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Are anterior urethral valve and anterior urethral diverticulum two separate entities: A radiological and endoscopic review

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Keywords
Anterior urethral valve; Anterior urethral diverticulum; Anterior urethral obstruction; Obstructive uropathy in children; Voiding cystourethrogram; Urethrocystoscopy

Abbreviations
AUV, anterior Urethral Valve; AUD, Anterior Urethral Diverticulum; PUV, Posterior Urethral Valve; USG, Ultrasound; VCUG, Voiding Cystourethrogram; DMSA, Dimercaptosuccinic Acid; UTI, Urinary Tract Infection; CKD, Chronic Kidney Disease; VUR, Vesico-ureteric reflux; TUR, Trans-urethral resection; UDS, Urodynamic study

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Summary

Background
Anterior urethral valve (AUV) and anterior urethral diverticulum (AUD) are two rare causes of anterior urethral obstruction with variable presentation and anatomy. Their existence as the same or different entity is still debatable, and management has not yet been standardized.

Objective
This study is a retrospective review of cases diagnosed with anterior urethral obstruction and correlation of radiological and endoscopic anatomy of AUV and AUD.

Study design
A retrospective review of cases diagnosed with AUV and AUD, between May 2013 and February 2020 is presented. The presentation, laboratory, radiological and endoscopic anatomy along with the management required was reviewed. A special emphasis has been given on the correlation of radiological and endoscopic anatomy and an attempt has been made to standardize the management.

Results
A total of 8 patients with age ranging from 2 months to 9 years were reviewed. Poor urinary stream and recurrent UTI was the commonest presentation. The anatomy of the anterior urethra on VCUG (voiding cystourethrogram) and Urethrocystoscopy was correlated. Two sets of patients were identified. In the first set, five cases on endoscopy had findings of the classical valve-like fold in the anterior urethra with immediate proximal dilation of the urethra giving the appearance of a 'pseudodiverticula' without any definite opening. In three of these cases, endoscopic findings correlated well with radiological findings of 'pseudodiverticula' in which dilated proximal urethra formed an obtuse angle with the ventral floor of the urethra. The other set of four patients had a 'true diverticula' on endoscopy with a well-defined mouth and prominent distal lip, correlating well with radiological findings of a 'true diverticula' forming an acute angle with the ventral floor of the urethra. One case on endoscopy had both an anterior urethral valve with a proximal 'pseudodiverticula and a large wide-mouthed bulbar 'true diverticula'.

All the patients with classical valves were successfully treated using a resectoscope while two patients with 'true diverticula' were successfully managed by incising the distal lip. One of the patients previously managed for the posterior urethral valve (PUV) had both classical valves in the anterior urethra with proximal 'pseudodiverticula' and a bulbar 'true diverticula'. The AUV was ablated with a resectoscope while 'true diverticula' required diverticulectomy. All the patients after follow up of 3 months—8 years, were asymptomatic except the one with 'true diverticulum' who remained symptomatic after TUR (Trans-urethral resection) and required vesicostomy.

Discussion
AUV and AUD both can cause obstructive uropathy. The proximal dilatation related to AUV cannot be labeled as a 'true diverticula', which lacks a classical orifice. The distal obstructing lip of 'true diverticula' should not be confused with a classical mucosal valve-like fold seen in AUV. While AUV and small AUD can be treated with endoscopic ablation, large diverticula as a result of wide spongiosal defects require surgical excision. A good understanding of their radiological and endoscopic anatomy is required to differentiate them and decide for appropriate management.

Conclusion
Based on our experience, AUV and AUD should be differentiated and should be considered as two separate entities.

