related with the involvement of rectovaginal septum, uterosacral ligaments, broad ligaments, and the ovaries.[20-22] Ureteral endometriosis may also cause more specific symptoms associated with the urinary tract such as flank or abdominal pain, renal colic, hematuria associated with flank pain, or cyclic gross hematuria. Unexplained hypertension and silent renal failure may also occur as the disease may run asymptomatic for a long time. Risk of renal failure in this cases is as high as 25%–50%.[18,23]

Considering that the symptoms are either non-specific or absent initally, a high index of clinical suspicion is required when patients of childbearing age have such a clinical presentation. This is why evaluation of the urinary tract is suggested when deep infiltrating endometriosis is suspected and more particularly if the rectovaginal septum is affected by nodules of >3 cm.[24] It is found that patients with rectocervical endometriosis have a 7-fold greater chance of having ureteral endometriosis, whereas patients with rectum-sigmoid endometriosis have a 22-fold greater chance.[25]

Physical examination

While there may be no physical findings, large endometriotic nodules may be palpated in the rectovaginal septum and their presence is highly related to ureteral endometriosis.[24]

Investigations

Serum Ca125 may be elevated in endometriosis but is neither sensitive nor specific for ureteral endometriosis.[26] Renal function should be assessed and urine should be examined for hematuria, and cytology to rule out malignant disease.

There are no specific diagnostic tests and the extent of the disease cannot be accurately estimated preoperatively. A step-by-step algorithm is proposed [Table 1]. A vaginal ultrasound may reveal the presence of ovarian endometriomas and/or nodules at the rectovaginal septum. Abdominal ultrasound can identify urinary tract obstruction. In case of normal findings, a kidney ultrasound should be obtained regularly in follow-up. Computed tomography has limited use in the diagnostis of ureteral endometriosis because of the high cost, poor specificity, and high radiation dose, which is avoidable for patients of childbearing age.[7]

Magnetic resonance imaging (MRI) allows assessment of disease extension in the pelvis and ureteric involvement and is the investigation of choice.[27-30] It allows evaluation of all endometriotic locations and can potentially distinguish intrinsic from extrinsic form of ureteral endometriosis and thus help decide the surgical approach.[31] In addition, MRI appears to be more sensitive (91% vs. 82%) but less specific (59% vs. 67%) than surgery for the diagnosis of intrinsic ureteral endometriosis.[32]

Isotope renography should be used to assess any patient with suspected ureteral endometriosis to evaluate renal function.[33,34] It is reported that 25%–50% of the nephrons are lost, and almost 30% of the patients present with reduced kidney function at the time of the diagnosis.[35]

Ureteroscopy is used to diagnose intrinsic endometriosis, although negative findings do not exclude the presence of ureteral endometriosis Apart from the macroscopic recognition of endometriotic lesions, which may appear as edematous and irregular with different shapes and colors, ureteroscopy allows biopsy, histological confirmation and ablation.[30,36,37] It may also reveal multifocality of the disease and helps measure the distance between the lower endometriotic margins and ureteral orifices which is of fundamental significance for the choice of surgical approach.[38,39]

Table 1: Step-by-step diagnosis of ureteral endometriosis

History
Vaginal/abdominal US
If abnormal renal US: MRI/urology-MRI
If hydronephrosis: Intravenous urography/isotope renography
Intrinsic ureteral endometriosis: Ureteroscopy
Confirmation of the disease: Laparoscopy

MRI=Magnetic resonance image, US=Ultrasound

Most commonly ureteral endometriosis is found accidentally in patients undergoing laparoscopy for infertility and/or endometriosis.

Treatment

Ureteral endometriosis is an uncommon clinical entity that affects young women of childbearing age with severe symptoms and/or infertility. Because of the rarity of the disease and the lack of prospective randomized studies, there are no clear guidelines for treatment. Each patient should be individually managed after a multidisciplinary team approach, including a skilled laparoscopic gynecologist, urologist, and colorectal surgeon. The therapeutic arsenal includes both conservative and operative treatments [Table 2]. The choice depends on the onset and renal function and the issues are: (1) relief of symptoms (2) renal preservation, and (3) prevention of relapse.

