Volume alteration of undescended testes: Before and after orchiopexy

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ABSTRACT

Objectives: We used ultrasound to investigate the volume of undescended testes before and after orchiopexy, and compared these data with normally descended testes.

Materials and Methods: We retrospectively reviewed boys in the age range of 0–18 years who had undergone unilateral or bilateral orchiopexy due to undescended testes (International Classification of Diseases-Ninth Revision, ICD-9 752.51) in National Taiwan University Hospital, Taipei, Taiwan between January 2010 and December 2013. A total of 116 boys received preoperative testicular ultrasound evaluation, and 75 of them received regular ultrasound during a mean follow-up period of 2.5 years. The volume of the testes was calculated by applying Hansen formula [testicular volume = length (L) × width (W)² × 0.52] and compared with a cohort of 92 boys constructed for normative values of testicular volume from The Netherlands.

Results: The mean volume of the 145 undescended testes among 118 boys was 0.238 mL. The volume of the undescended testes was significantly smaller (p < 0.001) than the mean normative value of 0.418 mL. The volume of postorchiopexy undescended testes (0.356 mL) revealed a growing trend in the mean 2.5-year follow-up with a significance increase of size (p = 0.001), but has not yet reached the normal testicular size (0.604 mL).

Conclusion: The preorchiopexy volumes of undescended testes are significantly smaller than normative values. The follow-up postorchiopexy volumes of undescended testes actually increased in size, although they were still smaller than normative values. These Taiwanese testicular growth curves should become reference values in pediatric clinical practice when evaluating testicular development.

Keywords: cryptorchidism, orchiopexy, testicular volume, treatment outcome, undescended testes

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1. Introduction

Undescended testes (UDT) are one of the most common congenital urological diseases. The prevalence of cryptorchidism at birth varies from 1% to 9%, and the testes mostly descend during the first 1/2 year of life. The prevalence is reported to be about 1% among boys at 1 year of age. The volume of the testes is significantly related to the semen profile and the testicular function, since 80–90% of the testes were composed of seminiferous ducts. Bahk et al1 reported that the testicular size reflects the degree of spermatogenesis, testosterone level, and semen profile. Therefore, accurate measurement of the testicular volume is crucial for evaluating the development of testes.

Several kinds of tools were applied to evaluate the size of testes, such as orchidometry, use of rulers and calipers, and ultrasound. Although the traditional methods are still reliable, ultrasound is a more preferable and accurate means of measuring testicular volume.2 We aim to record the undescended testicular size and normally descended testes (NDT) to establish the growth and developmental chart. We sought to compare our data with the nomogram reported by Goede et al3 from The Netherlands. Furthermore, we recorded the testicular volume after orchiopexy to determine the postoperative outcome of UDT.

2. Materials and methods

We retrospectively searched medical charts of children (<18 years old) who received unilateral or bilateral orchiopexy due to UDT (International Classification of Diseases-Ninth Revision, ICD-9 752.51) in National Taiwan University Hospital, Taipei, Taiwan between January 2010 and December 2013. Patients' clinical characteristics, concomitant diseases, laterality of the diseases, age of orchiopexy, pre- and postoperative scrotal echo findings, and
intraoperative findings were collected. Patients who underwent orchiopexy for retractile testes were excluded. A total of 225 patients were admitted for surgical management of UDT. The operative procedures were performed by three pediatric surgeons and two general urologists.

2.1. Definition of UDT

Congenital UDT were defined as the absence of the testicle in the scrotal position since birth. All testes that could not be pulled down to the scrotum at clinical examination by a urologist or pediatric surgeon were documented as UDT. If a testis could be pulled down to the scrotal position and retained in the scrotum during clinical examination, or the testis was found in the scrotum after general anesthesia before operation, it was finally defined as a retractile testis, and not UDT.

2.2. Ultrasonography of the testes

Patients without pre- and postoperative scrotal echo were not included in the testicular volume analysis. A total of 118 boys received preoperative testicular ultrasound evaluation, and 75 of them received regular ultrasound during a mean follow-up period of 2.5 years. High-resolution ultrasound was applied, and the image was uploaded to electronic medical record systems. Testicular length, width, position of the testes, and any abnormal findings were well documented. The testicular volume was then calculated with Hansen formula:

\[
\text{Testicular volume} = \text{length (L)} \times \text{width (W)}^2 \times 0.52.4
\]

2.3. Statistical analysis

The measured volume of the testes was calculated and analyzed with SPSS statistic software, version 22.0 (IBM Corp., Chicago, IL, USA).