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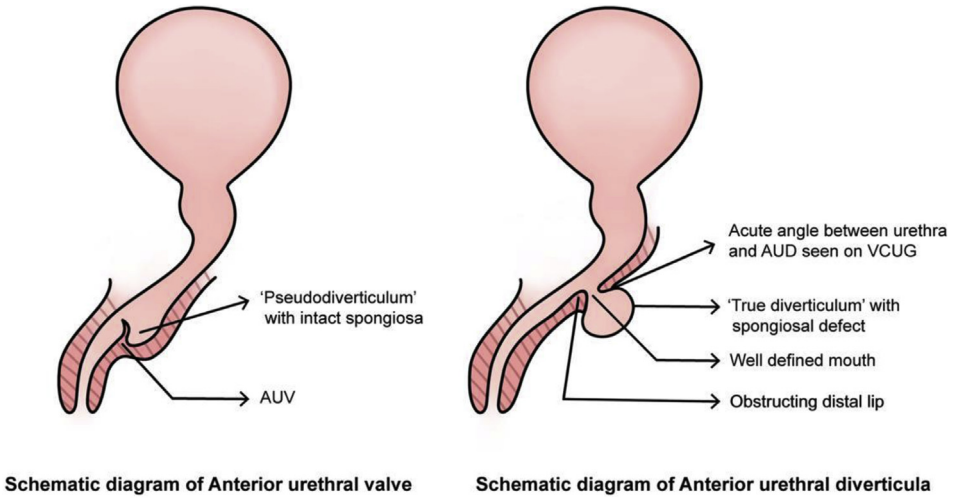

Summary Figure Schematic diagram showing differences between AUV and AUD based on imaging and endoscopic findings: AUV is an obstructing mucosal valve causing proximal dilatation of the urethra forming a 'pseudodiverticulum', while AUD is a 'true diverticulum' as a result of spongiosal defect with a definite orifice in endoscopy and obstructing distal lip, forming an acute angle with the urethra in VCUG.

Introduction

Anterior urethral valve (AUV) and anterior urethral diverticulum (AUD) are rare causes of obstructive uropathy in children. AUV is 7—30 times less frequent as compared to posterior urethral valve (PUV), but is one of the important and often missed causes of congenital obstructive uropathy in children [1,2]. AUV has been described as an isolated anomaly and also in association with an AUD [4]. Its association with diverticulum is still debatable, and it is not clear whether they are part of the same pathology or are

