Urethral diverticula in women

Tamsin J. Greenwell and Marco Spilotros

Abstract | Female urethral diverticula are rare, benign epithelium-lined outpouchings of the female urethra. Patients can present with a multitude of symptoms, most commonly urinary incontinence, recurrent UTIs and dyspareunia. These presenting symptoms are often confused with other diagnoses leading to delayed diagnosis or misdiagnosis. Diagnosis and preoperative assessment of bladder function is most accurate using a combination of clinical examination, T2-weighted postvoid MRI and videocystometrography. Best treatment is by vaginal excision, a procedure with a very low recurrence rate and high patient acceptability. Excision also results in high cure rates for associated dyspareunia, UTI and voiding dysfunction. Pre-existing urodynamically proven stress urinary incontinence (USUI) resolves in 50% of patients after excision of the diverticulum with Martius labial fat pad interposition without the need for further treatment. Potential adverse effects after surgery are new-onset USUI, urethrovaginal fistula and urethral stricture. The rate of onset of these potential adverse effects is low and related to the preoperative appearance of the diverticulum on an MRI scan and the complexity of the diverticulum.

Greenwell, T. J. & Spilotros, M. *Nat. Rev. Urol.* **12**, 671–680 (2015); published online 13 October 2015; doi:10.1038/nrurol.2015.230

Introduction

Female urethral diverticulum is a rare clinical entity and its diagnosis can often be delayed, which can cause considerable morbidity both by itself and as a consequence of misdiagnosis and subsequent mistreatment. Surgical treatment of this condition can be accompanied by serious adverse effects such as stress urinary incontinence (SUI) and urethrovaginal fistula.

The word diverticulum is defined in the Oxford English Dictionary as a blind tube leading from a cavity or a passage and is derived from the Latin 'deverticulum' meaning byway, which originates from 'devertere' that means to turn down or aside.

A urethral diverticulum is a benign, localized epithelium-lined outpouching of the urethra. William Hey[1] first described urethral diverticula in the medical literature in 1805. Following this description, only 17 cases were reported between 1894 and 1954, when Davis and Telinde[2] published their definitive series of 121 cases. The majority of diverticula are described as originating from the dorsal or dorsolateral surface of the urethra. However, this surface of the urethra in women actually corresponds to the ventral aspect of the male urethra (Figure 1). Ventral (or more correctly, true dorsal) origin of a diverticulum occurs but is rare and only mentioned occasionally in case series.[3]

Histopathologically, diverticula are virtually indistinguishable from paraurethral cysts: their epithelial lining cell-type is predominantly squamous (42%), followed by columnar (32%), combined squamous and columnar (18%) and cuboidal (14%), but it is never transitional.[4] Epithelial ulcerations can be present and the majority of diverticula show signs of inflammation (77%). The diverticulum wall is composed of fibrous collagen tissue only.[4]

Diverticula vary in size and shape and in the location of and number of communications with the urethra. Classically, a diverticulum opens into the urethra at 6 o' clock, but variance in the position of the opening can occur between 4 o' clock and 8 o' clock. Diverticula are multiple or complex in form in 30% of cases and have narrower (often fragile) communicating channels with the urethra than simple or single cases.[5] MRI scans of urethral diverticula indicate that a simple diverticulum might enlarge to extend anterolaterally and surround the urethra, becoming horseshoe or saddle-shaped in configuration. With time and further enlargement, these anterolateral forward projections surround the urethra completely on its ventral aspect to become a circumferential diverticulum. This Review describes the incidence of urethral diverticula in women, the risk factors for their development and pathogenesis, along with the more common presenting symptoms and the best diagnostic techniques and management options for this condition. The surgical management of urethral diverticula in women is given particular attention along with the benefits and harms of these techniques. Common and/or difficult management dilemmas are discussed and possible management options are detailed.

Incidence

Urethral diverticula occur in 0.02–6.00% of women worldwide.[6,7] For every 1 million women undergoing pelvic surgery <0.01% are reported to have a urethral diverticulum, the same is true of 4.7% of asymptomatic women admitted for gynaecological or obstetric

Department of Urology, University College London Hospital, Ground Floor North, 250 Euston Road, London NW1 2PG, UK (**T.J.G., M.S.**).

Correspondence to: T.J.G tamsin.greenwell@uclh.nhs.uk

Competing interests
The authors declare no competing interests.

Key points

- Urethral diverticula are rare outpouchings of the female urethra
- Urethral diverticula occur most commonly in parous women aged 30–60 years
- The most common presenting symptom is urinary incontinence
- Diagnosis is best achieved by clinical examination, T2-weighted MRI of the pelvis and videocystometrography
- The most effective treatment is vaginal surgical excision

indications and 40% of women with unexplained lower urinary tract symptoms seen in specialist clinics.[7,8] The incidence of urethral diverticula has been steadily increasing in the USA for the past 30 years and increased incidence has also been observed in the UK, with 74 diagnoses of urethral diverticulum recorded by hospital episodes statistics (HES) data in the 1998–1999 period and 164 in the 2013–2014 period.[9] This rise in diagnoses could be a result of increased awareness amongst clinicians or, on the other hand, be a true increase in incidence or a mixture of both.

Age at diagnosis

Urethral diverticula are most common in women between the ages of 30 years and 60 years—with a mean age of 36 years at time of diagnosis.[10] Age at surgery is increasing; one study showed an increase from a mean of 41.6 years old ± 15.7 years between 1979 and 1988 to a mean of 49.4 years old ± 14.8 years between 1989 and 1997.[11] This observation might reflect a genuine increase in age at onset, be related to an increase in age at first pregnancy or be caused by an increase in time to diagnosis (which would contradict the theory that the increase in incidence is related to increased awareness).

Parity at diagnosis

Parous women are more likely to experience urethral diverticula than nulliparous women, 80% of cases are in women who have given birth with a mean parity of 2.2 (range 1–6);[11,12] however, they do occur in nulliparous women (20% of cases), and the very rare congenital urethral diverticulum can present at a very young age, often in childhood (<12 years old), in patients who have no risk factors for acquired diverticula, but no data exist on the proportion of cases that are congenitital in nature.[12–14] Pregnancy and/or vaginal delivery can produce obstruction of the periurethral glands and result in diverticulum formation.[15,16]

Pathogenesis

The overwhelming majority of urethral diverticula are acquired; theoretically (as no developmental model exists, and researchers have had to rely on histopathological study of urethral diverticula), they are caused by rupture of chronically obstructed and/or infected periurethral glands into the urethral lumen.[15,16] Recurrent infection of periurethral glands, vaginal birth trauma and previous vaginal or urethral surgery (including urethral bulking agents and midurethral tapes for urodynamically proven stress urinary incontinence [USUI]) are also risk factors for the development of a urethral diverticulum.[17–21]

The function of the periurethral glands is to secrete mucins, which protect the urethra from the irritative and potentially toxic effects of urine. These mucins also act as a sealant within the urethra and contribute to urinary continence. The glands are generally sited between 3 o' clock and 9 o' clock within the submucosa of the urethra, adjacent to a rich network of vascular spongy tissue, predominantly within the distal two-thirds of the urethra. They terminate in the paraurethral glands of Skene which empty via 6–30 paraurethral ducts into the distal third of the urethra (Figure 2).[22]

