Current Treatment Options in Pediatrics (2024) 11:5
https://doi.org/10.1007/s40746-024-00316-2

PEDIATRIC UROLOGY (A BUCHANAN AND G CAMPBELL, SECTION EDITORS)

Diagnosis and Management of Pediatric Varicocele: A Modern Update for the Practicing Pediatrician

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Accepted: 17 October 2024 / Published online: 16 December 2024

Abstract

Purpose of Review Pediatric varicoceles are common, yet the paucity of data on long-term fertility outcomes does not establish recommendations for conservative management and reassurance versus pediatric urology referral for consideration of surgical intervention. This review incorporates recent literature to generate pragmatic, objective methodology for the evaluation and management of pediatric varicoceles.

Recent Findings The initial evaluation of pediatric varicoceles includes focused history, physical exam, and use of an orchidometer or ultrasound for volume assessment. In early puberty, asynchronous testicular growth may be transient and monitored serially via ultrasound. Further workup may include semen analysis (SA), ultrasound of spermatic veins to determine peak retrograde flow (PRF), and hormonal analysis. Pediatric varicoceles may be managed with observation and reassurance or referral to pediatric urology for consideration of surgical intervention. In patients presenting before Tanner V stage, management is typically expectant, with pain warranting referral. Definitive indications for referral once Tanner V is reached include pain, undesirable appearance, bilateral varicoceles, persistent testicular atrophy, low total testicular volume (TTV), elevated peak retrograde flow on Doppler ultrasonography, persistently low total mobile sperm count (TMSC) on repeat SA, or infertility.

Summary Most pediatric and adolescent patients with varicocele may be reassured and monitored serially. Straightforward and objective assessment tools should be used when further workup is warranted, providing clear guidance on elevation of care from pediatricians to pediatric urologists.

Keywords Varicocele · Pediatric varicocele · Testicular volume differential · Testicular atrophy index · Testicular asymmetry · Testis

Introduction

Varicoceles are relatively common in the pediatric population, with a prevalence that increases with age, reaching up to 14% at 15–19 years [1]. The idiopathic asymptomatic varicocele is the most common genital condition in adolescence [2]. A varicocele is defined as dilation of the pampiniform plexus, the network of testicular veins in the scrotum superior to each testis. Left-sided varicoceles are far more common, as the left testicular vein enters the left renal vein at a right angle creating an area of turbulent venous flow. In contrast, the right testicular vein drains directly into the inferior vena cava (IVC) via a straight course. Furthermore, the pressure within the left renal vein is higher than that of the IVC [3]. Resultant venous stasis may negatively impact testicular volume, spermatogenesis, sperm parameters, and spermatic function. This is thought to occur due to transient scrotal hyperthermia, accumulation of reactive oxygen species, and cellular apoptosis [4].

While the management of adult varicocele is relatively straightforward—with infertility as the primary indication for intervention in otherwise asymptomatic individuals—the guidelines for pediatric and adolescent varicocele are less clear. In a study analyzing males consulting for infertility,

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varicocele was found in 25.4% of those with abnormal semen and 11.7% with normal semen [5]. However, only 20% of adolescents with varicocele later develop fertility problems [6]. Little data exists regarding the long-term outcomes of conservative versus proactive management on long term fertility. In recent years, studies have enabled better understanding of when to treat versus manage expectantly, while also providing guidance on the use of objective clinical assessment tools. Here, we discuss the diagnosis and management of varicoceles in the pediatric population in light of recent findings.

Evaluation

Physical Examination

Physical examination is a central component of diagnosis as most adolescent varicoceles are detected during routine medical examination for school or sports [7]. In contrast, many adult varicoceles are identified by physical examination for infertility evaluation [7]. In pediatric patients with suspected varicoceles, a thorough history and physical exam should be performed, including scrotal examination in the standing and supine position in a warm environment [8]. The scrotum should be palpated, and the patient should be asked to perform a Valsalva maneuver [9]. Varicoceles are typically palpated as a plexus of veins with a consistency of a "bag of worms," which commonly decompresses when supine [10]. Important components of the physical examination include assessment of varicocele Grade, testicular volume, and testicular consistency [9]. A softer consistency of the involved testis will be noted in a small percentage of boys and is typically associated with decreased volume. Abnormal consistency is a subjective finding, and it has not been thoroughly studied [10]. Most clinical practice guidelines agree that the diagnosis of a varicocele in this population is primarily based on physical examination [11]. According to the American Urological Association (AUA) and the American Society of Reproductive Medicine (ASRM), if the physical examination is inconclusive, a scrotal ultrasound may be performed [12].

