DIVERTICULUM OF THE BLADDER IN CHILDREN
A Study of 13 Cases
By Ian W. Forsythe, M.D., M.R.C.P., and Brian T. Smyth, F.R.C.S.
Royal Belfast Hospital for Sick Children, Northern Ireland, and the Boston Floating Hospital for
Infants and Children, Boston, Massachusetts

The few reports of bladder diverticulum in children would suggest that this is a rare condition. In 1934, Kretschmer reviewed the literature and found 15 cases in children less than 12 years of age to which he added two more; in 1940, he reported three additional cases. Since then, 25 more cases have been described in children less than 15 years of age by Ward, Campbell, Kjellberg et al., and Miller. In addition, 17 cases have been reported at necropsy. We wish to add 13 cases occurring in children between 2 and 14 years of age, eight of which were discovered during the routine investigation of 487 children with persistent bed-wetting and three during investigation of 53 children with persistent infection of the urinary tract. The remaining two children were investigated for dysuria.

Among the 27 cases in the literature where the sex of the child is given only two occurred in females. In the present series of 13 cases, one occurred in a girl.

ETIOLOGY
Although several theories have been advanced to explain the occurrence of diverticulum of the bladder, none has found universal acceptance. Joly suggested that diverticula might be formed from accessory ureteral buds. Watson studied the development of the vesical cavity in early fetal life and demonstrated that ridge-like elevations of epithelial cells could bridge the bladder cavity. Each elevation ultimately contained all layers of the bladder wall and with growth became continuous with the wall of the bladder to form a diverticulum. This peculiar disturbance of growth occurred most frequently at the margins of the trigone where layers of epithelial cells were most abundant. Judd and Scholl thought that diverticula were due to embryologic defects causing weakness of the musculature of the bladder, usually at the base. In the opinion of most authors, urethral obstruction is necessary for the development of a diverticulum. As a result of his experience with five patients, Kretschmer states that children with diverticula of the bladder always have some type of bladder neck or urethral obstruction and that those patients without obstruction were insufficiently studied or the obstruction was overlooked.

PATHOLOGY
Diverticula of the bladder are usually single in children although multiple diverticula may occur. Their size varies from a centimeter in diameter to that of the whole bladder and they are found most commonly at the base near the ureteral orifices. A patent urachal remnant closely resembles a diverticulum of the bladder, but its shape and high position on the antero-superior wall of the bladder should help to identify it. Earlier authors, including Englisch and Rathbun, distinguished “true” diverticula where all coats of the bladder were present, from “false” diverticula where mucosa alone was present. This distinction is no longer made since it is thought that all diverticula initially contain a muscular layer. Chronic infection of the urinary tract may cause par-
tial or complete replacement of the muscle layer with fibrous tissue.

In the five cases in this series in which the diverticulum was removed, the histologic appearances varied considerably. The mucosa had no ulceration, but there were varying degrees of submucosal inflammatory reaction with capillary engorgement, edema, and leukocytic infiltration. The muscle coat was largely replaced by fibrous tissue, but in several areas the muscle bundles were readily identified.

**COMPLICATIONS**

**Infection**

Children with diverticula of the bladder may develop infection of the urinary tract, and this is usually attributed to urinary stasis from inability of the diverticulum to empty or from urethral obstruction. Four children in the present series had infection of the urinary tract.

**Chronic Infection and Calculus Formation**

Chronic infection in a diverticulum produces peridiverticulitis with adhesions to ureters, seminal vesicles and rectum. Urinary stasis and infection may lead to formation of calculi although this complication is rarely found today. Durrieux\(^4\) reported eight cases and Englisch\(^2\) 21 cases of calculi in diverticula in children less than 10 years of age. Kretschmer\(^1\) has cast doubt on the validity of these figures. None of the children in the present series had calculi.

**Ureteral Obstruction**

Because a diverticulum is frequently close to the lower end of a ureter, enlargement or adhesions from peridiverticulitis may cause ureteral obstruction. If not relieved, such obstruction will be followed by development of megaloureter, hydronephrosis and, eventually, loss of renal function on the affected side. Rarely, both ureters may be obstructed by a single diverticulum, or multiple diverticula may cause obstruction of the vesical orifice. Hyman\(^9\) has reported an example of each anomaly.

We have been unable to find any report of a neoplasm originating in a diverticulum in a child although such an occurrence is not unusual in adults.

