Journal of Pediatric Urology (2016) xx, 1.e1–1.e8

Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia

M.M. Marei [a], A.E. Fares [b], A.H. Abdelsattar [a], K.S. Abdullateef [a], H. Seif [c], M.M. Hassan [d], M. Elkotby [a], G. Eltagy [a], M.M. Elbarbary [a]

[a]Department of Pediatric Surgery, Cairo University, Egypt

[b]Department of Pediatric Surgery, El-Fayoum University, Egypt

[c]Department of Pediatric Radiology, Cairo University, Egypt

[d]Diabetes, Endocrinology and Metabolism Pediatric Unit (DEMPU), Cairo University, Egypt

Correspondence to: M.M. Marei, Department of Paediatric Surgery, Royal Hospital for Sick Children, 17 Rillbank Terrace, Edinburgh, EH9 1LL, Scotland, Tel.: +44 7528619806

m.marei@nhs.net, m.marei@kasralainy.edu.eg (M.M. Marei)

Keywords
Congenital adrenal hyperplasia; Urogenital sinus; Feminizing genitoplasty; Urogenital mobilization; Disorders of sexual development

Received 14 April 2015
Accepted 6 February 2016
Available online xxx

Summary

Background
Virilized females due to congenital adrenal hyperplasia represent the most common form of female disorders of sexual development. The anomaly therein is an external virilization to resemble male genitalia and a persistent urogenital sinus.

Objectives
To study the anatomical details of the virilized female cases operated upon between 2011 and 2015. This anatomical description is presented to support the current surgical strategy of partial urogenital mobilization to correct this anomaly.

Methods
Thirty cases (presenting to a single tertiary center) were prospectively studied by genitography, cystourethroscopy, and operated upon via a single-stage feminizing genitoplasty. A single surgical team operated upon all cases. External virilization was assessed by the Prader classification. The internal anatomy was studied by measuring the length of the urethra proximal to the confluence, and the vertical depth of the vaginal-urethral confluence from the perineum. The correlation coefficients between the external virilization and the internal anatomical measurements were derived.

Results
The median age at surgery was 19 months (range 6–42 months). External virilization did not obviously correlate with the length of the proximal (prejunctional) urethra ($r = -0.03$, $P = 0.5$), or strongly with the depth of the vaginal-urethral confluence ($r = 0.2$, $P = 0.2$). The mean length of the proximal urethra was 22 mm (range 10–32 mm), and the mean vertical depth of the vaginal-urethral confluence from the perineum was 16 mm (range 8–31 mm).

Discussion
Due to limitations of the radiological and endoscopic evaluation, the accurate anatomical assessment of this condition may be challenging. In order to assess or compare the anatomy of these cases, there are two important points to address: (1) the length of the urethra proximal to the urogenital sinus, as this will impact the urinary outcome; and (2) the depth (level) of vaginal entry into the urogenital sinus, as this will affect the mobilization required to exteriorize the vagina.

Conclusion
The degree of external virilization does not totally correlate with the internal anatomy. The depth of the vaginal-urethral confluence from the perineum is an indicator of the required mobilization for the current perineal approach. In 90% of cases in this age group (1–3 years old), this depth is ≤20 mm. This supports the current understanding that partial urogenital mobilization could be suitable for most cases Figure (Summary).

http://dx.doi.org/10.1016/j.jpurol.2016.02.008

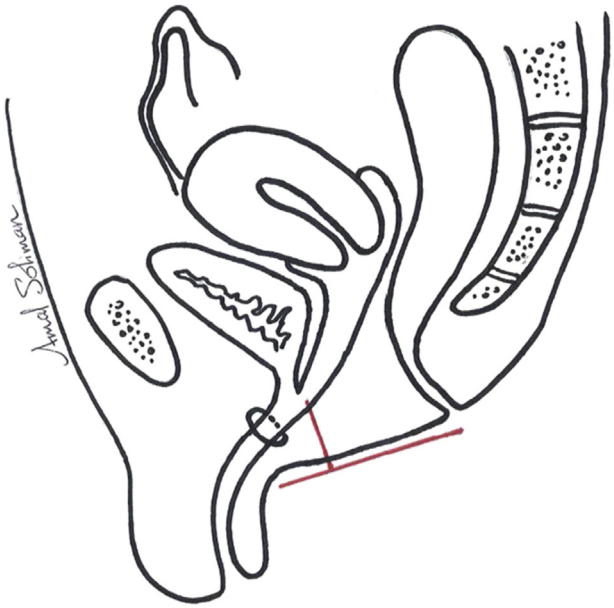

Figure (Summary) Diagram illustrating the vaginal depth from the perineal level (red lines).