Grading

Varicoceles are graded using the Dubin and Amelar system: Grade 0, subclinical varicocele (not detectable on clinical examination but identified on scrotal ultrasound [US] or venography); Grade I, small varicocele (palpated only during the Valsalva maneuver); Grade II, moderate size (readily palpable without the Valsalva maneuver but not readily visible without Valsalva); and Grade III, large size (readily visualized without Valsalva) [13]. Examination for the purpose of grading should be performed in the standing position. Grade II and III varicoceles are generally identifiable on physical exam and are commonly referred to urologists [8]. In adolescents, a direct correlation between varicocele Grade and semen parameters has not been observed [14]. Therefore, varicocele Grade alone has been argued to not be an indication for surgical repair [14]. In addition, varicocele Grade has not been proven to be a reliable indicator of future asymmetry, which is associated with abnormally low total motile sperm counts (TMSC) [15].

Volume

The European Society of Paediatric Urology (ESPU) recommends evaluating the size of both testicles by orchidometer or ultrasound, and a testis that is smaller by 2 ml or 20% compared to the other testis is considered hypoplastic [11]. The most commonly utilized method to calculate individual testicular volume is the Lambert formula, where volume = length (L) × width (W) × height (H) × 0.71. Total testicular volume (TTV) correlates with total sperm count in adolescents [8], although one study has suggested otherwise [16]. Testicular ultrasound has been found to be more sensitive than orchidometer in detecting volume differentials between testes [17]. Of note, testis ultrasound measurements may be imprecise due to sonographer variability and variable placement of cursors for determining length, width, and height [14]. Thus, many believe that the decision to undergo surgery should be based on several measures rather than one [14]. No matter what method is used to determine testicular volume, consistency is key to obtaining a reliable measure of testicular growth over time [14]. Therefore, annual ultrasound calculation of testicular volume to evaluate the adolescent with varicocele is recommended [17].

Testicular volumes should be compared to evaluate for asymmetry. The two commonly used formulas to compare volume asymmetry are the Testicular Atrophy Index (TAI) and Testicular Volume Differential (TVD, or TVDiff). While TAI represents the size discrepancy of one testicle relative to the other, TVD frames the discrepancy relative to the total volume of the testicles combined. TAI may be calculated using the formula [(volume of unaffected testis—volume of affected testis) / volume of unaffected testis] × 100%. Testicular volume differential is defined as TVD = [(volume of unaffected– volume of affected testis) / total testicular volume] × 100%. It is important to distinguish that "TVD" is sometimes misapplied to abbreviate "testicular volume discrepancy" or "testicular volume difference", which are in fact equal to TAI as they compare one testicular size to the other, rather than to TTV. The values TAI and TVD can be converted between one and the other, with a TAI of 20% corresponding to a TVD of approximately 11% [18].

In a study on 17 to 19 year-olds with grade 2 and 3 varicoceles, poorer semen quality correlated with greater asymmetry. Sonographically derived testicular volume differential (TVD) greater than 10% have been shown to correlate with a significantly decreased sperm concentration and total motile sperm count [19]. Similarly, in a study of 12 to 17 year-olds with idiopathic varicocele, those with TAI of 20% or more were significantly more likely to have sperm concentration falling below normal values [20].