Hormonal therapy

Hormonal therapy includes danazol, GnRH agonists (leuprolide, goserelin), medroxyprogesterone, estrogen-progestin combination, and progestin alone. The most popular between are danazol and GnRH agonists, which antagonize the effect of gonadotropin, entailing the eventual effect of inhibition of ovarian function. In addition, local progestogens in the form of intrauterine levonogestrel device lead to a high concentration of the drug at the endometrium and are effective in the management of pelvic and vesicovaginal septum endometriosis. The 5-year effectiveness in combination with preservation of fertility after cessation of therapy is simlar to intrauterine levonorgestrel devices.[40,41]

The best candidates for hormonal therapy are: (a) patients of childbearing age who desire pregnancy, with close follow-up with ultrasound at 6-month intervals

Table 2: Ureteral endometriosis: Therapeutic management

Hormonal therapy	Endoscopic management	Ureterolysis	Ureteral resection with ureteral reconstruction (ureteral termino-terminal anastomosis or ureteroneocystostomy)
Patients of childbearing age who desire pregnancy Postmenopausal women, under close follow-up Patients without significant fibrosis in combination with the suitable surgical intervention Contraindicated in the setting of ureteral obstruction and hydrone-phrosis	Patients with intraluminal endometriosis	Extrinsic endometriosis Lesions <3 cm No association with hydroureteronephrosis Localization up to the iliac vessels Laparoscopic or laparotomic approach	Intrinsic endometriosis with lesions >3 cm Below the level of the iliac vessels Hydroureteronephrosis Terminoterminal anastomosis Ureteroneocystostomy either with ureteral reimplant with an antireflux technique or with psoas hitch technique

to rule out an obstruction,[7] (b) patients without significant fibrosis in combination with the suitable surgical intervention,[30,36] and (c) postmenopausal women, under close follow-up.[39] Hormonal therapy functions through the shrinkage of affected tissues. It does not prevent the formation of fibrous tissue and adhesions. As a consequence, ureteral obstruction and hydroureteronephrosis may still occur.[42,43] Medical management alone is clearly contraindicated in the setting of ureteral obstruction and hydronephrosis, and medical management alone might not be a good option for ureteric endometriosis given the increased incidence of recurrence with the serious potential sequelae of reduced renal function.[7]

Moreover, the response to hormonal therapy may not be complete. A possible explanation is the desmoplastic reaction within the muscle layers and the serosa of the ureter due to repetitive bleeding and resorption of menstrual debris. In addition, the side effects of hormonal therapy are a reason for low compliance. The relapse rate is also high (55%) after treatment cessation.[44] Therefore conservative treatment is considered as palliative for deep infiltrative endometriosis.

Invasive therapy

Endoscopic management

Ureteroscopic management is indicated in patients with intraluminal endometriosis. Ureteroscopy allows ablation with laser, and balloon dilatation with stent placement.[38,45,46] However, this is often not curative and follow-up imaging, including ureteroscopic surveillance and retrograde urography, is recommended to early detect disease recurrence and/or progression.

Operative management

Conventionally, laparotomy was the approach of choice for the treatment of extensive ureteral endometriosis.[47] Laparoscopy, through a magnified view, allows greater ability to identify the extent of the disease.[48,49] In both cases, the preoperative ureteric stent is recommended as it functions as a guide for the identification of the ureter and the prevention of ureteral injury.

Operative approaches for ureteral endometriosis include ureterolysis, ureteral resection with ureteral reconstruction, and nephrectomy in cases of renal insufficiency. The choice of the suitable technique is based on the type of ureteral endometriosis (intrinsic vs extrinsic) and the location and the extent of the disease.

Ureterolysis

Ureterolysis is indicated in cases of extrinsic endometriosis with lesions <3 cm when not associated with hydroureteronephrosis.[20,50] Intrinsic endometriosis is a contraindication for ureterolysis since it is associated with high recurrence rates (16%) and ureteral restenosis. Patients should be warned about the possible need for reintervention and/or progressive renal failure, in combination with the need for close follow-up.[48,51]

Ureteral resection with ureteral reconstruction

Ureteral resection with ureteral reconstruction is considered in cases of intrinsic endometriosis, lesions longer than 3 cm situated below the level of the iliac vessels and hydroureteronephrosis.[48] The two basic techniques include the ureteral-ureteral anastomosis and ureteroneocystostomy.