Introduction

The traditional theory to explain the severity of the urogenital sinus anomaly in virilized females due to congenital adrenal hyperplasia is that the level of the vaginal entry into the urogenital sinus is determined by the degree of *in utero* exposure to adrenal androgens. Higher exposure is thought to lead to a more proximal entry of the vagina into the urogenital sinus, causing a higher confluence [1]. In a reliable mouse model, it was concluded that prenatal exposure to increasing levels of androgen causes a dose-dependent change in the anatomy, in the form of a distal elongation of the common urogenital sinus and a proximal migration of the bladder neck [2].

Other researchers have postulated that negligible variability in the proximal (prejunctional) urinary tract anatomy, with regard to the urethral length and the level of vaginal entry, occurs with increasing virilization [3].

It appears that both theories differ on the development of the proximal urethra and the level of vaginal entry into the urogenital sinus.

The aim of the present study was to add to these two views by describing the actual anatomical measurements of the urogenital sinus anomaly in virilized congenital adrenal hyperplasia around the age of 1—3 years.

In order to assess or compare the anatomy of these cases, there are two important points to address: (1) the length of the urethra proximal to the urogenital sinus, as this will impact the outcome of urinary function and continence; and (2) the depth (level) of vaginal entry into the urogenital sinus, as this will affect the mobilization required to exteriorize the vagina and dictate the likelihood of vaginal stenosis.

Recent studies have proven that the upper urethra is the most innervated structure of the pelvis, with completely circumferential innervations [4]. Sphincteric nerves cover the lateral and anterior aspects of the upper urethra and vagina [5]. Although these are descriptions of the innervation in normal individuals rather than virilized females, there are recommendations against routinely disrupting this high periurethral area. Dissection of the puboretheral ligament performed during total urogenital mobilization could endanger postoperative continence; consequently, exceptional care is needed when approaching the retro-pubic space [6,7].

The inaccurate classification of the persistent urogenital sinus anomaly into either high or low has led surgical teams to elect a flap vaginoplasty for cases designated as low urogenital sinus, and a pull-through vaginoplasty for cases designated as high urogenital sinus [8,9]. However, it is believed that this does not reflect the true situation, and that most cases lie between being low and high, and need a degree of urogenital mobilization, ranging from partial to total. Hence, to support the current surgical approach, the present study describes the measurements encountered in this group of patients.

Methods

This single-center study was prospectively approved and conducted under the guidance of the research ethics committee of Cairo University, Faculty of Medicine. All the included cases were diagnosed and managed by the Disorders of Sexual Development (DSD) team, based at the Diabetes, Endocrinology and Metabolism Pediatric Unit (DEMPU) of Cairo University Specialized Pediatric Hospitals (CUSPH). All of the cases referred to the DSD clinic that were diagnosed as 46 XX DSD due to congenital adrenal hyperplasia (CAH), with persistent urogenital sinus and external virilization were prospectively included. No cases with this diagnosis were excluded, nor was surgery deferred to a later age. All parents voluntarily provided informed consent for the planned procedure and possible risks, as well as for participation in this study.

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008

Thirty cases of female congenital adrenal hyperplasia with persistent urogenital sinus and external virilization were studied in the period from 2011 to 2015. For all cases, a clinical examination focusing on the Prader classification of external virilization was performed. This was followed by a genitography to assess the internal anatomy. To complete the information needed to proceed with surgery, a cysto-urethroscopy at the time of the operation was carried out in all cases. A single team of surgeons performed all operations and carried out the described measurements.

The internal anatomy was studied by measuring the prejunctional length of the urethra proximal to the confluence, and the vertical depth of the vaginal-urethral confluence from the perineum. The length of the proximal urethra was assessed and measured during the genitography and confirmed by cysto-urethroscopy. To assess the vaginal depth, the vertical shortest distance between the perineal floor and the vaginal opening into the confluence was measured in the lateral genitography views and confirmed intra-operatively by the depth of the dissection needed to identify the vagina. Intra-operative measurements were made at the instance when the vagina was found. All tension sutures were released at that point, to reduce any inaccuracy due to extensive dissection or applying tension on tissues.