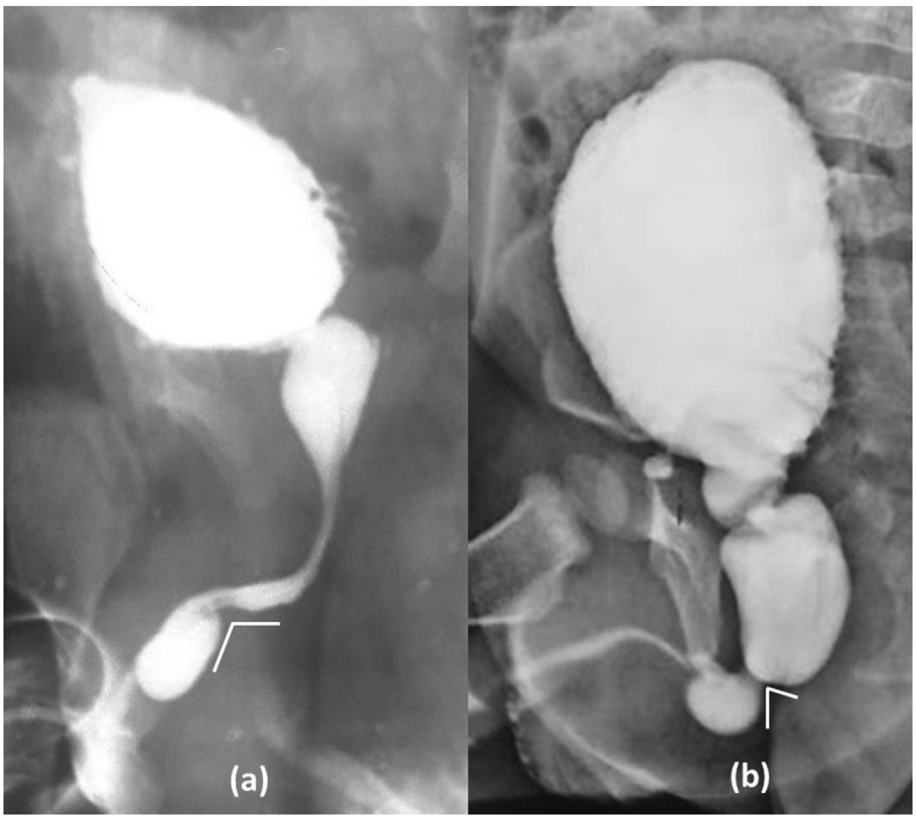

Fig. 1 a: An outpouching forming an obtuse angle with ventral floor of urethra labeled as 'pseudodiverticulum'; b: A well-defined wide-mouthed diverticulum with a proximal lip.

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Table 1 Clinical, radiological and endoscopic findings of cases with AUV/AUD and their management.

Case no.	Age	Presentation	Renal Functions	USG	VCUG on presentation	Findings on urethro-cystoscopy	Treatment	Follow up
1	4 years	Poor urinary stream with recurrent UTI H/o cystoscopy done twice.	Normal	No HN, Thickened small bladder, Increased PVR	Trabeculated small bladder, No VUR, dilated posterior urethra with 'true diverticulum' in bulbar urethra	Small 'true diverticulum' in bulbar urethra	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR
2	9 years	Poor urinary stream with dribbling and recurrent UTI. H/o cystoscopy and Urethral dilation done for suspected stricture	Normal	No HN, Thickened bladder, increased PVR	Trabeculated bladder, no VUR, dilated anterior and posterior urethra with a 'pseudo-diverticulum'	Thin mucosal semilunar valve in bulbar urethra with a proximal 'pseudo diverticulum'	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR
3	2 months	Antenatal diagnosed with bilateral HDUN	Deranged (CKD stage III)	Bilateral hydro-uretreonephrosis, thickened bladder with dilated urethra	Trabeculated bladder, no VUR, dilated anterior and posterior with a 'true diverticulum'	Large 'true diverticulum' at the bulbar urethra	TUR Vesicostomy for Persistent Obstructive Uropathy	Clinically stable Plan for excision of the diverticulum
4	1 year	Antenatal diagnosed bilateral HDUN. D10 USG – B/L HDUN with trabeculated bladder. Diagnosed as PUV and fulgurated outside at 1 month. Post fulgaration recurrent UTI and urinary dribbling. Penile swelling noticed at 8 months.	Normal	Thickened bladder with Bilateral HDUN	Trabeculated bladder, no VUR, large 'true diverticulum' at bulbar urethra, with dilated proximal posterior urethra	Semilunar thin mucosal valves in penile urethra with proximal 'pseudo-diverticulum' and a large 'true diverticulum in bulbar urethra'	TUR + Diverticulectomy	Asymptomatic Good stream No scrotal swelling

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Table 1 (*continued*)

Case no.	Age	Presentation	Renal Functions	USG	VCUG on presentation	Findings on urethro-cystoscopy	Treatment	Follow up
5	4 years	Poor urinary stream with dribbling since birth and recurrent UTI since 3 years of age.	Normal	Thickened bladder; increased PVR	Thickened trabeculated bladder, no VUR, dilated anterior and posterior urethra with a 'Pseudo diverticula'	Semilunar valves in bulbar urethra with 'pseudo-diverticulum' proximal to the valve	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR
6	4 years	Acute urinary retention Poor urinary stream with recurrent UTI H/o cystoscopy done outside	Normal	Thickened small bladder with dilated urethra, Increased PVR	Thickened small bladder, no VUR, dilated anterior and posterior urethra with a small 'true diverticulum' in bulbar urethra	True 'small diverticulum' in bulbar urethra	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR
7	5 years	Poor urinary stream Recurrent UTI	Normal	Thickened Urinary bladder, increased PVR	Trabeculated bladder, no VUR with dilated anterior and posterior urethra with a 'pseudo diverticulum'	Semilunar valve with a 'pseudo-diverticulum' in bulbar urethra	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR
8	9 months	Poor urinary stream with dribbling of urine and UTI	Normal	Thickened bladder	Thickened bladder, no VUR dilated anterior and posterior urethra, no diverticulum	Iris like valve in penile urethra with 'pseudo-diverticulum'	TUR	Clinically asymptomatic, good urinary stream, insignificant PVR