The first technique should be performed if the ureteral stenosis is limited to the ovarian fossa and distal ureter can be preserved.[52-57]

Ureteroneocystostomy is the operation of choice in cases of extended disease with ureteral stenosis close to the vesicoureteral junction.[53,58-61] The Lich-Gregoire, Leadbetter–Politano or a psoas hitch technique may be used.[62-64] Rarely, replacement with bowel segments or bladder flaps may be required.[65,66] A successful series of five laparoscopic nonrefluxing extravesical Lich-Gregoir reimplantations with no intra- or post-operative complications and a 100% success rate in accordance with the previous literature for open surgery has been reported.[67-69] Ureterocystoneostomy with the vesico-psoas hitch technique places the ureter away from the pelvis, the frequent site of recurrence.[59] Tension-free anastomosis is needed to reduce the risk of postoperative recurrence of stenosis and hydronephrosis.[70] Despite the modification of the anatomy of the urinary tract, the urodynamic parameters do not change.[71] The effectiveness of the psoas hitch and ureteral reimplantation in open surgery has been proven by multiple reports in the literature, with good results at follow-up.[71-75] On the other hand, Gozen *et al.* reported their series of laparoscopic psoas hitch and concluded that it is a versatile procedure with multiple indications and associated with excellent results.[69] In addition, Rassweiler *et al.*, in a retrospective comparison with open surgery, report a functional success rate of 10 out of 10 in the laparoscopic group.[74]

Nephrectomy

Nephrectomy is necessary in cases of deteriorated renal function, which unfortunately still occurs despite the surgical techniques developed and in cases when the lesions mimic an urothelial carcinoma.[63]

CONCLUSIONS

Ureteral endometriosis is a challenging disease presenting most commonly with nontypical symptoms and signs and may consequently lead to significant morbidity and most importantly renal function deterioration. The diagnosis should be suspected when women of childbearing age appear with atypical urological symptoms combined

with symptoms indicative of deep pelvic endometriosis. Preoperative imaging is helpful for the planning of the operative management. Surgery depends on the type, extent, and location of the disease, and a laparoscopic approach is preferred. Surgical management is effective in relieving symptoms and improving fertility. For the best results, a multidisciplinary approach from an experienced gynecologist, urologist, and general surgeon is advised.

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Supplementary Table 1: Illustrates the main studies with ureteral endometriosis and their characteristics