The genitography was carried out under sedation by a pediatric radiologist, and in the presence of a pediatric surgeon. The patient was stabilized in the lateral position for the study. It started by injection of contrast until the confluence appeared, followed by the delineation of the bifurcation of the urethra anteriorly and the vagina posteriorly. The depth (level) of the confluence from the perineal floor was noted. The distance between the confluence and the bladder neck was determined to assess the urethral length proximal to the confluence. The point from which the vaginal depth was measured was the usual site of the apex of the perineal inverted U-incision, where the vaginal orifice would be exteriorized, just behind the fusion of the labia in the midline. A marker on the perineum clarified this during genitography (Figs. 1—3).

The operative technique for all cases was a feminizing genitoplasty, when both the external genitalia and internal anatomy were corrected in one stage. For the internal anatomy, the procedure of choice was partial urogenital mobilization (PUM), which was used whenever possible and was performed in 21 cases out of 30 (70%). Two cases needed a Passerini-Glazel flap to be added to the PUM, and one case needed a total urogenital mobilization (TUM) (dissection anterior to the urethra). The remaining six cases (20%) needed a simple posterior flap or vestibuloplasty to exteriorize the vagina. For the external virilization, all cases had: reduction clitoroplasty, preputial reconstruction of the labia minora and V—Y labio-scrotoplasty.

All surgical reconstructions were preceded by a cysto-urethroscopy. Fluid flow was used to distend the urethra; this allowed identification of the vaginal orifice in the back wall of the urethra around the pseudo-verumontanum. At the beginning of each procedure, the cysto-urethroscopy was used to place a urethral and a vaginal balloon catheter to aid dissection.

The proximal urethral length was measured endoscopically, essentially by passing a graded 3-Fr ureteric catheter through the working channel of the scope into the bladder. The scope was then extracted with that catheter left inside, and re-introduced next to the graded catheter, which was employed as a ruler. The technical description of this method by Rink et al. (2005) helped with this technique [10]. Another method that was occasionally helpful was placing the scope at the bladder neck then withdrawing it to the confluence point, and measuring the length of the scope segment withdrawn from the external meatus on the outside. The measurement was recorded in 5-mm intervals (i.e. 10 mm, 15 mm, 20 mm, etc). Occasional cases were found to fall between these points.

The anatomical measurements were essentially and initially based on clear lateral-view genitography. The endoscopic and operative findings were then used to

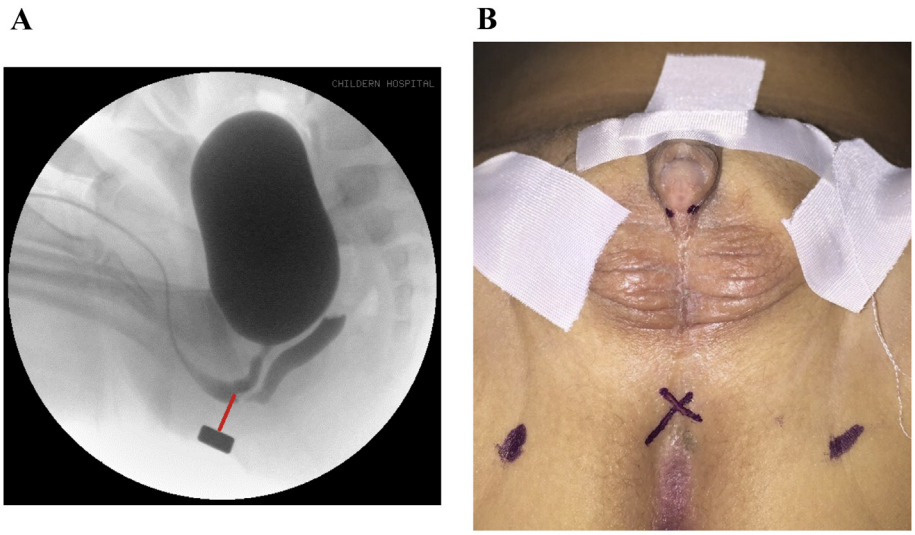

Figure 1 A. Lateral genitography showing vaginal depth (red line); B. External virilization (Prader IV) in the same patient.