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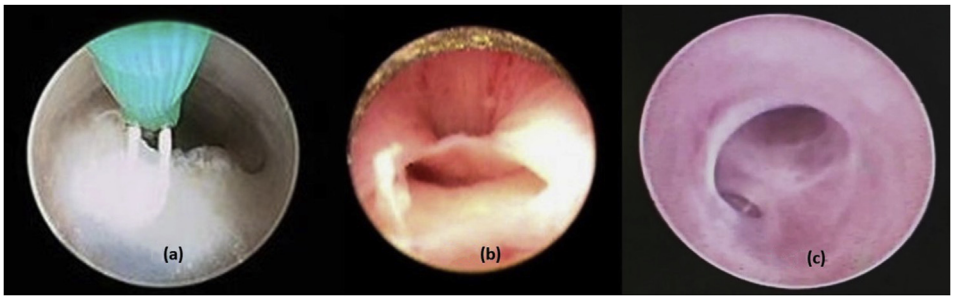

Fig. 2 a: Endoscopy findings of obstructing mucosal fold arising from the ventral wall of anterior Urethra (AUV); b and c: Endoscopy findings of 'true diverticulum' on the.

two different entities. Both of these can present as anterior urethral obstruction [5].

For a better understanding of the anatomy of AUV and AUD and their association, we reviewed the radiological and endoscopic anatomy of cases managed by us with a diagnosis of AUV and AUD.

The management of these associated entities can be challenging because of its confusing terminology, rarity, variable presentation, and anatomy. Moreover, no definite treatment and follow up protocol is available. However, if missed or mismanaged, the consequences can be devastating, with the incidence of renal failure varying from 5% to 18% [4,6,7].

Study methods

We retrospectively reviewed the medical records of cases diagnosed with AUV and AUD, between May 2013 and February 2020. The medical records were evaluated for demography, presenting history, renal functions, ultrasound (USG) of kidney and bladder and VCUG (voiding cystourethrogram), Dimercaptosuccinic Acid (DMSA scan), endoscopic findings, treatment modality and follow up. Also, a detailed review of VCUG imaging and endoscopic anatomy and their correlation was done through recorded fluoroscopic images and videos of urethrocystoscopy respectively. The diagnosis of AUV and AUD was suspected on VCUG findings of dilated anterior urethra, presence of diverticulum and then confirmed with findings on urethrocystoscopy. In VCUG, two forms of proximal outpouching from the ventral floor of the urethra were observed, 1) a diverticulum with proximal lip forming an obtuse angle with the ventral floor of the urethra, and was as labeled as 'pseudodiverticulum' (Figs. 1a and 2)) a well-defined wide-mouthed saccular diverticulum with a proximal lip forming an acute angle with the ventral floor of the urethra, labeled as 'true diverticulum' (Fig. 1b). These VCUG findings were then correlated with endoscopic findings. The outcome of patients was also reviewed with history, clinical examination, and USG.