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Huang *et al.*/2017	J Obstet Gynaecol Res	RS	46	37.07	26 (56.5%) left, 16 (34.8%) right, 4 (8.7%) bilateral	22 (47.8%) intrinsic, 24 (52.2%) extrinsic	11 ureterolysis (23.9%), 28 (60.9%) ureteroneocystostomy, 4 (8.7%) end-to-end ureteral anastomosis, 3 (6.5%) nephrectomy
Freire *et al.*/2017	Urology	RS	17	38	35.7% left, 14.3% right, 10.7% bilateral	14.3% extrinsic, 14.3% intrinsic	7 distal ureterectomy, 5 distal ureterectomy, and reimplantation (4 Lich-Gregoir and 1 Lich-Gregoir with psoas hitch), 3 ureteroureterostomy, 2 laparoscopic nephrectomy
Kanno *et al.*/2017	The Journal of Minimally Invasive Gynecology	CR	1	25	100% right	NR	Laparoscopic segmental ureteral resection and submucosal tunneling ureteroneocystostomy with a psoas hitch and Boari flap
Darwish *et al.*/2017	J Minim Invasive Gynecol	RS	42	34.8	8 (19%) bilateral, 17 (40.5%) right, 17 (40.5%) left	54.5% intrinsic	78% ureterolysis, 8% ureteral resection followed by end-to-end anastomosis, 14% ureteral resection and ureteroneocysostomy
Alves *et al.*/2017	J Minim Invasive Gynecol	RS	198	NR	7 (25%) left, 9 (32.1%) right, 12 (42.9%) bilateral	76.9% intrinsic	100% ureterolysis, 6.06% ureteral resection followed by end-to-end anastomosis, 1 (0.5%) ureteroneocystostomy with Boari flap
Abo *et al.*/2016	Journal de Gyne´cologie Obste´trique et Biologie de la Reproduction	RS	13	36	NR	NR	11 (84.7%) advanced ureterolysis in ureters with stenosis, 2 (15.3%) ureteral resection and ureterocystostomy
Butticè *et al.*/2016	Arch Ital Urol Androl	RS	32	NR	NR	22 (68.75%) extrinsic, 10 (31.25%) intrinsic	10 (31.25%) laser endoureterotomy, 16 (50%) ureteral resection and reimplantation, 3 (9.4%) ureteroneocystostomy with Boari flap, 9 (18.8%) ureterolysis
Gennaro *et al.*/2016	Urology	RS	15	41.3	10 (66.6%) left, 3 (20%) right, 2 (13.4%) bilateral	NR	9 ureteral reimplant and psoas hitch, 6 ureterolysis, 1 ureteral reimplant with ureteral stent placement
Mason *et al.*/2016	Can Urol Assoc	CR	1	44	100% left	100% intrinsic	Laparoscopic nephrectomy followed by open ureterectomy
Vrettos *et al.*/2016	Quant Imaging Med Surg	CR	1	43	Right, distal 1/3	NR	Open ureterocystoneostomy
Pant *et al.*/2016	Saudi J Kidney Dis Transpl	CR	1	29	100% right	NR	ureterolysis
Muthuppalaniappan *et al.*/2016	Postgrad Med	CR	1	30	Bilateral	100% intrinsic	Bilateral ureteral reimplantation
Wu *et al.*/2015	J Minim Invasive Gynecol	RS	24	NR	NR	NR	5 (20.8%) ureterolysis, 7 (29.2%) ureterolysis with ureteral stenting, 6 (25.0%) segmental ureterectomy with end-to-end ureteral anastomosis, 6 (25.0%) segmental ureterectomy with ureterocystoneostomy
Choi *et al.*/2015	Case Rep Obstet Gynecol	CR	1	45	Left	NR	Laparoscopic left nephrectomy
Ilea *et al.*/2015	Rev Med Chir Soc Med Nat Iasi	CR	1	30	100% right	NR	Ureterovesical reimplantation with psoas bladder-hitch
Wang *et al.*/2015	Int J Clin Exp Med	RS	82	38.9	54 (65.9%) left, 25 right (30.5%), 2 (2.4%) bilateral	74 (90.2%) extrinsic, 6 (7.3%) intrinsic	Segmental ureterectomy with ureteroureterostomy or ureterocystoneostomy
Naufel *et al.*/2015	Radiol Bras	CR	1	55	100% left	Intrinsic	No-therapy, patient asymptomatic, discontinuation of tamoxifen

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Supplementary Table 1: Contd...