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008

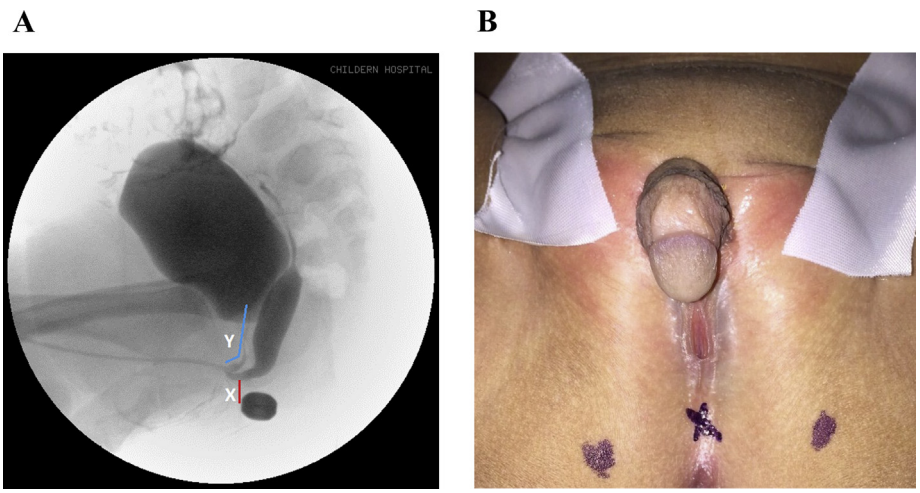

Figure 2 A. Lateral genitography showing the vaginal depth (red line, labelled X) and the urethral length (blue line, labelled Y); B. External virilization (Prader III) in the same patient.

ascertain that these measurements were correct, and that any measurement variability fell within a narrow range of 2–3 mm.

The observations were analyzed after all cases were operated upon. For measurements of urethral length and vaginal depth, descriptive statistics of mean, range and standard deviation (SD) were used.

The correlation coefficients between the external virilization and the internal anatomical measurements were calculated. The external virilization, represented by the Prader score, was plotted against both the length of the proximal urethra and the vaginal depth. In addition, the correlation between the vaginal depth and the length of the proximal urethra was assessed. A correlation coefficient was calculated for all three relationships. Figs. 1–3 show the external virilization vs the genitography measurements in three cases that were Prader II, III and IV, respectively. Pearson parametric correlation was used for the urethral length and vaginal depth, as they are continuous data. However, Spearman rank non-parametric correlation was used for the Prader degree of external virilization, as it is ordinal.

Results

Most cases ranged between Prader III and IV ($n = 27$); two cases were Prader II, and one case was Prader V. The median age at which surgeries were performed was 19 months (range 6–42 months), and the inter-quartile range was 17–30 months.

Prejunctional urethral length measurements were initially obtained from the genitography (mean = 22.8 mm, range 10–32 mm) and confirmed by cysto-urethroscopy (mean = 22.3 mm, range 10–32 mm). It was found that the concordance between both modalities was 87% (26 cases). In the remaining four cases, the discordance was within 3 mm; hence, the endoscopic measurements were chosen for subsequent analysis. Two thirds of the cases ($n = 20$) occurred within 1 SD from the mean (17–28 mm). Table 1

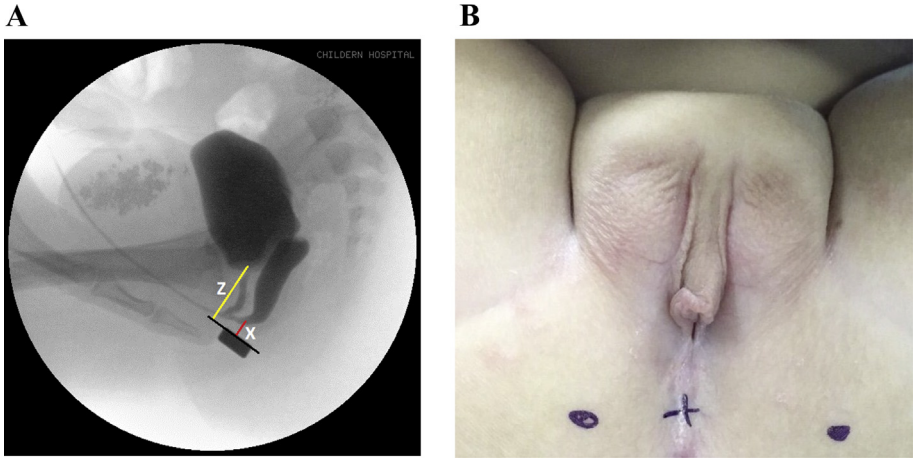

Figure 3 A. Lateral genitography showing the ratio of the vaginal depth (red line, labelled X) to the bladder neck depth (yellow line, labelled Z); B. External virilisation (Prader II) in the same patient.