Results

Between May 2013 and February 2020, a total of 8 patients with a diagnosis of AUV and AUD were managed at our center (Table 1). The age ranged from 2 months to 9 years (median 4 years). Poor urinary stream and recurrent urinary tract infection (UTI) was the commonest presentation (75%), while two cases had an antenatal diagnosis of hydroureteronephrosis (25%). Except one patient who had CKD (Chronic Kidney Disease) stage 3, rest of them had renal functions within the normal range. USG kidney and bladder revealed bilateral hydroureteronephrosis in two patients and increased post void residue in 5 patients. VCUG revealed dilated anterior or posterior urethra, along with trabeculated bladder in all patients. On VCUG scan, 'pseudo-diverticulum' type picture was seen in 3 patients (Fig. 1a) while a classical 'true diverticulum' was present in 4 patients (Fig. 1b). One patient although had a dilated urethra, did not show any diverticulum like outpouching. None of them had vesicoureteric reflux (VUR).

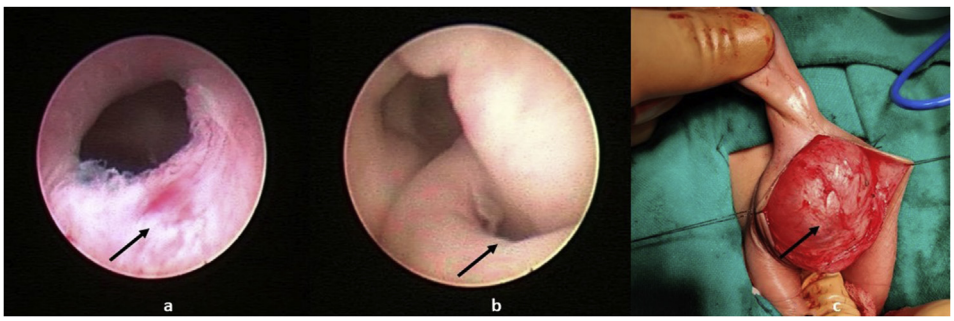

Fig. 3 Fig:A 8-month-old child with concomitant AUV and PUV. Endoscopic view of semilunar valves in the anterior urethra required endoscopic resection and a large.

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In 5 patients, cystourethroscopy done in our center revealed classical thin mucosal valves in the anterior urethra with proximal dilatation without a definite mouth, forming a 'pseudo-diverticulum' (Fig. 2a). These valves were semilunar in 4 cases and iris type in 1 case. Three patients had a valve in the bulbar urethra while 2 had valves in the penile urethra. In three of these cases, findings of endoscopy correlated well with the findings of 'pseudodiverticulum' on VCUG. The other two patients did not reveal 'pseudodiverticulum' on VCUG.

In four cases endoscopy revealed a saccular, 'true diverticulum' with well-defined orifice and a prominent distal lip which was relatively thick as compared to the mucosal fold of the AUV (Fig. 2b and c). All of these cases had findings of 'true diverticulum' on VCUG. One patient on endoscopy had both AUV with proximal 'pseudodiverticulum' and a 'true diverticulum'. This case had previously undergone fulguration for PUV and the diagnosis of AUV/AUD was initially missed on VCUG and cystourethroscopy. The patient continued to remain symptomatic and subsequently developed a large swelling on the ventral aspect of the penis and a repeat VCUG revealed a wide-mouthed 'true diverticulum'. All cases had mild to moderate bladder trabeculations. Four patients of AUV and AUD (50%) had already undergone urethro-cystoscopy before being referred to us but the diagnosis was missed.

The endoscopic ablation of mucosal valves was successfully performed in all 5 patients (100%). A pediatric resectoscope, which could easily engage the valves, was used for ablation (Fig. 2a). Out of 4 patients who had 'true diverticulum', 3 of them were treated with endoscopic incision of the distal lip using bugbee electrode, one of them subsequently required vesicostomy because of recurrent urinary retention. The 8-month-old child with concomitant AUV and PUV required endoscopic resection of semilunar valves along with diverticulectomy and urethral reconstruction (Fig. 3a, b and c).

All patients were followed for a period of 3 months—4.5 years and remained asymptomatic with a good urinary stream, normal renal functions, and normal USG. One patient had mild bilateral scars on the DMSA scan. One patient who had undergone diverticulectomy had a normal VCUG scan on follow up. None of these cases required any further interventions. One patient with CKD on vesicostomy is planned for diverticulectomy.