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Seracchioli *et al.*/2015	Hum Reprod	RS	77	35,1	Unilateral 70/77 (91%): Right side 21/70 (30%), left side 49/70 (70%), bilateral 7/77 (9%)	NR	83% endometriosis nodule excision, 17% ureteral resection
Vilos *et al.*/2015	J Minim Invasive Gynecol	RS	3	47	1 (33.3%) right, 2 (66.6%) left	NR	Low-dose intermittent danazol or GnRH-a alone or with add-back
Knabben *et al.*/2015	Fertil Steril	RS	106	33.3	54 (51%) left, 15 (14.2%) right, 37 (34.8) bilateral	NR	106 ureterolysis, 2 ureterocystoneostomy
Gudla *et al.*/2015	Radiol Case Rep	CR	1	63	100% right	NR	Laparotomy endometriosis mass excision
Chen *et al.*/2015	J Minim Invasive Gynecol	CR	1	31	100% left	NR	GnRH agonists, double J stent and robotic ureterolysis, ureterectomy and end-to-end anastomosis
Karadag *et al.*/2014	J Med Case Rep	CR	1	30	100% right	100% intrinsic	Open partial ureterectomy and ureteroneocystostomy with Boari flap
Babu *et al.*/2014	J Clin Diagn Res	CR	1	35	100% left	100% intrinsic	Endoscopic endometriotic node removal
Mu *et al.*/2014	Urol J	RS	23	37.7	14 (60.9%) left, 9 (39.1%) right	NR	5 ureterolysis, 6 segmental ureteral resection and ureteroneocystostomy, 12 segmental ureteral resection and ureteroureterostomy
Lakhi *et al.*/2014	Fertil Steril	CR	1	17	100% left	100% intrinsic	Laparoscopic rest ureterectomy
Seyam *et al.*/2014	Urol Ann	CR	1	32	100% left	100% intrinsic	Robotic nephroureterectomy
Breto´n *et al.*/2013	Eur J Obstet Gynecol Reprod Biol	RS	3	37.5	1 (33.3%) bilateral, 1 (33.3%) right, 1 (33.3%) left	NR	1 nephrectomy and ureteral reimplantation with antireflux technique, 1 ureteral reimplantation, 1 uretererolysis and left nephrectomy
Castaneda *et al.*/2013	Urology	RS	5	37.5	4 (80%) left, 1 (20%) right	NR	5 endoscopic laser ablations (with holmium YAG laser), 1 ureteroureterostomy
Nezhat *et al.*/2012	JSLS	RS	3	34	66.6% left, 33.3% right	66.6% intrinsic, 33.3% extrinsic	1 nephrouretectomy, 1 ureteroneocystotomy, 1 ureterolysis
Lusuardi *et al.*/2012	Urology	RS	7	30	6 (85.7%) left, 1 (14.3%) right	100% intrinsic	4 ureterectomy, ureterovesical reimplantation with psoas bladder-hitch. 3 ureterectomy and ureteroureterostomy
Papakonstantinou *et al.*/2012	Clin Exp Obstet Gynecol	CR	1	40	100% left	100% intrinsic	Laparotomy: Ureterolysis, segmental ureteral resection
Miranda-Mendoza *et al.*/2012	Eur J Obstet Gynecol Reprod Biol	RS	13	33	10 (76.9%) left, 2 (15.4%) right, 1 (7.7%) bilateral	NR	7 (53.8%) ureterolysis, 6 (46.2%) segmental ureterectomy with end-to-end ureteral anastomosis
Traşcă *et al.*/2012	Rom J Morphol Embryol	CR	1	36	100% left	NR	Distal ureterectomy with ureterocystoneostomy
Muñoz *et al.*/2012	Eur J Obstet Gynecol Reprod Biol	CR	1	32	Bilateral	NR	Ureterolysis and left nephrectomy
Kumar *et al.*/2012	Urol Ann	RS	10	30.16	6 (60%) left, 1 (10%) right, 3 (30%) bilateral	100% intrinsic	5 transurethral resection and GnRH, 3 distal ureterectomy and ureteric re-implantation, 4 laparoscopic ureterolysis, stenting and GnRH
Wu *et al.*/2012	Eur J Obstet Gynecol Reprod Biol	CR	1	40	100% right	Intrinsic	Segmental ureterectomy with ureteroureterostomy and ureteral catheter placement

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Supplementary Table 1: Contd...