Doppler Ultrasound Parameters of Maximum Vein Diameter and PRF

The European Association of Urology (EAU) recommends confirmation of varicocele by color duplex Doppler analysis after physical examination [11]. A 3.0 mm minimum vein diameter with retrograde blood flow has been accepted as the criteria for varicocele. Deferential vein reflux plays little role in the development of a varicocele or recurrence [15, 21]. Sonography should therefore focus primarily on large vein reflux rather than distal collaterals such as the deferential vein. Peak retrograde flow (PRF) in prominent vein(s) draining a testis affected by varicocele has been shown to be a clinically useful metric. The sonographic technique for PRF was first described in 2009. Patients should be supine and relaxed, and the largest diameter vein within the pampiniform plexus identified. Then, the patient should be instructed to perform Valsalva, and PRF should be measured within that vein on duplex Doppler ultrasound [22]. In a study on 17 to 19 year-olds with grade 2 and 3 varicoceles, poorer semen quality correlated with higher PRF. Boys with ≥ 20% testis asymmetry (TAI) in conjunction with a Doppler-detected PRF of 38 cm/s or greater will have persistent or worsening future asymmetry [22, 23].

Semen Analysis

Semen analysis (SA) may be the most accurate predictor of future fertility, but its role in the evaluation of varicoceles in adolescents is unclear [9]. SA is not commonly used by pediatric urologists in pediatric patients with varicoceles [8]. In a 2016 survey of Society for Pediatric Urology (SPU) members, only 13.1% routinely incorporate SA in their practice, with 48% having discomfort asking for one [24]. Repeated SAs are necessary in the management of these patients as nearly half of patients with an initially poor total motile sperm count (TMSC) demonstrated normal counts on the second SA, although a subpopulation of high-risk patients had persistently poor TMSC [25]. A SA has been considered preferable to relying on a moderate hormonal correlate [26].

Hormonal Evaluation

There is currently no consensus on the utility of hormonal evaluation in this population, although it is known to be beneficial in the adult population [8]. Inhibin B has been shown to be reduced in adolescents with untreated varicocele, and reduced levels are associated with decreased testicular volume [27]. In the adult population, varicocele presence has been associated with higher serum levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) with lower inhibin B levels [28], although a different study found that inhibin B levels decreased but FSH, LH, and testosterone were normal [27].

Management

Initial Work Up

The initial step in adolescent varicocele management should include a detailed history and physical examination. Important elements of the history include history of cryptorchidism, scrotal surgery, history of gonadotoxic therapy (e.g., chemotherapy for leukemia), and family history of testis cancer. Physical examination should be performed in the standing position for the purpose of grading. Assessment with orchidometer volume measurement and/or ultrasound volume and PRF assessment should follow. It is critical to record baseline values and TAI for serial comparisons. SA may be offered for patients who have reached Tanner V. However, in patients who are uncomfortable or unwilling to provide semen for sampling, it is acceptable to defer this.

Conservative Approach

In most cases, an asymptomatic adolescent varicocele may be managed conservatively with regular follow-up for reassessment. For patients who have not yet reached Tanner V, this approach should be considered as the first line. It is always important to educate patients on the rationale behind expectant management.

Initial volume analysis may reveal size atrophy of the affected testis. A TAI of ≥ 20% or volume difference of 2 mL has historically been an indication for surgical intervention, but more recent studies have challenged this guideline [29]. Rather, patients with a TAI of at least 20% should have a repeat ultrasound in one year to assess for resolution or persistence. Patients should be reassured that testicular size discrepancy is common and often self-resolving, a phenomenon commonly referred to as "catch-up growth." Glick et al. found that in patients 11–18 years old with at least 15% TVD and asymptomatic varicocele, 80% of patients with non-operative management will exhibit catch-up growth at

repeat ultrasound one year later [30]. These findings were consistent with Kolon et al. who showed a normalization of TVD in 85% of patients followed for 2 years [31]. A 2018 study found that 1 in 5 boys aged 11–16 years with ultrasound confirmed absence of varicocele had a TAI of at least 20%, and the average TAI was 17% [32]. In 2023, Lourdaux et al. also studied TAI in boys with confirmed varicocele absence, finding that 10% of them have a TAI of at least 20% [33]. Nearly 70% of this size discrepancy was resolved at some point in the future. A TAI of 10–20% should be followed regularly, but persistence of this size discrepancy is not an indication for intervention as it can be seen in healthy patients [34]. Lastly, a TAI of < 10% in the absence of other findings on PRF or SA does not warrant follow-up or repeat measurement [34]. In light of these studies, TAI should be serially measured in the absence of other factors regarding varicocele intervention. Follow-up should occur annually and include repeat of volume measurements at the very least [35].