3. Results

3.1. Patient characteristics

From January 2010 to December 2013, 234 boys underwent orchiopexy for management of UDT in National Taiwan University Hospital (Figure 1). Eight boys received orchiectomy because of atrophic testis, and in one boy testis was found to be absent after exploration. Of patients recruited in this study, 67 (29.8%) had bilateral UDT, 67 (29.8%) had right-sided UDT, and 91 (40.4%) had left-sided UDT. The median operative age was 1.25 years (range, 50–4360 days), and the average operative age was 2.1 years.

Among the patients, 53 boys presented underlying diseases, including 11 boys with genetic diseases (Prader–Willi syndrome, mitochondrial disorders, Robinow syndrome, etc.), six boys with neurological diseases (cerebral palsy, seizure, etc.), eight boys of congenital cardiovascular diseases (atrial septal defect, ventricular septal defect, and total anomalous pulmonary venous return), six boys with nephrourological diseases (hypospadias, hydronephrosis, nephrotic syndrome, etc.), eight boys with psychiatric problems (attention deficit hyperactivity disorder, autism, etc.), seven boys with endocrine diseases (hypogonadism), five boys with gastrointestinal anomalies (diaphragmatic hernia, tracheoesophageal fistula, etc.), and two boys with orthopedics disorders. Among the 159 boys with unilateral UDT, only 22 (13.8%) had concomitant diseases and eight (5%) of them had minor diseases such as asthma, autism, and attention deficit hyperactivity disorder. Among the 67 boys with bilateral UDT, up to 31 (46.3%) boys had major underlying diseases.

3.2. Preoperative volume: UDT versus NDT

A total of 118 boys with UDT received preoperative scrotal echo. The testicular volume of UDT was 0.238 ± 0.014 mL (number of testes, 145) and that of NDT was 0.418 ± 0.020 mL (number of testes, 91). The volume of UDT was significantly smaller than the mean normative value (p < 0.001). Testicular volumes of NDT and UDT according to age groups are described in Figure 2. The normogram

Figure 1. Study profile. UDT = undescended testes.
of testicular volume, as reported by Goede et al., which represented the 90 percentile, 50 percentile, and 10 percentile according to patients’ age and our data was plotted in. Our Taiwanese normal testicular volume data were very similar to the data from The Netherlands (Figure 2). The data for boys older than 6 years were omitted due to a relatively small sample size.

3.3. Postoperative volume: UDT versus NDT

Seventy-three boys received postoperative scrotal echo for a mean follow-up period of 2.5 years. Testicular volume of postoperative UDT was 0.355 ± 0.049 mL (number of testes, 88) and that of the contralateral NDT was 0.604 ± 0.086 mL (number of testes, 58). The postoperative testicular volumes of NDT and UDT according to age groups are described in Figure 3. The postorchiopexy testes revealed a growing trend, but have not yet reached the normal testicular size ($p < 0.001$).

Patients who did not receive scrotal echo follow-up underwent physical examination by a surgeon. In the unilateral UDT group, the testicular size was similar to that of the contralateral testicles or smaller, but with improvement. In the bilateral UDT group, physical examination revealed satisfied surgical results. No testicular atrophy was reported. Only five patients were lost to follow-up after one visit to our clinic.

Figure 2. Preoperative volumes of UDT and NDT in different age subgroups. (A) The average testicular volumes of UDT in all age subgroups (except the age 4 subgroup) are smaller than the 10 percentile of the reference values. (B) The average NDT volumes in all age subgroups are very close to the 50 percentile of the reference values. Reference values were adopted from the study of Goede et al., representing 10-, 50-, and 90-percentiles of the testicular volume. NDT = normally descended testes; UDT = undescended testes.