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Rozsnyai *et al.*/2011	JSLS	RS	16	38.3	10 (62.5%) left, 4 (25%) right, 2 (12.5%) bilateral	2 (40%) intrinsic, 3 (60%) extrinsic	13 (81.3%) uereterolysis, 3 (18.8%) ureterectomy + end-to-end ureteral anastomosis, 2 (12.5%) ureterectomy + ureteroneocystotomy
Frick *et al.*/2011	JSLS	RS	2	36.5	100% left	NR	2×robotic-assisted laparoscopic partial ureterectomy and ureteroneocystostomy
Gabriel *et al.*/2011	Urology	RS	13	32.3	51% left, 18% right, 31% bilateral	NR	100% ureterolysis, 69.2% resection with ureteroureterostomy
Yang *et al.*/2011	J Laparoendosc Adv Surg Tech A	CR	1	28	100% right	NR	Right distal ureterectomy with psoas hitch
Soriano *et al.*/2011	J Minim Invasive Gynecol	RS	45	32.8	37 (82.2%) left, 4 (8.9%) right, 4 (8.9%) bilateral	NR	41 (91.1%) ureterolysis, 4 (8.9%) ureteral reimplantation
Nozaki *et al.*/2011	J Laparoendosc Adv Surg Tech A	CR	1	38	100% right	100% extrinsic	Nephrectomy
Langebrekke *et al.*/2011	Acta Obstet Gynecol Scand	RS	3	31.5	100% left	NR	1 nephrectomy, GnRH analogs, 1 ureterolysis
Gupta *et al.*/2011	Saudi J Kidney Dis Transpl	CR	1	28	100% left	NR	Double J stent and levonorgestrel (IUD)
Azioni *et al.*/2010	Minim Invasive Ther Allied Technol	RS	6	34	100% left	100% extrinsic	Ureteral resection and ureteroneocystostomy with vesico-psoas hitch
Indraccolo *et al.*/2010	J Med Case Rep	CR	1	54	Bilateral	100% extrinsic	Ureterolysis and excision of the endometriotic nodules
Hsieh *et al.*/2010	Intern Med	CR	1	42	100% right	100% extrinsic	Nephroureterectomy
Smith *et al.*/2010	BMC Res Notes	RS	13	39.5	7 (53.8%) left, 5 (34.8%) right, 1 (7.7%) bilateral	NR	7 (53.8%) ureterolysis, 3 (21.3%) ureterolysis and placement of a double J ureteric stent, 3 (21.3%) segmental ureteric resection
Khong *et al.*/2010	J Minim Invasive Gynecol	CR	1	62	100% left	NR	Laparotomy endometriosis mass excision
Seracchioli *et al.*/2010	Fertil Steril	CR	1	32	100% left	NR	Laparoscopic left nephrectomy, ureterectomy
Seracchioli *et al.*/2010	Fertil Steril	PS	30	33.1	46.7% left, 26.7% bilateral, 26.7% right	22 (73.3%) extrinsic	22 (73.3%) laparoscopic ureterolysis, 5 (16.7%) segmental ureteral resection and ureteroureterostomy, 3 (10%) ureterectomy and ureterocystoneostomy
Chapron *et al.*/2010	Fertil Steril	PS	34	32.7	17 (58.6%) left, 7 (24.1%) right	13 (38.2%) intrinsic	29 ureteral ureterolysis, 7 segmental ureteral resection and ureteroureterostomy, 9 ureterectomy and ureterocystoneostomy
Mereu *et al.*/2010	Fertil Steril	PS	56	32.7	37 (66%) left, 13 (34%) right	NR	35 ureterolysis, 17 terminoterminal ureteral anastomosis, 2 ureteroneocystostomy, 2 nephrectomy
Bosev *et al.*/2009	J Urol	RS	96	34	53% left, 36% right, 10% biteral	NR	96 (100%) ureterolysis, 2 (2%) ureteroneocystostomy with psoas hitch, 6 (6%) ureteral stent placement
Camanni *et al.*/2009	Reprod Biol Endocrinol	RS	80	NR	38 (47.5%) left, 34 (42.5%) right, 8 (10%) bilateral	2 (50%) intrinsic	95% laparoscopic ureterolysis, 5% ureteroneocystostomy
Juan *et al.*/2009	Kaohsiung J Med Sci	CR	1	49	100% right	Intrinsic	Ureteroscopy and removal of the ureteric tumor
Kondo *et al.*/2009	Indian J Pathol Microbiol	CR	1	44	100% left	Intrinsic	Partial resection of the ureter and ureteroneocystostomy with Boari flap

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Supplementary Table 1: Contd...