In addition to testis asymmetry, low TTV in the setting of unilateral varicocele has been touted to likely have meaningful prognostic value. In a retrospective study of over three hundred Tanner V boys with unilateral varicocele, Fang et al. reported those with TTV < 29.5 cc demonstrated statistically significantly lower TMSC than those boys with larger TTV [29].

Though pre-pubertal varicocele is rare, conservative management can be similarly offered for these younger patients. Pre-pubertal presentation of varicocele has been shown not to affect outcomes, with similar rates of long-term testicular hypotrophy and need for surgical intervention in matched pre- and post-pubertal individuals with varicocele [36].

Semen analysis is a useful adjunct that may be offered to patients undergoing conservative management, though it can be deferred in patients who meet the previously described criteria. While this tool is considered a direct assessment of testicular function and fertility, it can be used as confirmation once conservative evaluation shows persistent TAI, low TTV, or elevated PRF.

Indications for Further Work-Up or Referral

Pain

Symptomatic painful varicoceles should always be offered referral, as this is a correctable issue with surgical intervention. Those with varicocele-related pain typically report dull, throbbing, or aching pain in the region of the scrotum, testicle, or groin [37]. This is exacerbated with prolonged standing and activity. Less common but still attributable pain may be described as sharp, stabbing, or acute.

Undesirable Appearance or Size

Appearance and size are relative indications for correction and should be evaluated on a case-by-case basis. Large varicoceles that cause patients distress out of fear that partners will notice or find their varicocele off-putting is a consideration for intervention. Similarly, large varicoceles may be bothersome to patients who are particularly physically active.

Bilateral Varicocele

The presence of bilateral varicocele warrants referral as these individuals may be immediate candidates for surgical repair. Because both testes may be affected, comparison of testicular volumes is not valid, making the varicocele difficult to follow and trend.

Persistent Testicular Atrophy

In Tanner V individuals, a persistent TAI ≥ 20% (TVD of 11% [18]) on two separate measurements taken 12 months apart should be considered for further evaluation. Failed catch-up growth may be a sign of persistent, non-resolving, varicocele-induced testicular atrophy that will continue to have a detriment to the affected testis. These individuals could be offered semen analysis for potential surgical repair or an opportunity to proceed directly to surgical repair.

Low Total Testicular Volume

In addition to persistent TAI, TTV insufficiency is an indication for semen analysis. A recent study including only Tanner V boys found that TTV < 29.5 cc was associated with significantly lower TMSC [29]. Assessment of TTV should be compared on at least 2 separate occasions separated by 12 months [14].

Peak Retrograde Flow > 38 cm/sec

Peak retrograde flow measured by ultrasound represents an objective tool for varicocele evaluation and management pathway. This may be of interest especially when providers encounter patients unwilling to provide a semen sample on initial consultation. It has been shown that PRF > 38 cm/s is associated with increased sperm DNA fragmentation [38]. Patients for whom PRF falls between 30–38 cm/s should have yearly follow-up, with sonography repeated at each visit [34].

"20/38 Harbinger"

At any point in evaluation, a simultaneous TAI of at least 20% and PRF > 38 cm/s warrants immediate urologic referral. This combination of findings has been labeled the "20/38 harbinger" and individuals with this set of findings rarely exhibit catch-up growth [39]. Rather, these patients have further progression of the already existing testicular asymmetry [38].

Semen Analysis

In Tanner V patients with any of the aforementioned parameters, SA should be offered as an accurate and confirmatory assessment of current testicular and sperm function. Discussion of SA may come with resistance by the patient, and an understandable level of discomfort on the physician's behalf. As such, this topic should be approached with emphasis on its objective diagnostic utility. Varicocelectomy has been shown to improve TMSC [40]. Furthermore, TMSC may be the most important aspect on SA to predict fertility [41]. The WHO considers 20 million TMSC as the lower fifth percentile, and values falling below this threshold are regarded as abnormal. Once SA is obtained, a repeat analysis should be performed in 3–6 months to confirm [14]. Although abnormal SA is an indication for referral and potential surgery, the need for surgical intervention is not immediate. It ought to be highlighted that improvement in SA and TMSC is seen regardless of when varicocele repair is performed, whether during the adolescent period or in young adulthood [42]. Acknowledging this, in a retrospective study examining pre- and post- microsurgical inguinal varicocelectomy in patients ≤ 20 years, 21–30 years, and ≥ 30 years, the greatest upgrade in TMSC was observed in patients < 20 years with Grade 3 varicoceles compared to other varicoceles Grades and older patients [42].