Very rarely, a urethral diverticulum is congenital in origin, but the rarity of this presentation is unknown as many series do not specify the type of diverticula encountered. A congenital diverticulum generally presents at a young age and arises as a consequence of embryonic Gartner duct remnants, the faulty union of primordial folds or persisting Müllerian rest cells.[14]

Presentation

Classically, a patient with a urethral diverticulum is thought to present with the '3 Ds'—dysuria, dyspareunia and dribble (after micturition)—but this triptych only

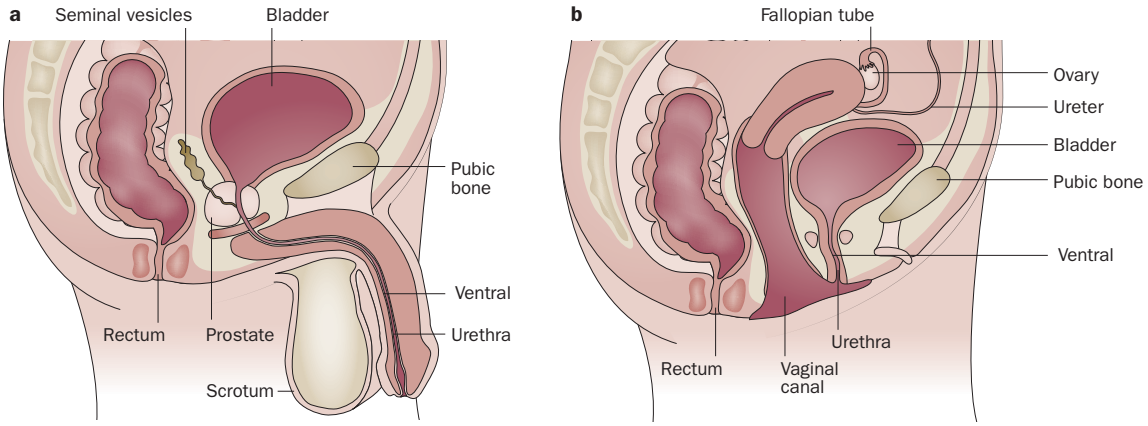

Figure 1 | The anatomy of the urethra. **a** | In men, and **b** | in women, highlighting the true anatomical ventral aspect of the urethra in men and women.

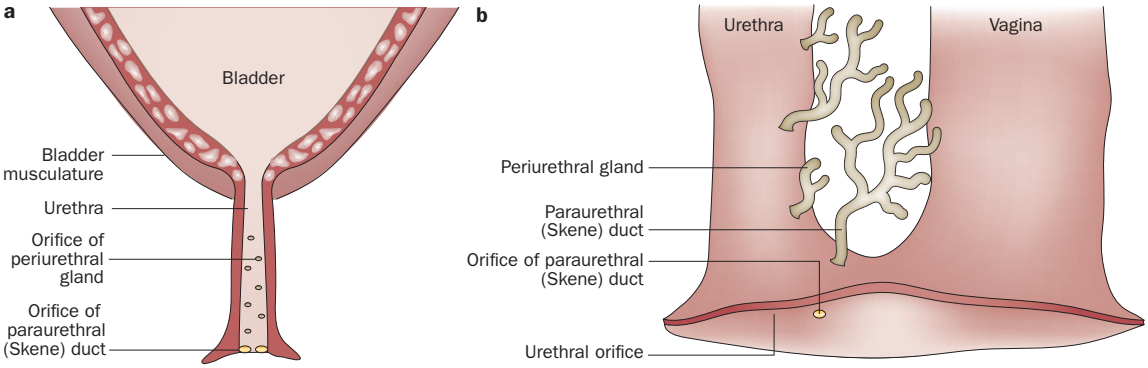

Figure 2 | The anatomy of the periurethral glands and the paraurethral glands of Skene in relation to the bladder and urethra in women. **a** | The openings of the periurethral glands and the paraurethral glands of Skene into the urethra. **b** | The location of periurethral ducts and paraurethral ducts of Skene in relation to the urethra. The function of the periurethral glands is to secrete mucins, which protect the urethra from the irritative and potentially toxic effects of urine. The glands are generally sited between 3 o' clock and 9 o' clock within the submucosa of the urethra, adjacent to a rich network of vascular spongy tissue, predominantly within the distal two-thirds of the urethra. They terminate in the paraurethral glands of Skene which empty via 6–30 paraurethral ducts into the distal third of the urethra.

occurs in about 20% of women.[23] In reality, patients can present with a variety of nonspecific lower urinary tract symptoms and a high index of suspicion is often required for diagnosis.[24] Symptomatic patients generally present between 30 years and 60 years of age with frequency and/or urgency and post micturition dribbling (which can coexist with other forms of incontinence, especially stress urinary incontinence), dysuria, localized pain and dyspareunia. Symptoms do not seem to correlate with the size of the diverticulum—although this observation has not been formally documented.

The most common presenting symptom of a patient with a urethral diverticulum is that of urinary incontinence, often in the form of postmicturition dribble followed by (in order of prevalence) recurrent UTI, frequency, urgency, dysuria and dyspareunia (Box 1). In up to 30% of patients, urinary incontinence is the only presenting symptom.[25,26] Other presenting symptoms include vaginal swelling, anterior vaginal discomfort, urethral discharge, periurethral abscesses and acute urinary retention.[23,27–29] These symptoms can present acutely, most commonly as a painful inflammatory mass on the anterior vaginal wall, which is detectable close to the vaginal introitus on examination of the vagina. Compression of this mass can result in purulent discharge from the external urethral meatus. The presence of blood in this discharge should raise suspicion of a malignant change or possibly calculi, especially if the anterior vaginal wall mass is associated with hardness or induration on palpation. On rare occasions, a diverticulum can be a necrotic ulcerated mass mimicking vaginal carcinoma.[30]

Voiding dysfunction and urodynamic abnormalities are present at the time of diagnosis in at least 50% of cases with equal incidences of stress urinary incontinence, urge incontinence and obstruction (Box 2).[31,32] The differential diagnosis for a urethral diverticulum includes any potential causes of an anterior vaginal wall mass and/or pain such as a paravaginal cyst, a vaginal cyst (also known as Gartner duct cyst), an anterior vaginal wall prolapse, a urethral mucosal prolapse, a benign urethral lesion (such as, a leiomyoma, a lipoma, an ectopic caeco [or blind-ending]-ureterocele inserting into the urethrovaginal septum or a urethral caruncle), along with all potential causes of urinary incontinence, dysuria and dyspareunia (such as pelvic inflammatory disease and endometriosis). This depth and breadth of possible alternative diagnoses can lead to delays in diagnosis or incorrect diagnosis and/or mistreatment (Box 2).[24,33,34]

Women are often diagnosed after years of symptoms and unsuccessful treatments, such as anterior repair for perceived anterior compartment pelvic organ prolapse. The mean diagnostic delay can be from 11–76 months (range 1–266 months).[23,35–38]

Diagnosis

The key to successful diagnosis of urethral diverticula is to maintain a high index of suspicion. A complete history including voiding symptoms, dyspareunia and urethral or vaginal discharge should be obtained, supplemented by a bladder diary. Coexisting conditions such as detrusor overactivity and USUI are common.

An anterior vaginal wall lump, positioned approximately on the midline, is present on examination in 52–90% of patients (Figure 3).[21,24] Fluid can be expressed from this lump in up to 30% of cases confirming communication. The anterior vaginal wall lump with the urethra and, therefore, confirming the diagnosis of urethral diverticulum.[21,24] A midstream urine sample should be assessed to exclude or confirm UTI.

