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Diagnostic imaging in cryptorchidism: utility, indications, and effectiveness

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Abstract

Background: Cryptorchidism (undescended testis) is the most common genitourinary anomaly in male infants.

Methods: We reviewed the available literature on the diagnostic performance of ultrasound, computed tomography, and magnetic resonance imaging (MRI) in localizing undescended testes.

Results: Ultrasound is the most heavily used imaging modality to evaluate undescended testes. Ultrasound has variable ability to detect palpable testes and has an estimated sensitivity and specificity of 45% and 78%, respectively, to accurately localize nonpalpable testes. Given the poor ability to localize nonpalpable testes, ultrasound has no role in the routine evaluation of boys with cryptorchidism. Magnetic resonance imaging has greater sensitivity and specificity but is expensive, not universally available, and often requires sedation for effective studies of pediatric patients. Diagnostic laparoscopy has nearly 100% sensitivity and specificity for localizing nonpalpable testes and allows for concurrent surgical correction.

Conclusions: Although diagnostic imaging does not have a role in the routine evaluation of boys with cryptorchidism, there are clinical scenarios in which imaging is necessary. Children with ambiguous genitalia or hypospadias and undescended testes should have ultrasound evaluation to detect the presence of müllerian structures.

1. Background

Cryptorchidism is the most common genitourinary anomaly in male infants. Cryptorchidism occurs in 1% to 3% of full-term and up to 30% of premature male infants [1,2]. Boys with cryptorchidism are at increased risk for infertility and testicular cancer [3-5]. Studies have shown that fertility parameters decrease the longer a testis remains undescended and that the risk of testis cancer can be decreased if orchiopexy is performed before puberty [5]. To possibly halt or reverse germ cell loss and decrease cancer risk, orchiopexy is recommended at 12 months of age [6,7].

Initial diagnosis and referral of boys with undescended testes is made by primary care providers who diagnose cryptorchidism during routine physical examination.

An undescended testis may be found adjacent to the kidneys in the retroperitoneum to any point along the path of testicular descent into the dependent hemiscrotum. The testis may also be ectopic and found in areas such as the superficial

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pouch of Denis Browne, along the penile shaft, or on the contralateral side. Physical examination is the cornerstone of the diagnosis of cryptorchidism and determination of the position of the undescended testis. Careful examination of the scrotum including a contralateral descended testis, preinguinal space, pubic tubercle, and the inguinal canal in the clinic will usually demonstrate an undescended testis at or distal to the internal inguinal ring. In 1 series, more than 70% of undescended testes are palpable [8]. That leaves approximately 30% of testes that cannot be localized by physical examination. A nonpalpable testis may be intraabdominal, absent, or ectopic or simply not appreciated on physical examination in the clinic in children who are uncooperative, obese, or have undergone previous surgery that has obscured inguinal-scrotal anatomy. Diagnostic imaging has been used to determine the anatomical location of nonpalpable testes. Accurate presurgical localization of the testis could spare a child an operation in the setting of an absent testis or limit the extent of surgery if the testis can be definitively identified. However, the potential benefits of imaging must be weighed against its risks, costs, and whether it provides information critical to the care of the child with cryptorchidism.

Current US Department of Health and Human Services guidelines state that ultrasound, computed tomography (CT), or magnetic resonance imaging (MRI) does not provide additional information to the physical examination [9]. Given the increased emphasis on the comparative effectiveness of diagnostic tests and interventions in medical practice, we believe that it is necessary to understand the reasons to image and not image a child with cryptorchidism. We review the utility of ultrasound, CT, and MRI in the evaluation of boys with undescended testes and also address clinical scenarios in which the presence of associated abnormalities merits the use of diagnostic imaging.

2. Surgical approach

With the possible exception of undetectable serum testosterone after human chorionic gonadotropic (HCG) stimulation in a boy with bilateral nonpalpable testes, all boys with cryptorchidism require surgery to bring a viable testis down to scrotum, remove nonviable testicular tissue identified in the exploration, or to confirm that a testis is absent [10]. The operative approach for cryptorchidism is based upon the palpability of the testis at the time of examination under anesthesia.