Discussion

Infravesical obstruction due to AUV and AUD is a rare entity, with debatable terminology, association, and management [1,3,4]. The clinical presentation of anterior urethral

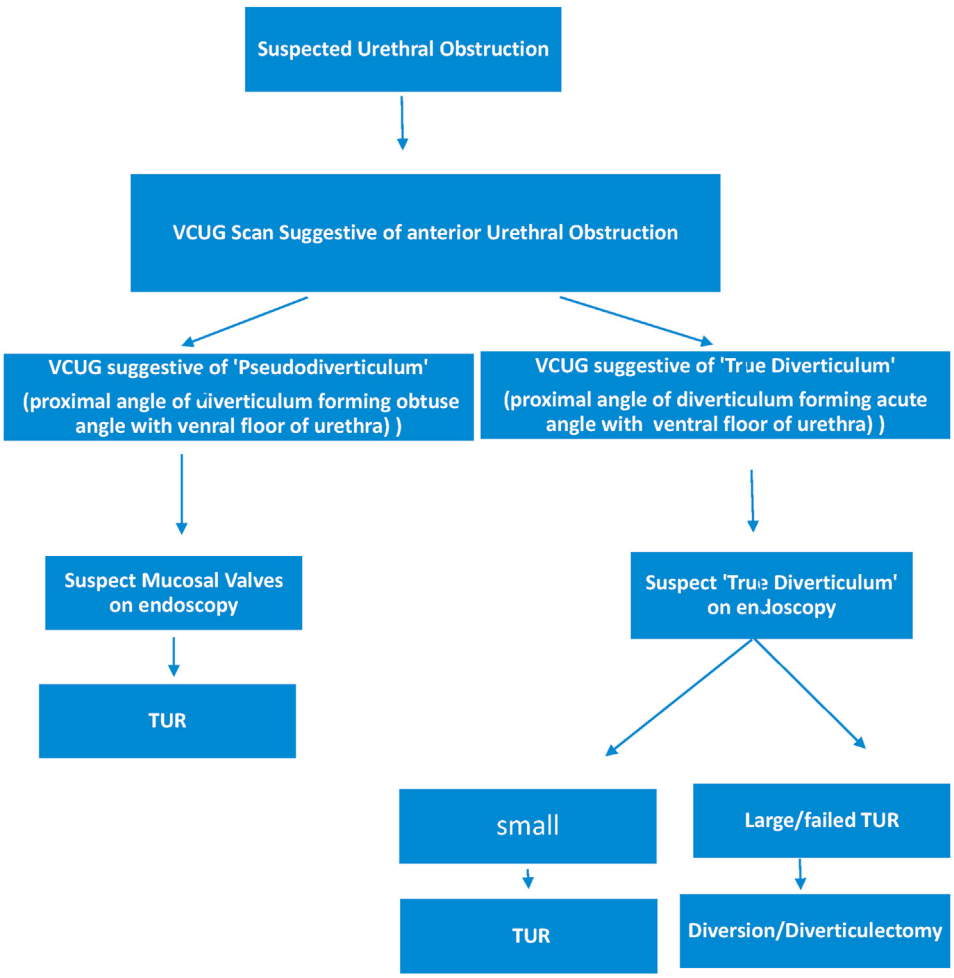

Fig. 4 Proposed algorithm for diagnosis and management of AUV/AUD.

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obstruction due to AUV and AUD is highly variable and depends on the severity of the obstruction and age of presentation [2,6,8–10]. The common presenting complaints include difficulty in voiding, dribbling, incontinence, poor urinary stream, and recurrent UTI [1,2,10,11]. During the neonatal period, AUV can present similar to PUVs with bilateral hydroureteronephrosis, severe obstructive uropathy, and severe azotemia [8]. When compared to PUV, AUV relatively has a mild and delayed presentation [8,10,11]. Patients with diverticulum usually have an early presentation and tend to have more symptoms, as also was observed in our cases. The presence of hydroureteronephrosis indicates the severity of obstruction, usually seen in the newborn period [8]. In our series one-fourth of the patients were diagnosed antenatally, the rest of them had delayed presentation with symptoms of urinary dribbling and recurrent UTIs.