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008

Table 1 Length of the urethra measured in cystoscopy and genitography, contrasted to the operative approach.

Length of urethra by cysto-urethroscopy	Length of urethra in genitography	Number of cases	Procedure
10–15 mm	10–18 mm	3	Passerini-Glazel flap 2 cases (10 and 15 mm) TUM 1 case (15 mm)
15–25 mm	15–28 mm	21	PUM 21 cases
>25 mm	>28 mm	6	Posterior flap vaginoplasty or vestibuloplasty

PUM: partial urogenital mobilization, TUM: total urogenital mobilization.

shows the length of the urethra measured by cysto-urethroscopy and genitography.

The vertical depth of the vaginal-urethral confluence from the perineum in the genitography showed a mean of 15.9 mm, and a range of 8–31 mm. The depth of surgical dissection had a mean of 16.43 mm, and a range of 8–31 mm. The concordance between both measurements was noted in 80% (24 cases). However, the discordance was within 2 mm in the remaining six cases. The genitography measurements were used for subsequent analysis, as the operative measurements could be liable to slight variation by dissection. In 73% of the cases ($n = 22$) this depth was within 1 SD of the mean (11–21 mm). Table 2 shows the depth of the vagina, measured by genitography, contrasted to intra-operative findings.

The correlation coefficient (r) between the vaginal depth and the proximal urethra was found to be −0.74 (strongly negative), with a P-value of 0.001, according to Pearson's correlation equation.

External virilization, expressed as the Prader score (from I to V), did not correlate with the length of the proximal urethra ($R_s = -0.03$, $P = 0.5$), and correlated weakly with the depth of the vaginal-urethral confluence ($R_s = 0.2$, $P = 0.2$). As the Prader scoring is a ranking, this was calculated using Spearman's rank correlation equation (Fig. 4).

As these patients were not studied at the same age, the effect of age on these measurements was studied. The age was not found to have a significant correlation with the vaginal depth ($r = 0.4$, $P = 0.02$), or the urethral length ($r = -0.22$, $P = 0.28$). However, as the data set was not large enough to allow a multivariate analysis, the data presented could only be considered valid within the age group that was studied.

Discussion

The length of the proximal urethra, extending from the bladder neck to the confluence, achieved a consensus of being the most important predictor of surgical complexity, regardless of the length of the distal common urogenital sinus [10–12].

The vaginal depth was found to be inversely proportionate, as a reciprocal image, to the proximal urethral length. This highlights the fact that the shorter the proximal urethra, the deeper the vagina could be. As the reconstruction of this anomaly is almost always currently through a perineal approach, the vertical depth of the vaginal confluence is an important measurement. This depth denotes the amount of dissection required to deliver the vagina to the perineum.

The importance of the level of the confluence has been stated in several previous reports [13–17], but there were no objective methods to describe this level or depth, hence the presentation of the measurements found in a representative sample. It has been previously reported that the high confluence types in CAH patients, requiring an extensively deep dissection, represent 5–10% of the overall cases [18–20]. The present results showed similar views (see Tables 1 and 2).

Few reports have addressed the question of what urethral length could be considered adequate or normal. They have arbitrarily used a cutoff point of 15 mm, measured endoscopically [15,21]. In the present series, it was found that the mean urethral length in these cases was 22 mm. This is an important consideration when counseling the patients regarding continence.

In 2005, Rink et al. proposed a very useful approach to classification of UGS cases. The present findings are in keeping with their view: that describing the UGS as either high or low does not provide sufficient insight into the operative difficulty. Their approach addressed the phallic size (P), the true location of vaginal confluence in relation to both the bladder neck and perineal meatus (V), and external genital appearance (E), and is termed the PVE classification. The first and third components are assessments of the external virilization by phallic size in mm and the Prader classification, respectively. For the vaginal (V)

Table 2 Depth of the vagina measured in genitography and intra-operatively, contrasted to the operative approach.