Figure 3. Postoperative volumes of UDT and NDT in different age subgroups. (A) The postorchiopexy UDT volume with the mean 2.5-year follow-up reveals a growing trend, but they are still smaller than the reference values. (B) The contralateral NDT volumes in all age subgroups are very close to the 50 percentile of the reference values (except the age 2 subgroup). The reference values were adopted from the work of Goede et al., representing 10-, 50-, 90-percentiles of the testicular volume. NDT = normally descended testes; UDT = undescended testes.
Table 1
Total average volume of unilateral UDT, bilateral UDT, UDT, and contralateral UDT.*

<table>
<thead>
<tr>
<th>Case number of pre/postop scrotal echo</th>
<th>Bilateral UDT</th>
<th>UDT</th>
<th>Contralateral NDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>91/58</td>
<td>27/15</td>
<td>118/73</td>
<td>91/58</td>
</tr>
<tr>
<td>Preoperative volume</td>
<td>0.223 mL (TN = 91) ± 0.018</td>
<td>0.263 mL (TN = 54) ± 0.023</td>
<td>0.238 mL (TN = 145) ± 0.014</td>
</tr>
<tr>
<td>Postoperative volume</td>
<td>0.397 mL (TN = 58) ± 0.073</td>
<td>0.276 mL (TN = 30) ± 0.049</td>
<td>0.355 mL (TN = 88) ± 0.049</td>
</tr>
<tr>
<td>Final testicular growth rate</td>
<td>1.780</td>
<td>1.049</td>
<td>1.492</td>
</tr>
</tbody>
</table>

NDT — normally descended testes; TN — testicular number; UDT — undescended testes.
* The final testicular growth is the ratio of average pre- and postoperative volume.

3.4. Testicular growth rate (post-/preoperative volume): UDT versus NDT

The ratio of post- and preoperative testicular volume was defined as the testicular growth rate. The final growth rate of testes was different in the unilateral and bilateral UDT groups. However, the final growth rates of UDT (combined unilateral and bilateral) and contralateral NDT were similar (Table 1). Further analysis of the unilateral UDT subgroup (N = 58) was performed to assess the alteration of the testicular volume before and after orchiopexy (Table 2). The final average growth rate of the 58 boys was 2.269 (0.397 mL/0.208 mL) in the UDT group, which was higher than 1.445 (0.604 mL/0.46 mL) in the NDT group after the mean 2.5-year follow-up. The annual testicular growth rate was 1.746 ± 0.516 in the UDT group and 1.208 ± 0.074 in the NDT group. In other words, postorchiopexy UDT actually revealed a growing trend and appeared to be faster than the NDT group. However, there were no statistically significant difference in the growth rate (p = 0.328) and annual growth rate (p = 0.292) between the UDT and NDT groups.

4. Discussion

We utilized the contralateral healthy UDT to establish the normative values of testicular growth and investigated the volume of UDT. This study demonstrated the Taiwanese data of testicular volume in different age groups, which were useful in clinical practice. Precise measurement of testicular volume is essential because its volume is significantly related to the testicular function. Traditional methods such as physical examination, and the use of rulers, orchidometer, calipers, etc. are convenient but lack objectivity. The thickness of scrotal skin, soft tissue, and epididymis would influence the measurement and result in an overestimation of testicular size. Nowadays, the use of high-resolution ultrasound has become prevalent in the examination of UDT.

However, some studies have revealed variability in ultrasound measurement depending on the examiner and the formula applied. An experimental study had used a canine model to determine the most accurate coefficient for ultrasound estimates. The result was known as Lambert equation:

\[
0.71 \times \text{length} (L) \times \text{width} (W) \times \text{height} (H).
\]

The prolate ellipsoid formula of:

\[
0.52 \times \text{length} (L) \times \text{width} (W) \times \text{height} (H)
\]

was often used, too. Lin et al proposed a new formula of:

\[
0.59 \times \text{length} (L) \times \text{width} (W)^2
\]

to assess smaller testes. We applied the Hansen formula:

\[
0.52 \times \text{length} (L) \times \text{width} (W)^2
\]

to calculate the testicular volume. The comparison of the NDT volume in the unilateral UDT boys with the nomogram from The Netherlands reveals very similar results in different age groups (from 0 years to 5 years). Some studies reported a larger testicular volume due to different measuring methods.