It is still controversial that AUV and AUD are part of the same pathology or are two different entities [12–14] and so the terms AUV vs AUD are sometimes inconsistently used in various reports causing confusion. Some authors have classified AUV and AUD under the term diverticulum [1,15], while others have considered it to be a part of the same pathology [4]. Also, they have been considered as two separate entities by some authors [3,13]. Firlit et al. [4] combined all under a single entity as valves and classified them into four types depending on the severity of the obstruction and back pressure changes and an association with a diverticulum.

Urethral diverticulum has been defined as epithelialized, saccular dilation that is separate from the urethra but communicates by means of a discrete orifice [14,16]. They are mainly of saccular type with a localized protrusion from the ventral wall or rarely diffuse forming megalourethra or urethral ectasia [17]. The most accepted theory about the formation of diverticulum is the faulty development of the corpus spongiosum [17,18] as a result of which true diverticulum develops outside the corpus spongiosum [19]. Various theories proposed for the formation of AUV are a faulty union of the glandular and penile urethral segments, abortive attempt at urethral duplication, congenital cystic dilatation of periurethral glands, etc [2,3]. The cause and effect relationship between AUV and AUD, proposes that a spongy defect in the urethra leads to diverticulum formation and the anterior lip of the diverticulum acts as a flap valve when it gets filled with urine [12,20]. While another theory proposes that AUV is the initial insult which, depending upon the extent of obstruction, results in maldevelopment of the proximal spongy tissue and forms AUD of varying sizes [9,11].

Based on our experience in this series, we believe that the AUV and AUD are two different entities, causing anterior urethral obstruction. When radiological imaging and endoscopic anatomy of the urethra was corelated, two sets of patients were identified. In the first set, five cases (62%) on endoscopy had findings of classical valve like fold in anterior urethra with immediate proximal dilation of urethra without a discrete mouth giving appearance of a 'pseudodiverticulum'. In three of these cases, findings corelated well radiologically in VCUG which revealed outpouching proximal to obstruction resulting in 'pseudodiverticulum' with proximal lip forming an obtuse angle with ventral floor of the urethra (Fig. 1a), also seen sometimes extending below the valve [21]. This appearance of pseudodiverticula although present in endoscopy was not evident radiologically in two cases. Depending on the severity of obstruction, the dilatation of the proximal urethra can vary but was very similar to the shield like dilatation seen in cases of posterior urethral valve. The urethra distal to obstruction appeared narrow. On endoscopy, these valves were like classical mucosal fold arising from the ventral surface of the urethra, very similar to that seen in cases of posterior urethral valve. They were usually thin and semilunar or iris like in shape [21], which could be easily engaged with resectoscope. These mucosal valves flatten against the urethral roof resulting in obstruction [1]. Semilunar valves were more common as seen in 4 of our cases. Immediate proximal dilatation gives appearance of outpouching/'pseudodiverticulum' without any distinct orifice.

In another set of cases, endoscopy revealed a separate well defined opening on the ventral wall of the urethra, seen in 4 cases (50%). Besides a very evident wide mouthed urethral diverticulum, a prominent distal lip was present. When corelated with imaging, a definite outpouching was seen along with the proximal dilated urethra. Also in imaging, the proximal lip of this 'true diverticulum' formed an acute angle with ventral floor of the urethra. This finding was in contrast to the previous sets of patients in which the 'pseudodiverticulum' was seen forming an obtuse angle. The distension of 'true diverticulum', presses the distal lip against the dorsal wall and causes obstruction [12].