Surgery

Surgical intervention should be considered in adolescents with pain, undesirable cosmetic appearance, bilateral varicoceles, significantly altered persistent TAI (> 20%) or TVD (> 11%), persistent low TTV (< 29.5 cc), PRF > 38 cm/s, the "20/38 harbinger," abnormal TMSC on serial SA, or infertility. With the exception for the "20/38 harbinger," prior to surgical intervention, testicular disproportion should be observed for at least one year in case spontaneous catch up growth occurs [10]. Adolescent surgery is likely overperformed [8].

Surgical approach is largely dependent on the surgeon's preference [10]. Surgical options for varicocelectomy include the open inguinal (Ivanissevich), high retroperitoneal (Palomo ligation of testicular veins and artery), inguinal and subinguinal microsurgical approaches, as well as laparoscopic repair (Palomo type mass ligation of artery sparing) [14]. A nonsurgical approach is antegrade or retrograde embolization or sclerotherapy [14]. Both scrotal antegrade sclerotherapy, microsurgical approaches, and laparoscopic Palomo surgery are safe and effective procedures for treatment of adolescent varicocele with significant positive effect on testicular catch-up growth [43].

Surgical complications include hydrocele formation, persistence or recurrence of varicocele, failure to improve semen parameters, and testicular atrophy [14]. A review of surgical techniques in adult males with varicoceles found that, overall, the microsurgical subinguinal or microsurgical inguinal techniques offer the best outcomes [44]. Pregnancy rates were highest and varicocele recurrence rates were lowest with microsurgical subinguinal technique [44]. Hydrocele formation rates were lowest with the microsurgical inguinal technique and surgical complications were highest in the laparoscopic technique [44]. There has been some discussion in the literature that testicular artery-sparing techniques ought to be considered in adolescents; such discussion is outside the scope of this review.

Conclusions

Recent developments in pediatric varicocele research have led to clearer guidelines for conservative management versus referral for surgical intervention. With these findings in mind, pediatricians can feel comfortable offering appropriate screening tools and recommendations that suit individual patient needs. In the office, the most important skills to have are good history and physical examination techniques. Ultrasound with color Doppler is the mainstay for evaluation and regular follow-up. Semen-analysis should be offered and may be used as a final confirmatory tool. Pre-Tanner V patients with testicular asymmetry should be followed, with the asymmetry often self-resolving. Referral at any point is warranted for pain, undesirable appearance, bilateral varicocele, persistent testicular atrophy, low TTV, specific PRF findings, and/or abnormalities on SA. In most cases, varicoceles can be safely monitored throughout adolescence.

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  Authors report Testicular Atrophy Index (TAI) ≥ 20% is seen even in boys without varicocele, and boys both with and without varicocele seem to resolve this discrepancy at equal rates. This study de-emphasizes the importance of singular instance TAI as an indicator for intervention, particularly in Tanner III and IV patients with a varicocele and one measurement of TAI ≥ 20%.

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  Peak retrograde flow > 38.4 cm/sec predicts sperm DNA fragmentation in Tanner V patients with unilateral varicoceles. The study offers one of the potential one-time objective indications for intervention.

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  Total testicular volume < 29.5 cc predicts abnormal total motile sperm count in Tanner V patients with unilateral varicocele. This study offers a potential objective indication for intervention and emphasizes the importance of following serial testicular dimensions throughout puberty.

Author Contributions RB, ME, and CB conceptualized project. RB and ME performed the investigation. RB and ME wrote the main manuscript text. CB and KC validated results and findings. All authors reviewed the manuscript. RB and CB oversaw project administration. CB supervised the project.

Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing Interests The authors declare no competing interests.

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