In our study, the development of UDT without orchiopexy is slow and mostly below the 10 percentile mark (Figure 2). UDT grow bigger in boys from 0.5 years to 1 year of age and then do not differ with age (except in the 4-year-old group). Besides, Kamisawa et al reported that the undescended testicular volume did not differ with age since birth to the age of 5 years. These findings suggest that the growth rate of UDT is suppressed early in 1-year olds, and orchiopexy is highly recommended to be performed before 1 year of age. About 2 decades ago, Taskinen and Wikstrom revealed no significant correlation between patient age at treatment and final testicular volume. Early orchiopexy at an age younger than 2 years was not necessarily essential. This old paradigm had already been challenged after more histopathological evidence was found. The American Urology Association guideline of “evaluation and treatment of cryptorchidism” suggested orchiopexy in the first 18 months of life to preserve available fertility potential. Recent pediatric urology guideline from the European Association of Urology suggested to perform orchiopexy as early as possible, starting after 6 months and finishing preferably at 12 months of age.

We observed a significant (p = 0.001) increase of UDT volume after orchiopexy at a median operative age of 1.25 years and with a mean follow-up of 2.5 years. The testicular size grew from 0.228 mL to 0.356 mL. Kim et al reported that orchiopexy performed at least 2 years from birth showed significant recovery of testicular volume at follow-up 2 years after surgery. Kollin et al reported an increase in testicular volume when orchiopexy was performed at the age of 9 months rather than at the age of 3 years. This result also supports the beneficial effect of early orchiopexy from the viewpoint of testicular growth. A comprehensive literature review by Murphy et al revealed the morphology and ultrastructural changes in UDT, as early as 3–6 months of age. However, such early surgery to improve the fertility outcome still requires more evidence.

The study of retractile testes by Goede et al reported that retractile testes were significantly smaller than the reference values. In the present study, a similar conclusion was made that...
UDT were significantly smaller than NDT. The possible reason for the inhibition of the growth of testis might be the thermal effect from the inguinal area or abdomen, because among the retractile testes, the testicular volume of the inguinal type is smaller than that of the scrotal type. As to the UDT boys, all the testicles are above the upper scrotum and the temperature are theoretically near the same, so the positions of the testes are not related to the testicular volume. In our study, the testes above internal ring including in the abdomen, the testicles in the inguinal canal and in the external ring showed no significant difference in size. A previous study also revealed that no difference was found in intra- and extra-abdominal testis size.14 Kamisawa et al15 and Varela-Cives et al14 also reported the same conclusion that the position of the testes is not related to its size. The future prognostic parameters such as paternity, sperm count, or hormone levels revealed no significant difference in different testicular sites.15 Therefore, preoperative testicular location in men with previous unilateral cryptorchidism is not a major determinant of fertility.

The contralateral NDT are often defined as the control group in the unilateral UDT patients. Some study proposed the testicular atrophy index according to the affected and normal testicular size ratio.14 In their study, van Brakel et al17 reported that the contralateral NDT had anomalies such as a small testicular volume and presence of testicular microlithiasis. However, these findings were rarely seen in our cohort. Besides, the testicular volume of the contralateral NDT is not reduced compared with the reference values. Whether both the testes from unilateral UDT patients are affected is still unclear.

The limitations of this study included hindsight bias from a retrospective chart review, short-term follow-up, and a lack of other testicular function evidence, such as hormone or sperm analysis. Only 25% of UDT boys received regular postoperative scrotal sonography follow-up. The measurement bias of UDT in the inguinal area might occur because of the inferior visual quality compared with that in the scrotal area. Future studies on testicular function, spermatogenesis, paternity, and testicular size could provide more solid evidence for the analysis of UDT patients after orchiopexy.

5. Conclusion

In conclusion, the volume of UDT is significantly smaller than that of NDT in all age subgroups and revealed a slow growing trend in 1–5-year olds. After the mean 2.5-year follow-up after orchiopexy, the UDT volume increased significantly compared with the preoperative testicular volume. Although an obvious growing trend was seen in the UDT group, the volume of UDT is still significantly smaller than that of NDT. Other major contributions of this study are the establishment of the per age volume growth curve, for both NDT and UDT. These Taiwanese data should become reference values and be helpful for the assessment of testicular volume in clinical practice.

Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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References