Vaginal depth (measured in genitography)	Vaginal depth (measured intra-operatively)	Number of cases	Surgical procedure
23–31 mm	23–31 mm	3 cases	TUM and Passerini-Glazel flap
12–20 mm	12–22 mm	21 cases	PUM
≤10 mm	≤12 mm	6 cases	Posterior flap vaginoplasty or vestibuloplasty

PUM: partial urogenital mobilization, TUM: total urogenital mobilization.

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008

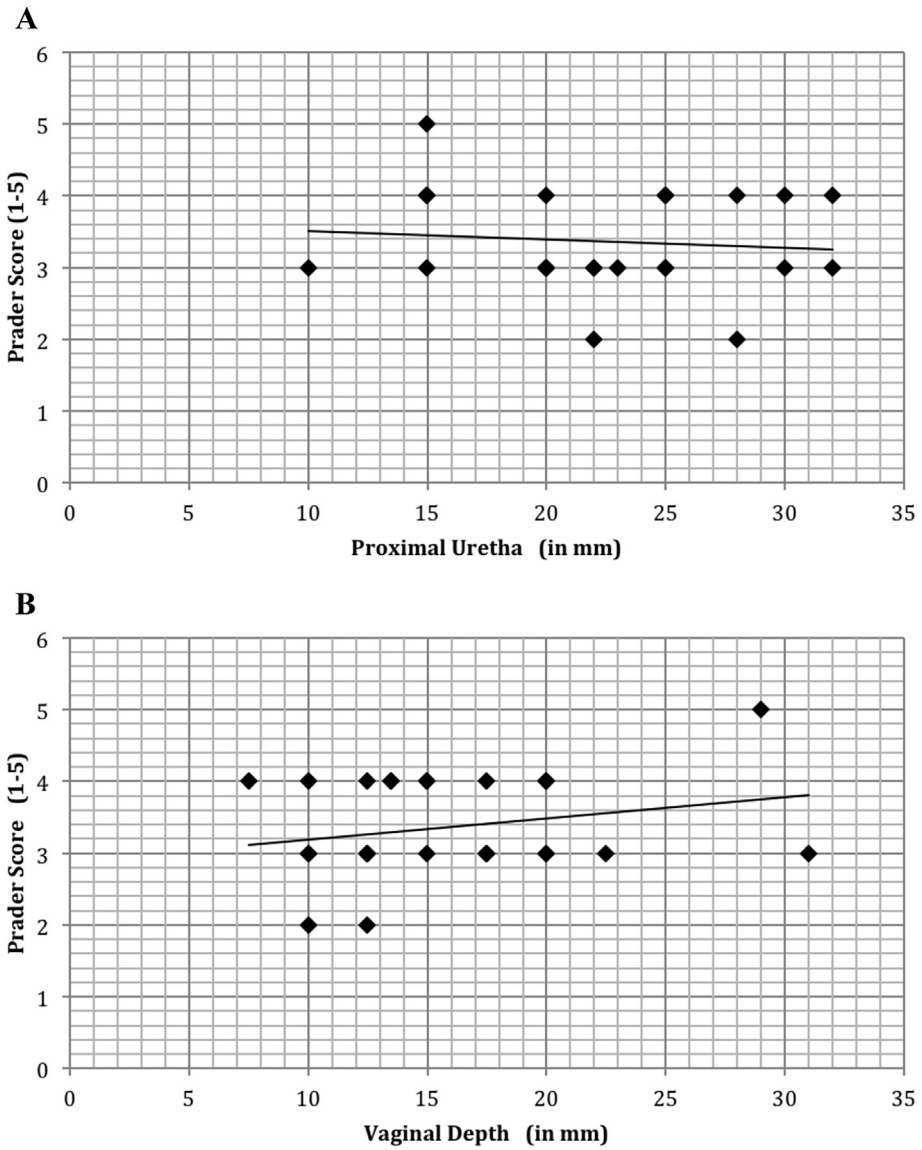

Figure 4 A. Correlation of the length of proximal urethra (in mm) to external virilization (Prader score); B. Correlation of the vaginal depth (in mm) to the external virilization (Prader score).

component, which is relevant to the present report, they used the location of the vaginal confluence in relation to the bladder neck and the perineal meatus, as determined endoscopically. The technique we used to endoscopically measure the prejunctional urethra, is similar to their technique. Although a uniquely structured approach, it carries the same limitation of the difficult evaluation of the absolute measurements in patients across different ages and sizes [10].