Cystourethroscopy, performed using a round-ended cystoscope (without a beak), to enable dilatation of the female urethra by irrigation, might show an ostium into the diverticulum in up to 71% of patients but is often an unrewarding procedure in the clinical setting as an ostium is not often observed.[24] The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of cystourethroscopy have been reported as 33%, 100%, 100% and 42%, respectively.[39] Visualisation of an ostium at time of cystourethroscopy can be enhanced by digitally compressing the diverticulum to

Box 1 | Presenting symptoms of urethral diverticula*

Symptoms and the percentage of patients who present with these symptoms:

- Dysuria, dyspareunia and dribble (the '3 Ds'): 23%
- Vaginal swelling: 52–90%
- Postmicturition dribble: 62–72%
- Recurrent UTI: 7–57%
- Frequency: 22–50%
- Anterior vaginal discomfort: 0–48%
- Urgency: 22–36%
- Dysuria (alone and as part of 3 Ds): 31–36%
- Urinary incontinence (all forms except postmicturtion dribble): 0–35%
- Dyspareunia (alone and as part of 3 Ds): 21–24%
- Urethral discharge: 0–13%
- Necrotic ulcerated mass: <1%
- Periurethral abscess:<1%
- Acute urinary retention:<1%

*See references 1–5,8–10,12–21,23,24,26–36,38,40,43,50, 53,54,56–60,71–75.

Box 2 | Differential diagnosis of urethral diverticula*

Diagnoses

- Anterior pelvic organ prolapse
- Skene gland cysts
- Vaginal cyst
- Ectopic ureter
- Leiomyoma of the urethra
- Melanoma
- Fibroepithelial polyp
- Endometriosis
- Urethral caruncle
- Urethral mucosal prolapse
- Interstitial cystitis/painful bladder syndrome/ urethral syndrome
- Stress urinary incontinence
- Urge urinary incontinence
- Frequency and/or urgency
- Sensory urgency
- Urethral carcinoma
- Vaginal carcinoma
- Wegener granulomatosis

*See references 1,2,5,8,10,12,16–21,23,24,26–34,36,38,40, 43,50,52,54,58,59,72,75.

extrude pus into the lumen of the distended urethra. Cystourethroscopy also enables assessment of the relationship between the ureteric orifices and the diverticulum and endoscopic placement of protective ureteric stents at the time of definitive excision if the diverticulum is of such a size that it encroaches upon the trigone.

A micturating cystourethrogram (MCUG) with or without positive pressure urethrography (PPU) is diagnostic in 55–87% of women and provides information on the size of the diverticulum in 72% of cases but does not reliably provide details on the configuration and site of communication. MCUG ± PPU is also invasive and, in the case of PPU, uncomfortable.[25,36] PPU requires simultaneous obstruction of the bladder neck and external urethral meatus using specially designed catheters. The procedure is time consuming and no longer used in routine clinical practice owing to concerns related to artefactual overdiagnosis and the sequelae injection of a radiocontrast agent under pressure (resulting in pain, extravasation and fibrosis).[40,41]

Ultrasound techniques including transvaginal ultrasonographic scanning (TVUSS), contrast-enhanced TVUSS, transrectal ultrasonography and transperineal ultrasonography have been reported, with varying degrees of success (up to 66% overall).[21,24] Urethral diverticula are imaged as anechoic or hypoechoic lesions with transmission of signal through the diverticulum. As with all ultrasound techniques, visualization is operator-dependent and somewhat subjective. Ultrasound does not give good definition of deeply sited soft-tissue structures and of intraurethral and/or periurethral masses and is not the technique of choice for imaging urethral diverticula or indeed periurethral lesions in general, although it has been reported to be superior to a videocystometrogram in demonstrating the extent and location of the diverticula.[42]

Videocystometrography (or videourodynamics) is diagnostic in 62–95% of patients (Figure 4).[21,25] It also provides additional information regarding pre-existing bladder dysfunction including USUI, which is present in up to 49% of cases.[21,23]

MRI is the most accurate method of diagnosis for urethral diverticula. It enables detailed classification, as it provides information on location, number, size, configuration and site of communication of the diverticula and has the advantage of not exposing the patient to ionizing radiation. The sensitivity, specificity, PPV and NPV of MRI have been reported as 100%, 83%, 92% and 100%, respectively.[42,43] T2, fine-section, postvoid pelvic MRI has obtained pre-eminence in the assessment of the configuration of urethral diverticula with the development of transverse MRI classification categories of simple, horseshoe and circumferential diverticula. Sensitivity and specificity of this technique are both approaching 100% and intraobserver agreement is reported as 93% in diagnosing urethral diverticulum (Figure 5).[37,43,44] Gadolinium contrast-enhanced MRI has been advocated by some groups to improve the diagnosis of site of communication but has not been compared with standard postvoid T2 imaging.[44]

MRI is the best imaging modality for the diagnosis of urethral diverticula but interpretation of scans requires expertise. A case series published in 2010 highlighted possible areas of confusion including: major discrepancies in surgically assessed versus MRI-assessed diverticulum anatomy in 7% of cases, diagnostic errors, which included a Bartholin cyst, a sterile abscess and changes after collagen injection being misdiagnosed as a urethral diverticulum, failure to diagnose an existing urethral diverticulum in 7% of cases and failure to diagnose cancer in the diverticulum in 5% of 41 cases.[45] These findings could represent a problem with MRI-based diagnosis or a problem with interpretation of scans, which is more likely. Performance of T2 pelvic MRI immediately after voiding to diagnose a urethral diverticulum is of upmost importance, to maximize chances of urine in the diverticulum, and should be

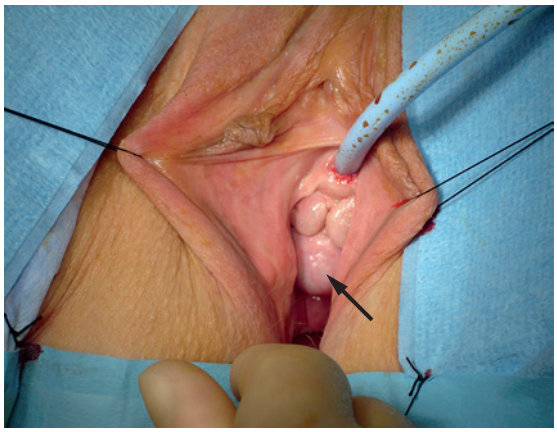

Figure 3 | A urethral diverticulum on clinical examination before surgery.

interpreted by an expert radiologist with an interest in female urology. Differential diagnoses of cystic urethral lesions and/or periurethral masses by MRI include a urethral diverticulum, an ectopic ureter, a Skene gland cyst, a vaginal cyst, urethral carcinoma, leiomyoma, melanoma, a fibroepithelial polyp, endometriosis, urethral caruncle and urethral mucosal prolapse.[45]

In 2014, voiding cystourethrography using CT was evaluated for diagnosis and classification of urethral diverticula.[46] This method enables transverse classification into simple, horseshoe and circumferential subtypes along with providing excellent detail with regards to the site and size of the ostium of communication between the urethra and the diverticulum. The location of the diverticulum in relation to the urethral sphincter is important, as the diverticulum could compromise the function of the sphincter and cause urinary incontinence as a presenting symptom or might indicate the likelihood of new-onset USUI after excision of the diverticulum (with diverticula that have large openings into the sphincteric region of the urethra, especially away from the 6 o'clock position, being more likely to result in USUI after excision).[47]