When the testis is palpable, an inguinal or prescrotal orchiopexy is performed. If the testis remains nonpalpable under anesthesia, laparoscopy is the preferred diagnostic and therapeutic approach, although open surgery is still a viable option. Initial diagnostic laparoscopy or inguinal exploration will identify a viable testis or confirm an absent testis by revealing blind-ending spermatic vessels or a nonviable nubbin [11-15]. With only rare reports of an inguinal testis misidentified during surgical exploration, laparoscopy has nearly 100% sensitivity and specificity to localize a testis or confirm its absence [16-18]. Indeed, diagnostic laparoscopy has become the criterion standard against which diagnostic imaging studies are measured [19-21]. However, if diagnostic imaging could reliably determine the presence and location of a nonpalpable testis, a child could be spared an operation (in the setting of an absent testis) or could undergo a more limited operation restricted to where the testis was seen on preoperative imaging evaluation.

3. Ultrasound

Ultrasound is noninvasive and does not emit ionizing radiation. It is heavily used in the evaluation of boys with cryptorchidism. In an online survey of a national sample of general pediatricians practicing in the United States, Tasian et al [22] reported that 67% of respondents order imaging during the presurgical evaluation of boys with cryptorchidism, with 34% always or usually doing so. Of those who reported ordering imaging, 96% reported using ultrasound. Although this study was limited by the weaknesses inherent to survey research such as recall and response bias, it is apparent that ultrasound is the most heavily used imaging modality in the evaluation of boys with cryptorchidism.

From the first reports of ultrasound evaluation of the undescended testicle in the 1970s, numerous subsequent studies have been conducted that have examined the utility of ultrasound in cryptorchidism [23]. Identification of the mediastinum testis, which appears as an echogenic band, is considered necessary to accurately identify a testis [24]. However, Weiss et al [26] reported a 10% false-positive rate in ultrasound evaluation of undescended testes, with both instances owing to incorrectly identifying the gubernaculum as the testis. Over the last 20 years, ultrasound technology has advanced with newer transducers having greater resolution and presumably greater ability to differentiate a gonad from surrounding structures. Using 5 and 7.5 MHz transducers, Kullendorff et al [25] reported in 1985 correctly localizing 87% of palpable testes, which is higher than the 70% reported by Weiss et al in 1986 [26]. Twenty years later, in 2007, using 5 to 12 MHz and 7 to 10 MHz transducers, Nijs [27] reported that ultrasound failed to identify all 14 of viable intraabdominal testes. Thus, despite the advances in ultrasound technology, ultrasound cannot reliably identify intraabdominal testes, which comprise 20% of all undescended testes [8].

For palpable testes, there are widely discordant reports of the concordance between physical examination and ultrasound findings. Kullendorff et al [25] reported that ultrasound demonstrated accordance with the physical examination 93% of the time. However, in 2002, Elder [28] reported that, of the 45 testes palpable either in the scrotum or in the inguinal canal on physical examination by a

pediatric urologist, only 12 were identified by ultrasound. Therefore, for palpable testes, it appears that ultrasound, at best, adds little to the physical examination and, at worst, provides misleading information.

However, 80% of pediatricians indicate that a nonpalpable testis is the factor that most influences them to order an ultrasound, and 86% reported the belief that ultrasound reliably identifies a nonpalpable testis [22]. The question then becomes, in the setting of a nonpalpable testis, how effective is ultrasound in accurately localizing a testis or confirming its absence? Kullendorff et al [25] reported that ultrasound correctly located 33% of nonpalpable testes. Of the 4 nonpalpable testes identified by ultrasound, 1 was at the internal ring, 2 in the inguinal canal, and 1 at the external ring. No intraabdominal testes were identified [25]. Elder [28] also reported on the cohort of patients who had nonpalpable testes all of whom had negative ultrasounds. All of these boys were found to have either viable intraabdominal testes or atrophic nubbins upon surgical exploration [28]. From these studies, we can draw the conclusion that ultrasound can potentially identify nonpalpable testes in the inguinal canal but not within the abdomen.