Contrarily, it is postulated here that the depth of the confluence from the perineum, rather than the length of the common UGS, is the important determinant of operative difficulty, as the common UGS can extend externally to a variable degree in the hypospadias-like phallic structure in Prader III—V cases.

Currently, there is a rationale against using a preoperative genitography for assessment of anatomy, and it is believed that cysto-urethroscopy is sufficient under the same anesthetic as the surgical reconstruction. It is not suggested that a genitography be performed for all cases, unless a particular difficulty is expected with the procedure.

From experience, within a society where families invariably request the surgical reconstruction to occur as early as possible, and find DSD and genital reconstruction a cause of exceptional anxiety, preference is to use the preoperative genitography under brief sedation as a strategic opportunity to properly counsel the families about the expectations of the outcome and the severity of the internal anomaly; this is not necessarily the situation in other societies.

The Prader score for external virilization did not show a correlation with the proximal urethral length, and showed a weak correlation with the vaginal depth. This means that

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008

the external virilization is generally not strongly predictive of the internal anatomy, but it is more related to the vaginal depth than the proximal urethral length.

One limitation of this study was the subjectivity of the true lateral genitography views. Another difficulty was that the cases with this condition are usually of different ages, body mass index, hormonal control, and nutritional status. Additionally, radiological and endoscopic assessments carry different magnification indices. During surgery, the vertical depth measurement may be, to some extent, subjective; however, the surgeons were conscious about this, and took these measurements at the first instance when the vagina was identified, and released any traction sutures beforehand. Additionally, this was used to confirm radiological and endoscopic findings, and was not considered independently reliable.

It was found that the anatomical measurements across different modalities, using either genitography, cysto-urethroscopy or intra-operatively were similar in 86% of cases for the urethral length (comparing genitography to cysto-urethroscopy), and in 80% of cases for the vaginal depth (comparing genitography to the depth of surgical dissection). There was a 5 mm difference for either the mean urethral length or the mean vaginal depth across different modalities in the overall analysis. The variability was 2–3 mm when differences were found in any individual case (four cases for urethral length, and six cases for vaginal depth).

It is important to note that normative data about the anatomical measurements of the vagina in this age group, as well as its rate of growth, were not available, which posed a limitation to the anatomical assessment. As most surgeons would offer the reconstruction within a similar age range to the present series, the present results may provide general guidance to their surgical strategy.

Conclusion

The degree of external virilization does not exactly reflect the internal anatomy, but still correlates weakly with the vaginal depth. Cysto-urethroscopy remains the most reliable modality for anatomical assessment. However, genitography is highly predictive of the vaginal depth. The direct vertical depth of the vaginal-urethral confluence from the perineum is an important measurement, being an indicator of the required mobilization, as the reconstruction is usually through a perineal approach. The depth of the vaginal-urethral confluence is $\leq$20 mm in 90% of cases within this age group (1–3 years old). This indirectly supports the current understanding of most pediatric surgeons and urologists – that partial urogenital mobilization is a suitable procedure for most cases.

Ethical approval

This work has been conducted under supervision of the research ethics committee (REC) of the Faculty of Medicine, Cairo University, Egypt. The patients involved provided a prospective informed consent to the usage of their data for the purpose of this research.

Conflict of interest

Nil.

Acknowledgments

We would like to express our gratitude to Professor Mona Hafez, MD and the staff members of the Diabetes, Endocrine and Metabolism Pediatric Unit (DEMPU), at Cairo University, for their support of this work, and for their effort and passion with the DSD patients and their families in Egypt. We would like, as well, to acknowledge Ms. Amal Sharaf, MRCS for her diagrammatic illustration, and help with the figures.