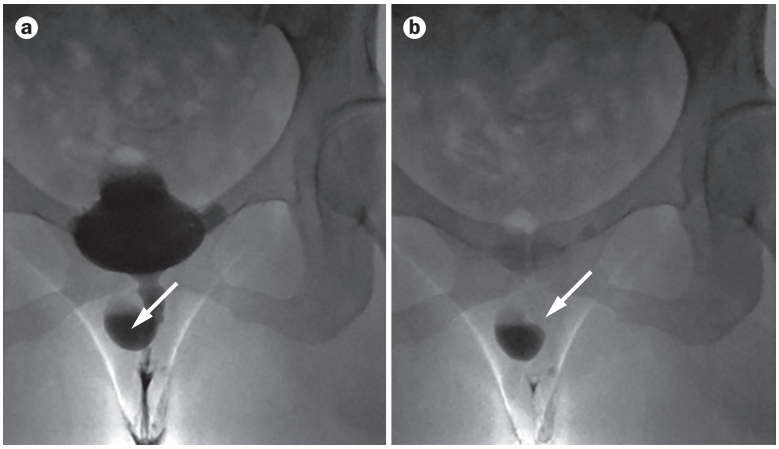

Figure 4 | A videocystometrograph for diagnosis of a urethral diverticulum. **a** | The diverticulum during voiding. **b** | The diverticulum after voiding.

Classification

In 1993, Leach *et al.*[48] proposed the clinical and imaging classification system L/N/S/C3 for urethral diverticula in which 'L' refers to the location of the diverticula on the urethra (distal, mid or proximal, with or without extension beneath the bladder neck), 'N' refers to the number of diverticula (single or multiple) and 'S' to the size of the diverticula in centimetres. 'C3' refers to three aspects of the diverticulum: its configuration (single, multiloculated or horseshoe) its site of communication with urethra and the continence of the patients (for example, whether they have pre-existing genuine stress urinary incontinence). However, this classification has not been widely adopted owing to its complexity, and most clinicians classify urethral diverticula into simple or complex,[48,49] or according to transverse MRI configuration as simple, horseshoe or circumferential.[37,40] A classification of complex is given if the diverticulum is proximally sited, loculated, >3 cm in diameter in any plane, associated with previous pelvic or vaginal surgery, is horseshoe or circumferential on transverse MRI or if multiple diverticula are present.[50,51]

Natural history

The natural history of urethral diverticula is mostly unknown. The main consequences of no treatment seem to be the persistence of presenting symptoms, in particular recurrent UTIs, urinary incontinence or frequency and/or the development of infection, abscess formation or stone formation within the diverticulum.[47,52,53] Malignant change has been reported in 3–9% of patients in larger series, with 100 cases of malignant change reported in 60 years, but not all cases are reported in the literature so the true rate is not known.[23,54,55] The types of cancer reported have been transitional, squamous, clear cell, adenocarcinoma or high-grade poorly differentiated.[56,57]

Other associated pathological changes that have been documented include chronic inflammation and periglandular fibrosis (which can be associated with thinning and/or loss of urethral and bladder epithelium), chronic cystitis and cystitis cystica.[58] Squamous metaplasia, adenomatous metaplasia, cystitis glandularis and nephrogenic adenoma (a benign entity) have also been reported to occur within a considerable proportion of diverticula, but these reports are infrequent.[55,59]

Inflammation and associated pathological changes are exacerbated by the presence of stones within the diverticulum. Calcium oxalate and calcium phosphate stones occur in up to 10% of urethral diverticula (Figure 6) and are thought to be a consequence of urinary stasis within the diverticulum.[59]

Suspicion of carcinoma is best investigated with gadolinium-enhanced MRI followed by transvaginal trucut biopsies of the diverticulum. Once diagnosed, treatment of cancer is generally exenterative (with radical excision of the urethra, bladder, uterus, anterior vaginal wall and formal pelvic lymphadenectomy) owing to the propensity for local spread through the thin diverticulum wall. Prognosis is very poor with death occurring in up to 40% of affected patients.

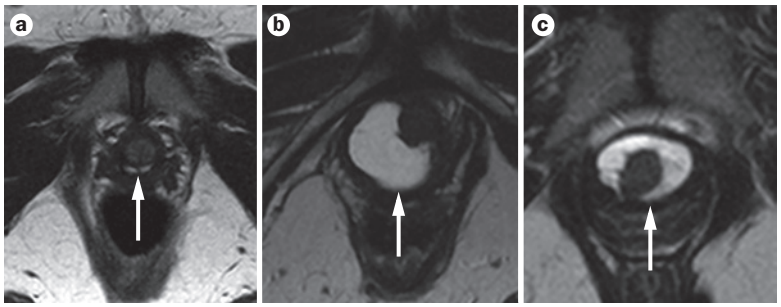

Figure 5 | A urethral diverticulum on T2-MRI transverse section. In each case the diverticulum is white. **a** | A simple diverticulum. **b** | A horseshoe diverticulum. **c** | A circumferential diverticulum.

Malignancy might develop as a spectrum of changes resulting from premalignant lesions—villous adenoma, intestinal metaplasia and high-grade dysplasia have all been described in cases of urethral diverticulum supporting this hypothesis.[60–62] Benign tumours, such as leiomyoma and nephrogenic adenoma, have also been described.[57,63]

Treatment

Many treatments have been described for the management of urethral diverticulum ranging from endoscopic aspiration to open abdominovaginal excision.

Short term results of case series of minimally invasive and minimally effective treatments (in terms of cure of urethral diverticulum and resolution of symptoms) such as fulguration,[52,64] endoscopic deroofing and marsupialisation (of a distal diverticulum only) have been published and these techniques might be of use in high-risk patients, including pregnant women or surgery-averse patients.[23] The numbers of participants in these case series are small and no long-term or even medium-term results are available to suggest that these are not effective treatments in the medium and long term. Thus, no conclusions can be drawn other than to note that they exist as techniques and might be applicable in difficult situations.

Figure 6 | An excised urethral diverticulum containing calculi.

In cases of an acute infection of a urethral diverticulum, treatment should be limited to appropriate antibiotics, as guided by discussion with a microbiologist, and subsequent incision and drainage of the diverticulum should be performed if the infection fails to settle or an abscess forms. Any further definitive treatment should be deferred for a minimum of 3 months to allow complete resolution of all associated inflammation.

The most effective form of treatment is transvaginal surgical excision via an anterior vaginal wall inverted U or midline incision, with excision of the diverticulum and three-layer closure with or without a Martius labial fat pad or a vaginal flap. This technique has a reported 83–97% success rate.[20,21,54] Vaginal excision of a urethral diverticulum aims to dissect and excise the diverticulum, with identification and formal closure of the ostium (or all the ostia if multiple diverticula are present) that connects the diverticulum to the urethra with a layered, well vascularized and watertight closure with or without an interpositional flap (a Martius labial fat pad).