Tasian and Copp [29] recently performed a systematic review and meta-analysis of literature on ultrasound evaluation of nonpalpable undescended testes. They found that the sensitivity and specificity of ultrasound in correctly identifying a nonpalpable testis was 45% and 78%, respectively. The positive and negative predictive values, which are the increase and decrease in the odds of a testis actually being in the position, identified by ultrasound were 1.48 and 0.79, respectively [29]. Previously published studies on the anatomical location of consecutive subjects with nonpalpable testes in whom testis location was prospectively recorded at the time of surgery demonstrated that the likelihood that a nonpalpable testis is intraabdominal is 55%. The remainders are located in the inguinal scrotal region (30%) or are absent (15%) [8,30,31]. Using the positive and negative predictive values, a positive ultrasound increases, and negative ultrasound changes the probability that a nonpalpable testis is located within the abdomen from 55% to 64% and 49%, respectively. Using the upper and lower confidence intervals of the positive and negative predictive values, which assume the best possible performance of ultrasound, the probability that a nonpalpable testis is located within the abdomen is 83% and 36% if the testis is seen or not seen on ultrasound, respectively (Fig. 1). From this, the authors conclude that preoperative ultrasound does not reliably localize nonpalpable testes and is not useful in determining the surgical management of these patients [29].

Reliance on ultrasound to detect or rule out intraabdominal testes confers potential significant consequences. Because there is still a significant likelihood (up to 49%) that a testis is intraabdominal even if it is not seen by ultrasound, choosing not to operate in this setting potentially increases the risk that a testis is left in the abdomen and subsequently develops testicular carcinoma. In addition, given the intraabdominal location of the testis, the child would be at higher risk for presentation with advanced disease because of the inability to perform routine screening physical examinations [5,32].

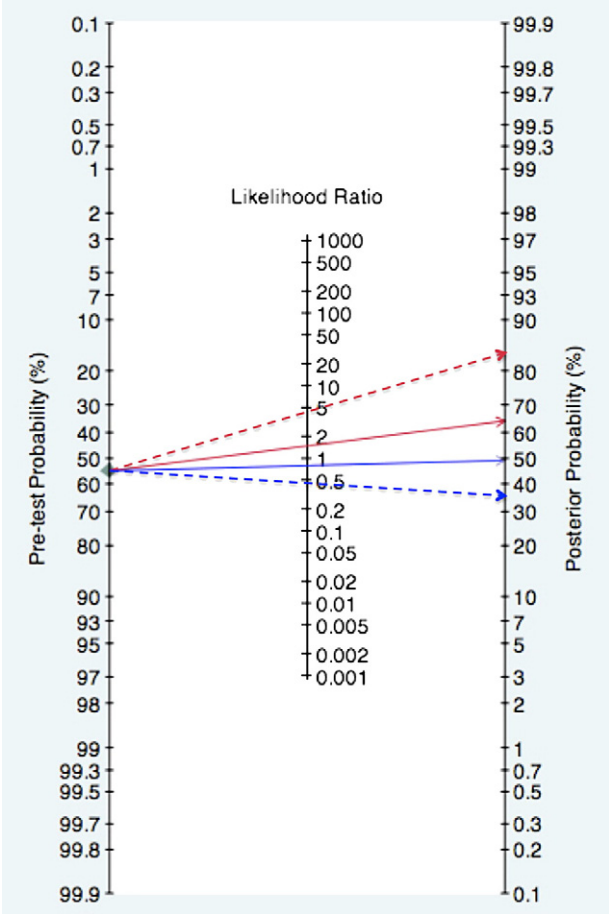

Fig. 1 Effect of ultrasound on the probability of testis location. The pretest probability that a nonpalpable testis is within the abdomen is 55%. Using the positive likelihood ratio point estimate (solid red line) and upper confidence interval (dashed red line), an ultrasound that localizes a nonpalpable testis within the abdomen increases the probability that the testis is truly in the abdomen to 64% and 83%, respectively. Using the negative likelihood ratio point estimate (solid blue line) and lower confidence interval (dashed blue line), an ultrasound that does not visualize a nonpalpable testis decreases the probability that the testis is truly in the abdomen to 49% and 36%, respectively. (Originally published in *Pediatrics* 2011; 127:119-128; permission for reproduction obtained from *Pediatrics*.)