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Carmignani *et al.*/2009	Fertil Steril	PS	13	36.8	9 (69.2%) left, 3 (23.1%) right, 1 (7.7%) bilateral	NR	Laparotomy: Ureteroneocystostomy with a psoas hitch
Pérez-Utrilla Pérez *et al.*/2009	Urology	RS	7	37.75	2 (28.6%) bilateral, 2 (28.6%) left, and 3 (42.8%) right	NR	2 laparoscopic ureterolysis, 5 ureteroneocystostomy, 1 later ureteral resection and end-to-end anastomosis
Nezhat *et al.*/2009	J Reprod Med	CR	1	31	100% right	100% intrinsic	Laparoscopic ureteroneocystostomy and vesico-psoas hitch (double ureter)
Li *et al.*/2008	Chin Med Sci J	RS	10	41.9	8 (80%) right, 1 (10%) left, 1 (10%) bilateral	9 (90%) extrinsic, 1 (10%) intrinsic	3 segmental ureterectomy and terminoterminal anastomosis, 1 segmental ureterectomy and ureterocystoneostomy, 6 ureterolysis
Seracchioli *et al.*/2008	J Minim Invasive Gynecol	RS	30	33.33	46.7% left, 26.7% right, 26.7% bilateral	86.7% extrinsic, 13.3% intrinsic	73.3% laparoscopic ureterolysis, segmental ureteral resection and terminoterminal anastomosis in 16.7%, segmental ureterectomy and ureterocystoneostomy in 10%
Bohrer *et al.*/2008	Fertil Steril	CR	1	47	Bilateral	100% extrinsic	Anastrazole and exploratory laparotomy, ureterolysis, excision of endometriotic implants, and bilateral ureteroneocystostomy with a right psoas hitch
Al-Khawaja *et al.*/2008	Hum Pathol	RS	7	51	6 (85.8%) left, 1 (14.2%) right	4 (57.1%) extrinsic, 3 (42.9%) intrinsic	Nephrectomy in 2 cases, distal ureterectomy with reimplantation in 3 cases, ureteral stent placement followed by ureteroureterostomy in 1 case, and relief of ureteral obstruction by resection of pelvic endometrioma in 1 case
Leonhartsberger *et al.*/2008	Urol Int	CR	1	23	100% left	1 intrinsic	1 segmental ureterectomy and ureterocystoneostomy
Marugami *et al.*/2008	Radiat Med	CR	1	45	Bilateral	NR	Ureteroscopy and removal of the ureteric tumor
Frenna *et al.*/2007	J Minim Invasive Gynecol	RS	54	31.5	47.4% left, 31.6% right, 21% bilateral	100% extrinsic	100% laparoscopic ureterolysis
Stamatiou *et al.*/2007	Clin Exp Obstet Gynecol	CR	1	42	100% left	NR	Double J stent and danazole
Kijvikai *et al.*/2007	J Med Assoc Thai	CR	1	40	100% left	NR	Laparoscopic nephrectomy and uretrectomy
Chen *et al.*/2006	Taiwan J Obstet Gynecol	CR	1	37	100% left	NR	Ureterolysis-segmental resection of the distal ureter and reconstruction by end-to-end reanastomosis
Yee *et al.*/2006	Int Urol Nephrol	CR	1	33	Bilateral	Both intrinsic and extrinsic	Ureterolysis, and ureteroneocystostomy with psoas hitches and ureteral stent placements
Shukla *et al.*/2006	J Minim Invasive Gynecol	CR	1	41	100% right	100% extrinsic	Laparoscopic extravesical neoureterocystostomy
Schneider *et al.*/2006	Int J Urol	RS	7	31.8	5 (71.6%) left, 1 (14.2%) right, 1 (14.2%) bilateral	6/7 extrinsic (85.7%)	2 open ureterolysis, 2 laparoscopic ureterolysis, 6 Open ureretectomy and re-implantation, 1 Open excision of ureteral stump (postnephrectomy)
Ghezzi *et al.*/2006	Fertil Steril	PS	33	31	24 (72.7%) left, 5 (15.2%) right, 4 (12.1%) bilateral	32 (97%) extrinsic, 1 (3%) intrinsic	33 laparoscopic ureterolysis, 1 segmental ureteral resection with vesico-psoas hitch

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Supplementary Table 1: Contd...