The procedure for performing a vaginal excision of a urethral diverticulum comprises several steps: following review of preoperative imaging (MRI and videocystometrogram) and the WHO safety checklist, prophylactic antibiotics (such as gentamicin and a combination of amoxicillin and clavulanic acid) are given. An initial rigid cystourethroscopy is performed to exclude any coexisting bladder pathology, to assess the relationship of the ureteric orifices to the diverticulum and to identify the ostium of the urethral diverticulum into the urethra if possible. If required, 5 French open-ended ureteric catheters (also known as Pollack catheters) can be inserted to identify the ureters perioperatively. A 16 French urethral catheter is then inserted to drain the bladder and enable visualization of the lumen of the urethra. Following infiltration of the overlying vaginal wall with local anaesthetic containing adrenaline (at a concentration of 1 in 200,000), an anterior vaginal wall incision is made, which is centred vertically in the midline (if a Martius labial fat pad interposition is to be used) or, more classically, an inverted U-shaped incision centred horizontally over the midpoint of the diverticulum is performed (if the likelihood that tissue interposition will be required is low). The periurethral tissues and the external (vaginal) aspect of the diverticulum wall are then carefully dissected until the lateral aspect of the anterior-most projection of the diverticulum bilaterally has been identified (Figure 7a). For smaller diverticula, the plane between the inner (urethral) aspects of the diverticulum wall is then developed to enable identification of the area or areas of communication (the ostium or ostia of the diverticulum). For larger, more complex diverticula, this dissection can be aided and advanced by incising the vaginal aspect of the diverticulum wall in the midline, to enter the diverticulum. Identification of the lateral and anterior limits of the diverticulum along with the ostium of the diverticulum from within is then possible (Figure 7b). Next, the plane between the urethra and the inner aspect of the diverticulum wall (the urethral aspect) can be developed and the diverticulum excised in two halves.

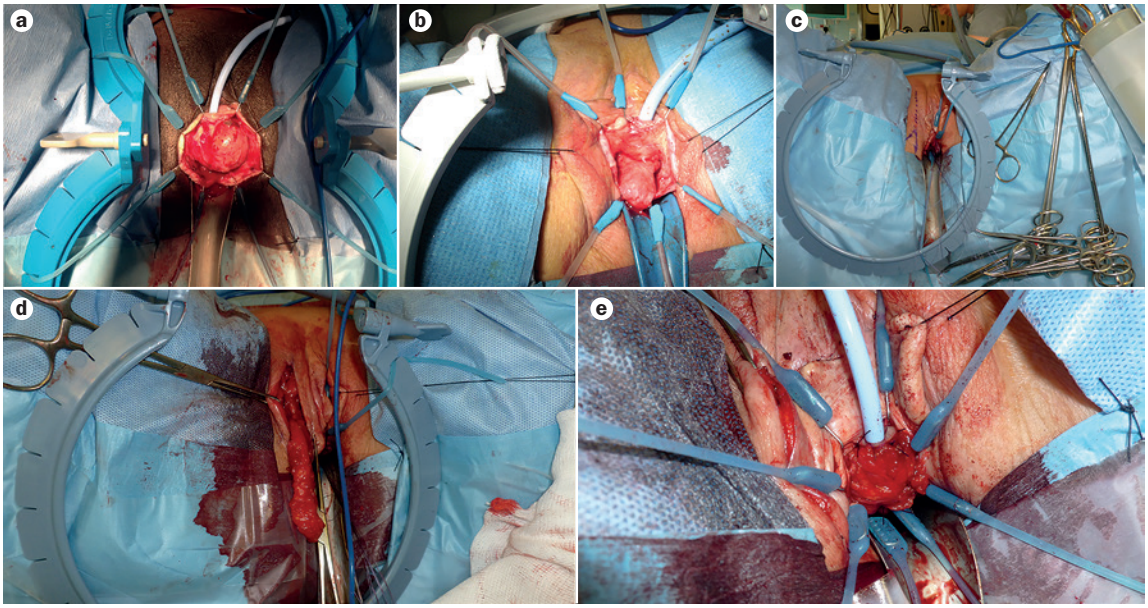

Figure 7 | Operative excision of a urethral diverticulum with a Martius fat pad interposition. **a** | Exposure of a urethral diverticulum following midline incision of the vagina and dissection between the anterior vaginal wall and the dorsal aspect of the diverticulum. **b** | Lateral mobilisation of the diverticulum, the dorsal aspect of the distal urethra is visible above the diverticulum. **c** | The incision and blood supply for a right Martius fat pad. **d** | Completion of the harvest of the Martius fat pad on the inferolateral pedicle. **e** | The Martius fat pad is then sutured over the dorsal aspect of the urethra after excision of the diverticulum and closure of the urethral ostium.

A three-layer closure is performed—either of the urethral wall, the periurethral fascia and the vaginal mucosa or of the urethral wall, the Martius labial fat pad and the vaginal wall—with absorbable suture material (such as 4/0 or 5/0 VICRYL® [polyglactin 910] [Johnson & Johnson, USA] for the urethra and 3/0 VICRYL® for the other layers) (Figures 7c–7e).[64–67] The aim of this closure is to avoid overlapping suture lines and reduce the risk of subsequent urethrovaginal fistula formation. Martius fat pad interposition is advocated in all patients by some clinicians including ourselves[65,66] owing to its minimal morbidity and ease of harvest, others suggest that it is used for patients with large urethral wall defects after the excision and/or a large diverticulum and also for complicated repairs and those with concomitant SUI.[67]

At the end of surgery, a small (20–30 cm) vaginal pack is inserted to aid with haemostasis (larger packs cause greater patient discomfort without any marked additional benefits over the small packs) and is removed on day 1 or day 2. If a Martius labial fat pad is harvested, a small vacuum drain such as a Mini-Vac® (Romsoms, India) is inserted at the end of surgery to drain any subsequent haematoma and eliminate dead space and also removed on day 1 or day 2. The urethral catheter remains in place for 10–21 days (depending on surgeon preference and/or the complexity of the repair). Our routine practice is to confirm healing with a pericatheter urethrogram at 21 days after surgery and remove the urethral catheter. If healing is not confirmed the catheter is left *in situ* and the urethrogram repeated at weekly intervals until healing is confirmed. Other groups simply remove the catheter at an arbitrary time after surgery, which varies from 1 week to 3 weeks.[23,32] Removal of a urethral catheter too early, without confirmation of healing, possibly accounts for early recurrence of diverticula and might increase the risk of urethrovaginal fistula development. Length of stay in hospital for patients after surgery was around 3.2 days ± 1.7 days in 1997 reducing to 0 days (interquartile range [IQR] 0–1) in 2012 (although this study is likely to have reported on predominantly small simple diverticulum given the short operating time reported, so potentially underestimates the overall hospital stay.[11,68] Length of stay is variable and depends on many factors including funding method of health care (with shorter stays in self-funded or private-insurance based systems), patient expectations, patient age, comorbidities and the level of community and family support as well as size and complexity of the urethral diverticulum.[68–70]

The posterior approach to the urethral diverticulum and the urethra (at 6 o' clock) minimizes damage to the horseshoe-shaped rhabdosphincter overlying the urethra anterolaterally. An alternative approach of urethral transection with end-to-end anastamosis has been described for the management of complex diverticulum but has not been widely adopted, probably owing to the fact that few (if any) situations exist in which excision of a diverticulum is not possible using standard means and complete transection of the female urethra at sphincteric level presents a considerable risk of new onset USUI.[50,67]

Factors associated with worse outcomes in terms of recurrence of diverticula, new onset USUI or urethrovaginal fistula development are a horseshoe or circumferential configuration, >3 cm size and having a proximal location.[23] Simultaneous insertion of a pubovaginal sling or tape for SUI has been advocated by