4. Computed tomography

In the early 1980s, Lee et al [33,34] reported that CT correctly localized 100% of 8 undescended testes; however, 5 of these were potentially palpable in the inguinal canal. Recent studies have demonstrated the risk of secondary malignancies conferred by ionizing radiation, which is

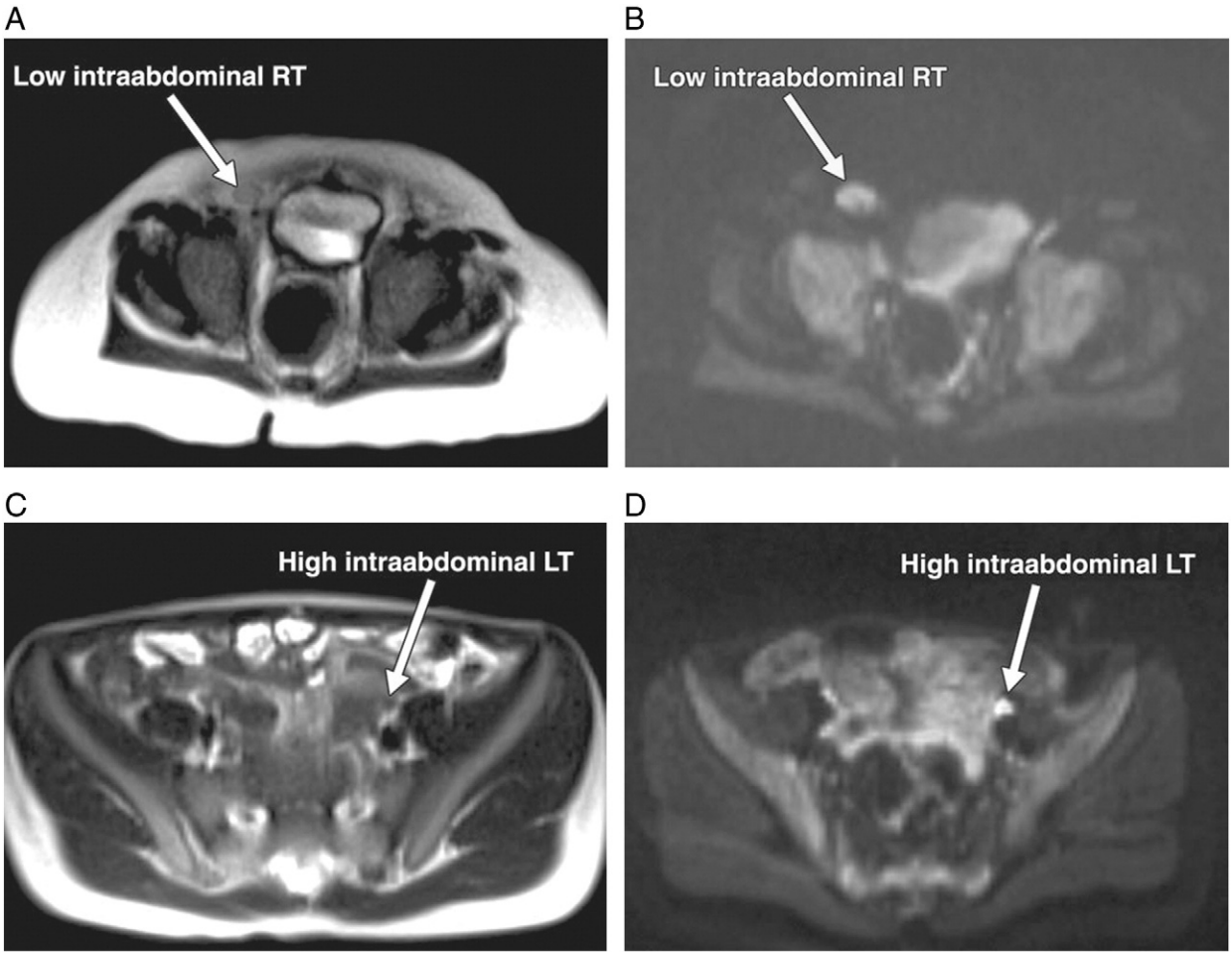

Fig. 2 Magnetic resonance imaging evaluation of nonpalpable testes. A 10-month-old boy with low intraabdominal nonpalpable undescended right testis. A, T2-weighted magnetic resonance image shows isointense testis close to internal ring. B, Diffusion-weighted magnetic resonance image with a b value of 800 s/mm^2 shows markedly hyperintense testis. A 7-year-old boy with high intraabdominal nonpalpable undescended left testis. C, T2-weighted magnetic resonance image indistinctly shows isointense testis adjacent to iliac vessels. D, Diffusion-weighted magnetic resonance image with a b value of 400 s/mm^2 clearly shows markedly hyperintense testis among loops of small bowel. (Reprinted with permission from *Am J Roentgenol* 2010; 195:W268-273.) RT indicates right testis; LT, left testis.

especially pronounced in the pediatric population [35]. Although CT has an important role in the staging of testis cancer for which boys with history of cryptorchidism are at risk, we believe that there is no role for routine CT evaluation of boys with undescended testes.