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Antonelli *et al.*/2006	Eur Urol	RS	19	33.1	12 (63.2%) left, 4 (21%) right, 3 (15.8%) bilateral	4 (36.4%) intrinsic, 7 (63.6%) extrinsic	2 nephrectomy, 2 ureterectomy and terminoterminal anastomosis, 9 ureterectomy and ureterocystoneostomy, 6 ureterolysis
Pugliese *et al.*/2006	Urology	RS	3	47	2 (66.6%) left, 1 (33.3%) right	2 extrinsic, 1 NR	2×nephroureterectomy, ureterolysis, and omental flap
Generao *et al.*/2005	J Endourol	CR	1	49	100% right	100% intrinsic	Stent and ureteroscopy and holmium laser ablation and leuprolide therapy
Bowring *et al.*/2005	J Obstet Gynaecol	CR	1	39	100% left	NR	Laparotomy ureterolysis
De Giovanni *et al.*/2004	Arch Ital Urol Androl	CR	1	30	100% left	NR	NR
Giri *et al.*/2005	Ir J Med Sci	CR	1	49	100% right	100% intrinsic	Right nephroureterectomy
Strang *et al.*/2004	Int Braz J Urol	CR	1	65	100% left	100% intrinsic	ureterectomy and ureteroneocystostomy
Nezhat *et al.*/2004	JSLS	CR	6	39	3 (50%) left, 3 (50%) right	NR	6 laparoscopic ureteroneocystostomy and vesico-psoas hitch
Horn *et al.*/2004	Urol Int	CR	1	49	100% left	100% intrinsic	ureteroureterostomy and danazole
Dominici *et al.*/2004	Arch Ital Urol Androl	CR	1	41	100% left	NR	LH-RH analogs, ureteral resection, and ureteroneocystostomy
Watanabe *et al.*/2004	Int J Urol	CR	1	43	100% left	NR	Ureterolysis and stent and buserelin acetate (GnRH analog)
Sanyal *et al.*/2003	J Obstet Gynaecol	CR	1	29	100% right	NR	Segmental ureteral resection with vesico-psoas hitch
Peringa *et al.*/2002	JBR-BTR	CR	1	50	100% left	100% intrinsic	Removal of the ureteric tumor
Aldington *et al.*/2002	Int J Clin Pract	CR	1	29	100% left	NR	LHRH analogs and segmental ureteral resection and ureteroureteric anastomosis
Tanuma *et al.*/2001	Hinyokika Kiyo	CR/ review	1	42	100% left	100% intrinsic	partial ureterectomy with ligation of the distal end of the ureter
Anaf *et al.*/2001	Eur J Obstet Gynecol Reprod Biol	CR	1	30	100% left	100% intrinsic	GnRH agonists
Gagnon *et al.*/2001	Nephrol Dial Transplant	CR	1	27	100% left	NR	Double J stent
Ludwig *et al.*/2001	Arch Gynecol Obstet	CR	1	41	100% left	NR	Goserelin acetate and laparoscopic ureterolysis
O'Sullivan *et al.*/2001	BJOG	CR	1	31	100% right	NR	Laparotomy: Ureterolysis, ureteric stent, GnRH analogs
Nezhat *et al.*/1999	Fertil Steril	CR	1	36	100% left	NR	Laparotomy: Ureterolysis, segmental ureteral resection with vesico-psoas hitch
Akçay *et al.*/1999	Clin Nephrol	CR	1	35	Bilateral	100% extrinsic	Bilateral ureteroneocystostomy
Zanetta *et al.*/1998	Obstet Gynecol	CR	1	37	100% right	100% intrinsic and extrinsic	Ureteroscopy and removal of the ureteric tumor, ureteric stent, and medroxyprogesterone
Deprest *et al.*/1997	N. Engl J Med	CR	1	46	100% left	NR	Double J stent and progestogen therapy
Takeuchi *et al.*/1997	J Obstet Gynaecol Res	CR	1	47	100% right	100% intrinsic	Ureteral resection and ureteroneocystostomy
Nezhat *et al.*/1996	Fertil Steril	RS	21	35	11 (52.4%) left, 9 (42.9%) right, 1 (4.7%) bilateral	17 (81%) extrinsic	10 ureterolysis with vaporization and excision of endometriosis, 7 partial ureteral wall resection, 3 segmental ureteral resection and ureteroureterostomy, 1 segmental ureteral resection and ureteroneocystostomy
Sakellariou *et al.*/1996	Eur J Obstet Gynecol Reprod Biol	CR	1	33	100% left	NR	Laparotomy: Segmental ureteral resection and reconstruction by end-to-end reanastomosis

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Supplementary Table 1: Contd...

Author/year	Journal	Type of study	Number of cases (*n*)	Mean age	Ureteral localization, *n* (%)	Histological type, *n* (%)	Management, *n* (%)
Body *et al.*/1996	Eur J Obstet Gynecol Reprod Biol	CR	1	49	Bilateral	NR	Laparotomy: Ureterolysis, double J stent on the left side and a percutaneous nephrostomy on the right side
Brough *et al.*/1996	BMJ	CR	1	47	Bilateral	NR	Left nephrostomy and right double J stent
Susini *et al.*/1996	Gynecol Endocrinol	CR	1	24	Unilateral side	100% extrinsic	Laparotomic segmental ureteral resection and ureteral reimplantation and GnRH analogs
Total		5 PS + 37 RS + 62 CR	1384	38.6			

PS=Prospective studies, RS=Retrospective studies, CR=Case report, NR=Nonreported, GnRH=Gonadotropin-releasing hormone, YAG=Yttrium aluminium garnet, IUD=Intrauterine device, LHRH=Luteinizing hormone releasing hormone