Box 3 | Long-term complications of diverticulum excision*

Complications and their prevalence

- New-onset stress urinary incontinence: 8–49%
- Persistence of dysuria: 0–26%
- Persistence of recurrent UTI: 0–23%
- Recurrence: 0–22%
- New-onset urgency: 0–13%
- Urethrovaginal fistula: 0–8%
- Urethral stricture: 0–2%

*See references 1–5,8–10,12–21,23,24,26–36,38,40,43,50, 53,54,56–60,71–79.

some authors who report complete continence following combined excision of urethral diverticula and insertion of pubovaginal sling.[71] Others feel this approach is overtreating the majority of patients who do not suffer new-onset USUI after excision of a urethral diverticulum and also those with pre-existing USUI in whom USUI resolves after diverticulum excision (up to 50% of patients with pre-existing USUI). The majority of surgeons advocate initial excision of the urethral diverticulum and subsequent reassessment of symptoms before proceeding with SUI surgery if it is indicated.[72–74] Recurrence after excision depends on the complexity of the diverticulum. A diverticulum is labelled complex if it is proximally sited, loculated, >3 cm in diameter in any plane, associated with previous pelvic or vaginal surgery or is horseshoe or circumferential on transverse MRI or if there are multiple diverticula.[73,74] Clinical recurrence is associated with all of these factors with the exception of loculation.[72,73] Interestingly, previous excision of urethral diverticulum does not seem to be a risk factor for recurrence, as weakness or narrowing at the site of previous excision would logically be risk factors for recurrent diverticulum.[72] Transverse MRI is useful in predicting both clinical and MRI-diagnosed asymptomatic recurrence.[66] Clinical recurrence following excision of a simple diverticulum has not been specifically documented but has been reported in up to 20% of patients after excision of a circumferential diverticulum; however, no data have been published concerning clinical recurrence after excision of a horseshoe diverticulum.[50] MRI-diagnosed recurrence, which includes both asymptomatic and symptomatic recurrence, is much more common and occurs in 33% of patients with horseshoe diverticulum and 66% of patients with circumferential diverticulum, but no recurrence of simple diverticulum after excision has been reported using this technique.[50] Up to 86% of patients have their presenting symptoms relieved after surgery with the prevalence of urgency and frequency reduced from 60% to 16% and dyspareunia reduced from 56% to 8%.[72,73] Recurrent UTIs and dysuria can persist in up to 23% and 26% of patients, respectively.[72,73]

Complications of surgery

The acute complications of urethral diverticula surgery are those that are common to all vaginal surgery and include pyrexia in 0–8% of patients, UTI in 4–40% of patients, vaginal bleeding in 4–10% of patients and acute retention in 4–12% of patients.[23,24,72–75] Long-term complications include clinical recurrence, urethral stricture, urethrovaginal fistula, urgency and new-onset SUI (Box 3).[23,24,72–74] New-onset SUI is the most common considerable long-term complication and has been reported in as many as 50% of patients in some series; however, most authors report new-onset SUI in a much lower percentage of patients (8–29%).[72–77] This complication settles with time and conservative treatment in the majority of women, with surgical treatment required in only 4–10% of cases. An increased risk of new-onset USUI seems to exist if the diverticulum is proximally located and/or of a large size (>3 cm) and/or of a circumferential configuration according to MRI.[72–77] A measure of the overall efficacy of urethral diverticulum excision surgery with its relative paucity of serious adverse effects is the finding that 92% of patients would recommend excision of urethral diverticulum to a friend.[75,76]

Common treatment dilemmas

Management of the asymptomatic diverticulum

Management of an asymptomatic diverticulum is entirely by patient choice. The limited information that is available about the natural history of a urethral diverticulum should be discussed with the patient, in particular the reported incidence of progression to malignancy in up to 9% of cases.[23,54,55] The potential adverse effects of treating and of not treating should also be detailed to enable a fully informed decision. Those patients electing to have no treatment should be followed up with an annual MRI and clinical examination, for future delineation of the natural history of urethral diverticula and also owing to the potential risk of malignant changes.

Diverticula and pregnancy

Little data exist to guide the patient and clinician with regards to the optimal mode of delivery for the pregnant patient with a urethral diverticulum or one who has had surgical treatment for a urethral diverticulum. A pre-existing urethral diverticulum can enlarge during pregnancy (and conversely involute after pregnancy), causing pelvic dystocia, especially if it is associated with acute urinary retention.[78] Resection or incision and drainage (essentially creating a urethrodiverticulovaginal fistula) might be required during pregnancy to enable vaginal delivery.[78,79] No other treatments for urethral diverticula during pregnancy have been reported and an endoscopy would be extremely difficult after week 8 of the pregnancy, owing to anatomical changes caused by the enlarged uterus. Diathermy should also be avoided.

Pregnancy following excision of a urethral diverticulum might be best delivered by Caesarean section owing to the risk of urethrovaginal fistula formation (if the second stage of labour is prolonged) and of damage to the vascular supply to a Martius labial fat pad if it was used at time of original diverticulum excision. The choice of whether to undergo a Caesarean section rests solely with the patient after the potential risks, alongside the advantages and disadavantages, of vaginal and Caesarean delivery have been discussed. Again,

note should be kept of patients electing to have vaginal delivery and follow-up clinical examination and/or MRI performed to review outcome with regards to the urethral diverticulum.

Managing pre-existing SUI

De novo SUI requiring treatment occurs in up to 29% of patients, whereas pre-existing SUI resolves after excision of a urethral diverticulum in 50–100% of women.[31,76] In an attempt to avoid any persistent SUI, simultaneous anti-incontinence procedures have been performed with diverticula excision, resulting in resolution of SUI in 78% of patients.[77] The persistence of pre-existing stress incontinence is, therefore, 0–50% in patients who receive diverticulectomy excision alone compared with 22% in those who have simultaneous procedures and, on balance, diverticulectomy alone should be favoured.

Conclusions

Female urethral diverticulum is a rare, but increasingly common, clinical entity that is difficult to diagnose. Diagnosis is best achieved by clinical examination and T2-pelvic MRI in combination with videocystometrography and best treated by vaginal surgical excision, which is successful in almost 100% of patients and gives high patient satisfaction. Clinical symptomatic recurrence is dependent on MRI-based classification and occurs in 20% of patients with circumferential diverticula but not in patients with simple diverticula. New-onset SUI occurs in 8–29% of patients and urethrovaginal fistula in 0–8% of patients after surgical excision. The mechanism of development of new-onset SUI after excision of the diverticulum should be investigated and preventative strategies or techniques to avoid this complication should be developed to improve patient outcomes following surgery.