References

[1] Hendren WH, Crawford JD. Adrenogenital syndrome: the anatomy of the anomaly and its repair. Some new concepts. J Pediatr Surg 1969;4:49–58.
[2] Yucel S, Cavalcanti AG, Wang Z, Baskin LS. The impact of prenatal androgens on vaginal and urogenital sinus development in the female mouse. J Urol 2003;170(4):1432–6.
[3] Ganesan A, Smith GHH, Broome K, Steinberg A. Congenital adrenal hyperplasia: preliminary observations of the urethra in 9 cases. J Urol 2002;167:275–9.
[4] Kalfa N, Liu B, Cao M, Vilella M, Hsieh M, Baskin LS. 3–dimensional neuroanatomy of the human fetal pelvis: anatomical support for partial urogenital mobilization in the treatment of urogenital sinus. J Urol 2008;180:1709–15.
[5] Karam I, Droupy S, Abd-Alsamad I, Uhl JF, Benoît G, Delmas V. Innervation of the female Human urethral sphincter: 3D reconstruction of Immunohistochemical studies in the fetus. Eur Urol 2005;47:627–34.
[6] Colleselli K, Stenzl A, Eder R, Strasser H, Poisel S, Bartsch G. The female urethral sphincter: a morphologic and topographical study. J Urol 1998;160(1):49–54.
[7] Hamza AF, Soliman HA, Abdel Hay SA, Kabesh AA, Elbehery MM. Total urogenital sinus mobilization in the repair of cloacal anomalies and congenital adrenal hyperplasia. J Pediatr Surg 2001;36:1656–8.
[8] Ruggeri G, Gargano T, Antonellini C, Carlini V, Randi B, Destro F, et al. Vaginal malformations: a proposed classification based on embryological, anatomical and clinical criteria and their surgical management (an analysis of 167 cases). Pediatr Surg Int 2012;28:797–803.
[9] Powell DM, Newman KD, Randolph J. A proposed classification of vaginal anomalies and their surgical correction. J Pediatr Surg 1995;30(2):271–6.
[10] Rink RC, Adams M, Misseri R. A new classification for genital ambiguity and urogenital sinus anomalies. BJU Int 2005;95:638–42.
[11] Gosalbez R, Castellan M, Ibrahim E, Disandro M, Labbie A. New concepts in feminizing genitoplasty – is the Fortunoff flap obsolete? J Urol 2005;174:2350–3.
[12] Marei MM, Fares AE, Abdelsattar AH, Hasan MM, Elkotby MM, Elbarbary MM. Evaluation of early outcomes of feminizing genitoplasty in virilised female children with congenital adrenal hyperplasia. Kasr El Aini Med J 2014;20(1):17–27.
[13] Palmer BW, Trojan B, Griffin K, Reiner W, Wisniewski A, Frimberger D, et al. Total and partial urogenital mobilization: focus on urinary continence. J Urol 2012;187:1422–6.
[14] Ludwikowski BM, González R. The surgical correction of urogenital sinus in patients with DSD: 15 years after description of

total urogenital mobilization in children. Front Pediatr 2013; 1(41):1–5.
[15] Jenak R, Ludwikowski B, Gonzalez R. Total urogenital sinus mobilization: a modified perineal approach for feminizing genitoplasty and urogenital sinus repair. J Urol 2001;165:2347–9.
[16] Farkas A, Chertin B, Hadas-Halpren I. 1-stage feminizing genitoplasty: 8 years of experience with 49 cases. J Urol 2001; 165:2341–6.
[17] Marei MM, Abdelsattar AH, Fares AE, Elkotby MM, Elbarbary MM, Seif HM. Accuracy and predictivity of cystoscopy and genitography to operative findings in persistent urogenital sinus due to virilized female congenital adrenal hyperplasia. Kasr El Aini J Surg 2014;15(1):21–5.
[18] Dumanian GA, Donahoe PK. Bilateral rotated buttock flaps for vaginal atresia in severely masculinized females with adrenogenital syndrome. Plast Reconstr Surg 1992;90:487–91.
[19] Rink RC, Pope JC, Kropp BP, Smith ER, Keating MA, Adams MC. Reconstruction of the high urogenital sinus: early perineal prone approach without division of the rectum. J Urol 1997; 158:1293–7.
[20] Elhalaby EA. One-stage feminizing genitoplasty in patients with congenital adrenal hyperplasia. Ann Pediatr Surg 2006; 2(2):88–98.
[21] Ludwikowski B, Oesch Hayward I, Gonzalez R. Total urogenital sinus mobilization: expanded applications. BJU Int 1999;83: 820–2.

Please cite this article in press as: Marei MM, et al., Anatomical measurements of the urogenital sinus in virilized female children due to congenital adrenal hyperplasia, Journal of Pediatric Urology (2016), http://dx.doi.org/10.1016/j.jpurol.2016.02.008