5. Magnetic resonance imaging

Unlike CT, MRI does not involve ionizing radiation and thus makes it a more attractive imaging modality for pediatric patients. However, MRI is expensive, not as readily available, and often requires that children are sedated or anesthetized. Undescended testes have similar magnetic resonance signal characteristics to scrotal testes; there is low signal intensity on T1-weighted images and high intensity of T2-weighted images (Fig. 2). Miyano et al [36] also reported that coronal images are the best plane for identification of undescended testes. Several studies have evaluated the diagnostic performance of MRI evaluation of undescended testes. In 1999, Yeung et al [37] reported that the gadolinium-enhanced MRI identified 20 of 21 nonpalpable testes of which 4 were intraabdominal and 8 were intracanicular nubbins. These findings demonstrated that MRI had a sensitivity and specificity of 96% and 100%, respectively. From this, the authors conclude that laparoscopy could have been avoided in 78% of patients who had preoperative identification of inguinal testes or nubbins [37]. However, even for MRI, which has greater sensitivity and specificity compared with ultrasound, not identifying a testis does not completely exclude its absence [36,38].

This is supported by the findings of Kanemoto et al [39] who reported that MRI had a sensitivity and specificity of 86% and 79%, respectively. More contemporary studies that have used conventional MRI in conjunction with diffusion weighted

MRI to identify nonpalpable testes have demonstrated similar performance characteristics. In this series, conventional MRI had a sensitivity of 85% and a specificity of 87.5%. When combined with diffusion-weighted imaging, the sensitivity increased marginally to 89.5%, and the specificity remained the same. There was some interobserver variability between the radiologists interpreting the MRIs [19].

6. Economic impact

Imaging is expensive. In the Medicare population, diagnostic imaging adds significantly to annual health care expenditures and is growing faster than any other physician-ordered service [40,41]. Population-based studies assessing the economic impact of diagnostic imaging in children have not yet been performed; however, it is likely that the pediatric population mirrors the increasing use of and cost of imaging seen in the adult population. There may be significant variability in the cost of diagnostic imaging as charges vary by patient insurance status, region of the country, and whether the examination was performed in the hospital outpatient imaging department or in a freestanding imaging center.

The need for studies that assess the cost of imaging is becoming more apparent. It seems likely that, in the short term, health care expenses will increase after implementation of the Patient Protection and Affordable Care Act [42]. Consequently, physicians and others in health care must develop new ways to decrease costs and improve resource use. In 2010, Brody [43], a medical ethicist, proposed that medical specialties identify and recommend against ordering heavily utilized and expensive diagnostic tests that offer little benefit for whom they are ordered. Ultrasound evaluation of cryptorchidism, which is associated with heavy use and poor diagnostic performance, meets these criteria. We recommend against routinely using ultrasound to evaluate children with cryptorchidism and propose that the diagnostic algorithm for the evaluation of a boy with cryptorchidism consist of physical examination and surgical evaluation (Fig. 3).