1. Hey, W. *Practical observations in surgery* 303–305 (Humphreys, J., 1805).
2. Davis, H. J. & Telinde, R. W. Urethral diverticula: an assay of 121 cases. *J. Urol.* **80**, 34–39 (1958).
3. Burst, M., Schott, G., Rosch, W. & Schrott, K. M. Ventral urethral diverticulum: case report of a 10 year old girl. *Urologe A* **38**, 372–375 (1999).
4. Tsivian, M., Tsivian, A., Schreiber, L., Sidi, A. A. & Koren, R. Female urethral diverticulum: a pathological insight. *Int. Urogynecol. J. Pelvic Floor Dysfunct*. **20**, 957–960 (2009).
5. Drutz, H. P. Urethral diverticula. *Obstet. Gynecol. Clin. North Am*. **16**, 923–929 (1989).
6. Anderson, M. J. The incidence of diverticula in the female urethra. *J. Urol.* **98**, 96–98 (1967).
7. El-Nasher, S. A. *et al*. Incidence of female urethral diverticulum: a population-based analysis and literature review. *Int. Urogynecol. J.* **25**, 73–79 (2014).
8. Stewart, M., Bretland, P. M. & Stidolph, N. E. Urethral diverticula in the adult female. *Br. J. Urol.* **53**, 353–359 (1981).
9. Health & Social Care Information Centre. *hscic.gov.uk* [online], http://www.hscic.gov.uk/hesdata/
10. El Khader, K. *et al*. Diagnostics and therapeutic aspects of suburethral diverticuli; Apropos of 9 cases and review of the literature. *J. Urol. (Paris)* **102**, 107–110 (1996).
11. Burrows, L. J., Howden, N. L., Meyn, L. & Weber, A. M. Surgical procedures for urethral diverticula in women in the United States, 1979–1997. *Int. Urogynecol J. Pelvic Floor Dysfunct*. **16**, 158–161 (2005).
12. Kochakarn, W., Ratana-Olam, K., Viseshsindh, V., Leenanupunth, C. & Muangman, V. Urethral diverticulum in females: 25 years experience at Ramathibodi Hospital. *J. Med. Assoc. Thai*. **83**, 1437–1441 (2000).
13. El Khader, K. *et al*. Urethral diverticulosis in women. Analysis of 15 cases. *Prog. Urol.* **11**, 97–102 (2001).
14. Glassman, T. A., Weinerth, J. L. & Glenn, J. F. Neonatal female urethral diverticulum. *Urology* **5**, 249–251 (1975).
15. Routh, A. Urethral diverticulum. *Br. Med. J*. **1**, 361–365 (1890).
16. Cocco, A. E. & MacLennan, G. T. Unusual female suburethral mass lesions. *J. Urol.* **174**, 1106 (2005).
17. Clemens, J. Q. & Bushman, W. Urethral diverticulum following collagen injection. *J. Urol.* **166**, 626 (2001).
18. Kumar, D., Kaufman, M. R. & Dmochowski, R. R. Case reports: periurethral bulking agents and presumed urethral diverticula. *Int. Urogynecol. J*. **22**, 1039–1043 (2011).
19. Athanasopoulos, A. & McGuire, E. J. Urethral diverticulum: a new complication associated with tension-free vaginal tape. *Urol. Int.* **81**, 480–482 (2008).
20. Hammad, F. T. TVT can also cause urethral diverticulum. *Int. Urogynecol J. Pelvic Floor Dysfunct*. **18**, 467–469 (2007).
21. Tancer, M. I. & Ravski, N. A. Suburethral diverticulae. *Clin. Obstet. Gynaecol*. **25**, 831–837 (1982).
22. Huffman, J. The detailed anatomy of the paraurethral ducts in the human female. *Am. J. Obstet. Gynecol.* **55**, 86–101 (1948).
23. Ockrim, J. L., Allen, D., Shah, P. J. & Greenwell, T. J. A tertiary experience of urethral diverticulectomy: diagnosis, imaging and surgical outcomes. *BJU Int.* **103**, 1550–1554 (2009).
24. Romanzi, L. J., Groutz, A. & Blaivas, J. G. Urethral diverticula in women: diverse presentations resulting in diagnostic delay and management. *J. Urol.* **164**, 428–433 (2000).
25. Dai, Y., Wang, J., Shen, H., Zhao, R. N. & Li, R. Z. Diagnosis of female urethral diverticulum using transvaginal contrast-enhanced sonourethrography. *Int. Urogynecol. J*. **24**, 1467–1472 (2013).
26. Ganabathi, K., Leach, G. E., Zimmern, P. E. & Dmochowski, R. R. Experience with the management of 63 urethral diverticulum in women. *J. Urol.* **152**, 1445–1452 (1994).
27. Butler, J. M., Benetsen, D. & Dias, A. An unusual cause of pelvic pain and fever: periurethral abscess from an infected urethral diverticulum. *J. Emerg. Med.* **40**, 287–290 (2011).
28. Shindo, T. *et al*. Urinary retention caused by female urethral diverticulum. *Hinyokika Kiyo* **53**, 821–823 (2007).
29. Pradhan, M. R., Ranjan, P. & Kapoor, R. Female urethral diverticulum presenting with acute urinary retention: reporting the largest diverticulum with review of the literature. *Indian J. Urol.* **28**, 216–218 (2012).
30. Billow, M., James, R., Resnick, K. & Hijaz, A. An unusual presentation of a urethral diverticulum as a vaginal wall mass: a case report. *J. Med. Case Rep.* **7**, 171 (2013).
31. Wilson, A. *et al*. Female urethral diverticula: evaluation of voiding dysfunction before and after surgery. *J. Urol.* **187** (Suppl.), e630 (2012).
32. Reeves, F. A., Inman, R. D. & Chapple, C. R. Management of symptomatic urethral diverticula in women: a single centre experience. *Eur. J. Urol.* **66**, 164–172 (2014).
33. Jadhav, J., Koukoura, O., Joarder, R. & Edmonds, S. Urethral diverticulum mimicking anterior vaginal wall prolapse: case report. *J. Minim. Invasive Gynecol.* **17**, 390–392 (2010).
34. Fletcher, S. G. & Zimmern, P. E. Differential diagnosis of chronic pelvic pain in women: the urologists approach. *Nat. Rev. Urol.* **6**, 557–562 (2009).
35. Gillon, G., Kessler, O. & Servadio, C. Surgery for women with urethral diverticulum. *Harefuah* **131**, 242–243 (1996).
36. Chang, Y. L., Lin, A. T. & Chen, K. K. Presentation of urethral diverticulum is usually not typical. *Urol. Int.* **80**, 41–45 (2008).
37. Kim, B., Hricak, H. & Tanagho, E. A. Diagnosis of urethral diverticula in women: value of MR imaging. *AJR Am. J. Roentgenol*. **164**, 809–815 (1993).
38. Rufford, J. & Cardozo, L. Urethral diverticula: a diagnostic dilemma. *BJU Int.* **94**, 1044–1047 (2004).
39. Pathi, S. D. *et al*. Utility of clinical parameters, cysto-urethroscopy, and magnetic resonance imaging in the preoperative diagnosis of urethral diverticula. *Int. Urogynecol. J*. **24**, 319–323 (2013).
40. Dwarkasing, R. S. *et al*. MRI evaluation of urethral diverticula and differential diagnosis in symptomatic women. *Am. J. Roentgenol*. **197**, 676–682 (2011).
41. Chancellor, M. B. *et al*. Intraoperative endoluminal ultrasound evaluation of urethral diverticula. *J. Urol.* **153**, 72–75 (1995).
42. Woodhouse, C. R., Flynn, J. T., Molland, E. A. & Blandy, J. P. Urethral diverticulum in females. *Br. J. Urol.* **52**, 305–310 (1980).
43. Foster, R. T., Amundsen, C. L. & Webster, G. D. The utility of magnetic resonance imaging for diagnosis and surgical planning before transvaginal periurethral diverticulectomy in women. *Int. Urogynecol. J. Pelvic Floor Dysfunct*. **18**, 315–319 (2007).