The distal prominent lip of 'true diverticulum' (Fig. 2b and c) should not confused with classical mucosal fold of AUV (Fig. 2a). The dilation seen proximal to valves should not be considered as 'true diverticulum' [3]. This fact is further supported by the observation in one of our case of concomitant AUV/AUD and PUV, where classical semilunar valvular fold in penile urethra had a proximal 'pseudo diverticulum'. Also, there was an associated large wide mouthed 'true diverticulum' in bulbar urethra not related with AUV.

Transurethral resection of AUV and distal lip of small AUD is the standard treatment [11,19]. The loop of the resectoscope easily engages the mucosal fold and so confirms the diagnosis, also ablating it at the same time [3,7]. All the patients with AUV were successfully treated with endoscopic ablation using resectoscope. The use of sachse knife has been described for incising the orifice of the diverticulum with good results, less surgical complications and shorter hospital stay [22]. The distal lip of 'true diverticulum' was incised in 3 cases with bugbee electrode as it was not easy to engage the lip with the resectoscope. One newborn patient with 'true diverticulum' remained symptomatic requiring vesicostomy. One patient with concomitant PUV and AUV had proximal 'pseudodiverticulum' and a large bulbar 'true diverticulum', required endoscopic resection of AUV and diverticulectomy with urethral reconstruction (Fig. 3a, b and c). These 'true diverticulum' are formed outside the corpus spongiosum and if small, obstruction can be relieved by incising the distal lip, while a large diverticulum will have wide spongiosal defect requiring diverticulectomy [1,10]. Sheth et al.[10] recommended to move

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directly to a diverticulectomy once a large diverticulum is identified without doing any endoscopic procedure. We recommend diverticulectomy for large diverticulum or in cases where endoscopic treatment fails. Urinary diversion should be used in cases with intractable urosepsis, patients with persistent symptoms, or when appropriate size instrument is not available [11]. Based on these observations we propose a management algorithm in cases of AUV/AUD (Fig. 4).

It is not uncommon to miss an AUV on VCUG and urethrocystoscopy. A good VCUG with voiding phase is mandatory to look specifically for urethral dilatation, level of obstruction, and to differentiate between 'pseudodiverticulum' and 'true diverticulum'. On endoscopy, the findings of obstructing mucosal fold can be easily missed because of retrograde flow of fluid which flattens the valve against the urethral valve [2,8,23]. A careful endoscopy with antegrade pressure over the bladder helps in delineating the valves [5].

All cases of AUV in our series had a prompt recovery following transurethral resection of the valves and had good urinary stream on follow up. The cases with 'True diverticulum' sometimes might require surgical resection if initial TUR fails as happened in of our case. Kajbafzdeh et al. [23] did a urodynamic study (UDS) of eight boys with AUV, before and after valve ablation. He reported different UDS patterns in patients with AUV ie hypercontractile bladder which resolved in all the cases. He was of the opinion that the distal location of the obstruction as compared to PUV and also a proximal diverticulum results in lower intravesical pressure in AUV cases, thus the better outcome [23]. Many reports show that AUV has an overall good outcome [6,8,14].

Conclusion

AUV and AUD are rare but important entities, requiring high index of suspicion along with detailed imaging and careful cystourethroscopy. Their association is still controversial. No clear definition of valve and diverticulum further increases the challenges in the management. We believe AUV and AUD should be considered as two different entities. A valve is a typical mucosal fold which can be successfully managed by incising with resectoscope. To avoid confusion, the proximal dilatation associated with the valve should not be labelled as 'true diverticulum', but a 'pseudodiverticulum'. A 'true diverticulum' has typical imaging and endoscopic view which should be differentiated to plan the appropriate management. The obstructing distal lip of a 'true diverticulum' should not be considered as valve, which although can be managed endoscopically may sometimes require surgical intervention. Even the presentation and prognosis of both entities can vary and so differentiation between AUV with AUD is important. A more detailed prospective study with a large series is required for a better understanding of these two entities.

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Conflict of interest statement

There are no personal, professional, or financial conflicts of interest.

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