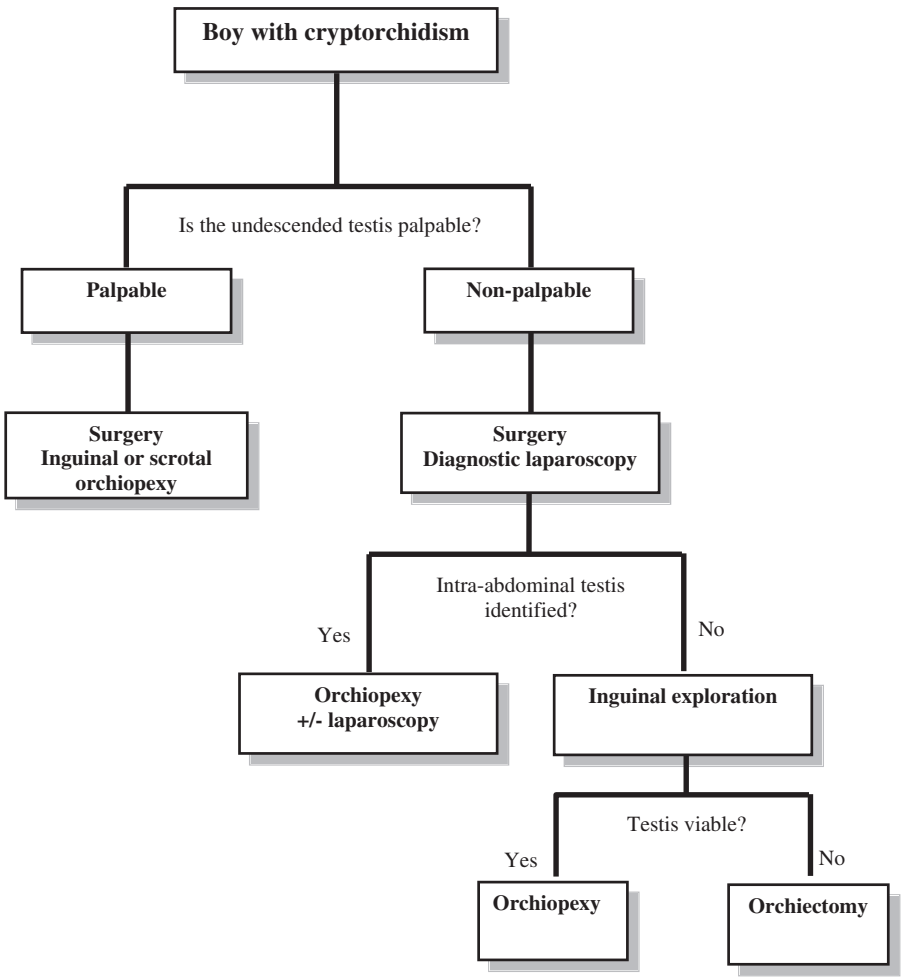

Fig. 3 Suggested algorithm for evaluation and treatment of a boy with cryptorchidism without the need for imaging.

7. Obese patients

In a survey of a national sample of general pediatricians, Tasian et al observed that only 11% of pediatricians reported that an obese child was a factor influential in ordering ultrasound [22]. However, obesity has been cited as a factor, making detection of the undescended testis on physical examination more difficult, and some authors have recommended MRI be used to localize testes in obese patients [44,45]. In 2009, Breyer et al [46] classified patients by body mass index and determined the ability of physical examination in the office and physical examination under anesthesia to predict operative findings. The overall predictive value of physical examination under anesthesia was less than 82%. Although office physical examination was more reliable in nonobese patients, the accuracy of physical examination under anesthesia was similar between obese and nonobese patients [46]. Because all children with persistence of undescended testes require surgery, the equal ability of the physical examination under anesthesia to localize testes in obese patients and the low-operative risk of laparoscopy, preoperative imaging in obese boys with cryptorchidism is likely not necessary.