44. Chung, D. E., Purohit, R. S., Girshman, J. & Blaivas, J. G. Urethral diverticula in women: discrepancies between magnetic resonance imaging and surgical findings. *J. Urol.* **183**, 2265–2269 (2010).
45. Portnoy, O. *et al*. Correlation between MRI and double-balloon urethrography findings in the diagnosis of female periurethral lesions. *Eur. J. Radiol*. **82**, 2183–2188 (2013).
46. Lee, Y. J., Son, S. J., Paick, J. S. & Kim, S. W. Preoperative CT voiding cystourethrography using 16-multidetector CT in female urethral diverticulum. *PLoS ONE* **9**, e107448 (2014).
47. Leach, G. E., Sirls, L. T., Gabanathi, K., Zimmern, P. E. L N. S. C3: a proposed classification system for female urethral diverticula. *Neurourol. Urodyn*. **12**, 523–531 (1993).
48. Rovener, E. S. & Wein, A. J. Diagnosis and reconstruction of the dorsal or circumferential urethral diverticulum. *J. Urol.* **170**, 82–86 (2003).
49. Ingber, M. S. *et al*. Surgically corrected urethral diverticula: long-term voiding dysfunction and reoperation rates. *Urology* **77**, 65–69 (2011).
50. Shim, J. S. *et al*. Calculus in a female urethral diverticulum. *Int. Neururol. J.* **15**, 55–57 (2011).
51. Diabate, I. & Sow, I. Female urethral diverticulum containing multiple calculi. *Prog. Urol.* **21**, 229–2320 (2011).
52. Ahmed, K. *et al*. Urethral diverticular carcinoma: an overview of current trends in diagnosis and management. *Int. Urol. Nephrol*. **42**, 331–341 (2010).
53. Laudano, M. A. Pathologic outcomes following urethral diverticulectomy in women. *Adv. Urol.* http://dx.doi.org/10.1155/2014/861940 (2014).
54. Shalev, M., Mistry, S., Kernhan, K. & Miles, B. J. Squamous cell carcinoma in a urethral diverticulum. *Urology* **59**, 773 (2002).
55. Weng, W. C. *et al*. Clear cell carcinoma of urethral diverticulum—a case report. *J. Formos. Med. Assoc.* **112**, 489–491 (2013).
56. Aspera, A. M., Rackley, R. R. & Vasavada, S. P. Contemporary evaluation and management of the female urethral diverticulum. *Urol. Clin. North Am.* **29**, 617–624 (2002).
57. Scarpero, H. M., Dmochowski, R. R.& Leu, P. B. Female urethral diverticula. *Urol. Clin. North Am.* **38**, 65–71 (2011).
58. Flynn, C., Oxley, J., McCullagh, P. & McCluggage, W. G. Primary high-grade serous carcinoma arising in the urethra or urethral diverticulum: a report of 2 cases of an extremely rare phenomenon. *Int. J. Gynecol. Pathol.* **32**, 141–145 (2013).
59. Clayton, M., Siami, P. & Guinan, P. Urethral diverticular carcinoma. *Cancer* **70**, 665–670 (1992).
60. Thomas, A. A. *et al*. Urethral diverticula in 90 female patients: a study with emphasis on neoplastic alterations. *J. Urol.* **180**, 2463–2467 (2008).
61. Karadag, D., Caglar, O., Hallaglu, A. H. & Ataoglu, O. Leiomyoma in a female urethral diverticulum. *Jpn J. Radiol*. **28**, 369–371 (2010).
62. Fugigawa, K., Matsui, Y., Fukuzawa, S., Soeda, A. & Takeuchi, H. A case of female large urethral diverticulum treated with electrofulgaration. *Int. J. Urol.* **6**, 620–622 (1999).
63. Lee, D., Dillon, B. E. & Zimmern, P. E. Long-term morbidity of Martius labial fat pad graft in vaginal reconstruction surgery. *Urology* **82**, 1261–1266 (2013).
64. Hussain, M. *et al*. The uses and outcomes of martius fat pad in female urology [abstract 525]. *Eur. Urol. Suppl*. **11**, e525–e525a (2012).
65. Judd, G. E. & Marshall, J. R. Repair of urethral diverticulum of vesicovaginal fistula by vaginal flap technique. *Obstet. Gynecol.* **47**, 627–629 (1976).
66. Inneh, A. The combined influence of sociodemographic, preoperative comorbid and intraoperative factors on longer length of stay after elective primary total knee arthroplasty. *J. Arthroplasty* http://dx.doi.org/10.1016/j.arth.2015.05.032 (2015).
67. Raup, V. T. *et al*. Patient characteristics and preoperative outcomes of female urethral diverticulectomy: analysis of a multi-institutional prospective database. *Urology* **86**, 712–715 (2015).
68. Oxlan, M., Stubberfield, J., Stuklis, R., Edwards, J. & Ward, T. D. Psychological risk factors for increased post operative length of stay following coronary artery bypass graft surgery. *J. Behav. Med.* **29**, 179–190 (2006).
69. Chan, R., Rajanahally, S., Hollander, A. & Khavari, R. Urethral diverticulum after midurethral sling erosion, excision, and subsequent management. *Female Pelvic Med. Reconstr. Surg.* **21**, e3–e5 (2015).
70. Nickles, S. W. *et al*. Simple versus complex urethral diverticulum: presentation and outcomes. *J. Urol.* **84**, 1516–1519 (2014).
71. Han, D. H., Jing, Y. S., Choo, M. S. & Lee, K. S. Outcomes of surgery of female urethral diverticula classified using magnetic resonance imaging. *Eur. Urol.* **51**, 1664–1670 (2007).
72. Stav, K., Dwyer, P. L., Rosamilla, A. & Chao, F. Urinary symptoms before and after urethral diverticulectomy—can we predict *de novo* stress urinary incontinence? *J. Urol.* **180**, 2088–2090 (2008).
73. Ljungvist, L., Peeker, R. & Fall, M. Female urethral diverticulum—26-year follow-up of a large series. *J. Urol.* **177**, 219–224 (2007).
74. Kavia, R. *et al*. The effect of urethral diverticulum MRI configuration on new onset urodynamic stress urinary incontinence on excision [abstract 1846]. *J. Urol.* **189**, e758 (2013).
75. Ginsberg, P. & Finkelstein, L. H. Urethral diverticulum with calculi: report of a case. *J. Am. Osteopath Assoc.* **82**, 588–590 (1983).
76. Lee, U. J. *et al*. Rate of *de novo* stress urinary incontinence after urethral diverticulum repair. *Urology* **71**, 849–853 (2008).
77. Juang, C. M. *et al*. Combined diverticulectomy and anti-incontinence surgery for patients with urethral diverticulum and stress urinary incontinence: is anti-incontinence surgery really necessary? *Taiwan J. Obstet. Gynecol.* **45**, 67–69 (2006).
78. Allen, L. E., Mount, J., Kline, D. & Mertz, J. H. Pelvic dystocia secondary to urethral diverticulum and urinary retention. *J. Urol.* **102**, 451–453 (1969).
79. Iyer, S. & Minassian, V. A. Resection of urethral diverticulum in pregnancy. *Obstet. Gynecol.* **122**, 467–469 (2013).

Author contributions

Both authors researched data for the article, discussed the content, wrote the manuscript and reviewed and edited the article before submission.