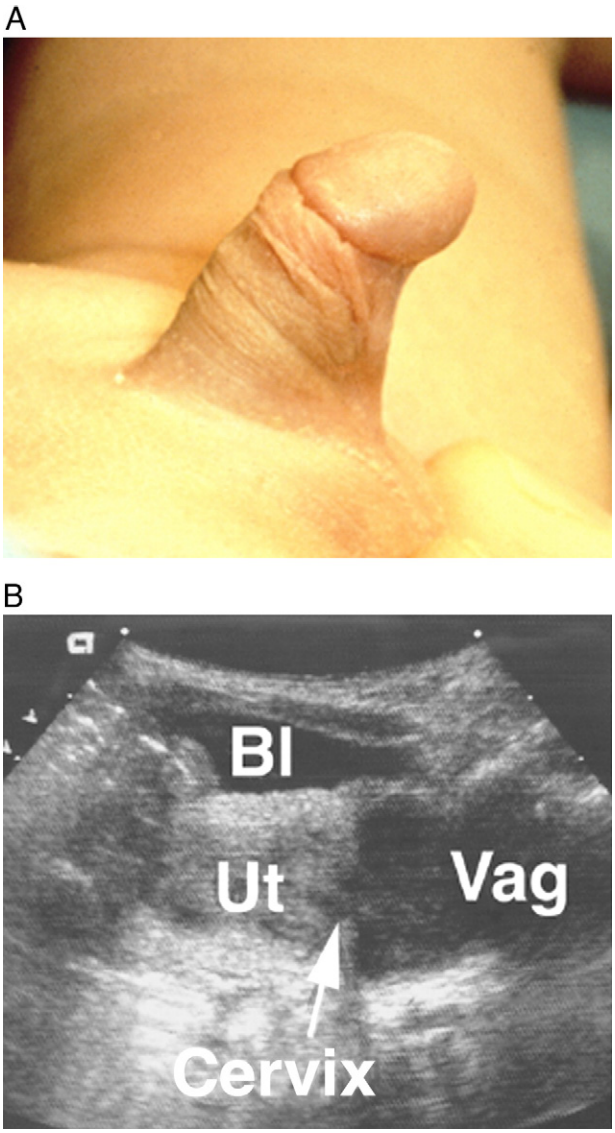

Fig. 4 Neonate with ambiguous genitalia. Examination of this patient (A) revealed a phallus, a hypoplastic empty scrotum, and nonpalpable gonads. The karyotype was XX, and abdominal-pelvic ultrasound (B) demonstrated müllerian structures. Serum assays of adrenal steroids established the diagnosis of congenital adrenal hyperplasia. Bl indicates urinary bladder; Ut, uterus; Vag, vagina.

8. Ambiguous genitalia

Patients with undescended testes and ambiguous genitalia should have diagnostic imaging evaluation given the increased incidence of disorders of sexual development (DSD) in this cohort. For example, a presumed male with a normal phallus and bilateral nonpalpable testes requires a karyotype and sonogram to identify possible müllerian structures, which would be seen in a XY female with congenital adrenal hyperplasia (Fig. 4). It is critical to identify patients with DSD to make an accurate diagnosis of the specific disorder and to facilitate early multidisciplinary care, which is crucial to the appropriate psychosocial development of these children. Identification of these patients will also avoid inappropriate surgery and, in the appropriate setting, allow early removal of precancerous gonads [47-49].

In addition to those with ambiguous genitalia, boys with both hypospadias and cryptorchidism have an approximately 30% likelihood of having DSD [50]. This risk increases 3-fold in those children with proximal hypospadias and nonpalpable testes [51]. The DSDs identified in this group included mixed gonadal dysgenesis, incomplete testicular feminization, and ovotesticular DSD. Given the significant risk of having DSD, ultrasound is indicated in this population to look for the presence of a uterus and secondary assessment of testes. Magnetic resonance imaging can be obtained as clinically indicated.

In some children with DSD, 1 or both testes may be descended into the scrotum. Only 10% of boys with persistent müllerian duct syndrome have bilateral nonpalpable testes; the remainder has at least 1 palpable testis. Therefore, because ultrasound is not routinely performed for unilateral cryptorchidism, early diagnosis of this rare disorder may be missed [52].

9. Reoperation

Identification of the testis can be quite difficult in children who have previously had inguinal or scrotal surgery. Because of the scarring, increased risk of injury to the testis, and limited mobility of the spermatic cord, accurate presurgical localization

of the testis can provide the surgeon with anatomical knowledge that can be used to tailor the operative approach. However, in the setting of a child who has previously undergone inguinal or scrotal surgery, the specificity of ultrasound decreases significantly. Kullendorff et al [25] reports that, of the 8 children who had previously been operated on, the ultrasound findings in 5 were uninterpretable or were discordant with the operative findings. In 2008, Kattak et al [53] confirmed these findings in a series of 11 boys undergoing reoperative orchiopexy after failed primary orchiopexy or other inguinal surgery. Physical examination detected approximately 50% of potentially palpable testes, whereas ultrasound found only 36% of the testes. In 1 patient, no testicle was found at surgical exploration [53]. Although definitive studies have not yet been performed, it is our opinion that MRI, which has relatively high sensitivity and specificity in localizing testes, might be indicated in this population to guide the surgeon to the testis given the unreliable physical examination and obscured tissue plains in previously operated on patients. We hope that future studies can provide evidence to test this hypothesis.

10. Conclusions

Diagnostic imaging has no role in the routine evaluation of boys with undescended testes. Given the poor diagnostic performance of ultrasound and its high use in this setting, we recommend that efforts be developed to discourage its routine use in the evaluation of a boy with cryptorchidism. Ultrasound is an appropriate screening evaluation for children with ambiguous genitalia or hypospadias and cryptorchidism. Future studies should examine whether preoperative MRI has utility in reoperative orchiopexy.

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