Posterior urethral valves or obstruction at the bladder neck may be found in association with a diverticulum of the bladder. The resulting increase in intravesical pressure may lead to hypertrophy and trabeculation of the wall of the bladder, enlargement of the bladder and diverticulum, and possibly vesicoureteral reflux with pathologic changes in the upper urinary tract. In the present series three children had obstruction at the bladder neck and two had posterior urethral valves.

**SYMPTOMS AND SIGNS**

Symptoms referable to the urinary tract were present in all 13 patients. Six children had infravesical obstruction and three of these complained of difficulty or straining on voiding, while two had poor urinary stream as well. The remaining three children had urinary incontinence only.

Seven children had no evidence of infravesical obstruction. Five of them had nocturnal and diurnal incontinence of urine and as investigation failed to disclose any pathologic changes apart from the diverticulum, it appeared that these symptoms were functional in origin. One of the children had transient hematuria for which no cause was found. The sixth child had recurrent attacks of infection of the urinary tract associated with bilateral ureteral reflux (Figs. 1 and 2). The seventh child had dysuria and pyuria from birth associated with left aperistaltic megaloureter and hydronephrosis. The diverticulum was on the right side and did not cause ureteral obstruction.

**DIAGNOSIS**

Since diverticulum of the bladder does not give rise to any characteristic symptoms or signs, special investigations are necessary to establish the diagnosis. During clinical examination any palpable enlargement of the bladder, ureters, or kidneys should be noted. If neurologic examination reveals
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saddle anesthesia or lack of function in the legs, a lesion of the spinal cord may be responsible for dysfunction of the bladder. The act of voiding should be observed in all cases for hesitancy, straining or dribbling. The character of the stream is important. If urine is expelled with diminished force, it may suggest infravesical obstruction.

Voiding Cystography

Diverticula are most easily diagnosed by outlining the bladder with contrast media. With aseptic precautions, a urethral catheter is passed and the ease with which this is done is noted. The amount of residual urine is recorded and contrast material is instilled slowly until abdominal discomfort is present. We usually use a suspension of 18% barium sulfate unless excretory urography has shown marked dilatation of the ureters and kidneys. For the initial film during voiding, the patient is placed in the supine position with the pelvis rotated 35° to the right and the roentgen tube inclined 15° toward the patient's head in order to obtain a clear view of the base of the bladder and the posterior urethra. Roentgenograms are subsequently made in the right and left oblique positions during voiding. The final or fourth roentgenogram is taken when voiding is complete. It is now our practice to protect the testes with a lead shield to avoid radiation.

Excretory Urography

An excretory pyelogram will show delayed emptying of contrast media from a ureter obstructed by pressure from a diverticulum. If the obstruction is severe, hydronephrosis may be evident.

TREATMENT AND RESULTS

Six children had infravesical obstruction (Table I). Three of these had obstruction at the bladder neck (Cases 1 to 3) and were treated by resection of the bladder neck via a suprapubic approach. One child had the diverticulum excised at the same time and
TABLE I

INFORMATION ABOUT CHILDREN WITH DIVERTICULA OF THE BLADDER AND INFRAVESICAL OBSTRUCTION

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Symptoms</th>
<th>Residual Urine</th>
<th>Infection of Urinary Tract</th>
<th>Type of Obstruction</th>
<th>Complications</th>
<th>Treatment</th>
<th>Period of Follow-up</th>
<th>Result of Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 6 yr</td>
<td>Dysuria</td>
<td>+</td>
<td></td>
<td>Bladder neck contracture</td>
<td>Bladder neck contracture</td>
<td>Bilateral hydronephrosis</td>
<td>Diverticulectomy and bladder neck resection</td>
<td>1 yr</td>
</tr>
<tr>
<td>2. 8 yr</td>
<td>Dysuria, enuresis</td>
<td>+</td>
<td></td>
<td>Bladder neck contracture</td>
<td>Bladder neck contracture</td>
<td>—</td>
<td>Diverticulectomy and bladder neck resection</td>
<td>3 yr</td>
</tr>
<tr>
<td>3. 5 yr</td>
<td>Frequency, enuresis</td>
<td>+</td>
<td></td>
<td>Bladder neck contracture</td>
<td>Bladder neck contracture</td>
<td>—</td>
<td>Diverticulectomy and bladder neck resection</td>
<td>3 yr</td>
</tr>
<tr>
<td>4. 5 yr</td>
<td>Frequency, enuresis</td>
<td>+</td>
<td></td>
<td>Posterior urethral valve</td>
<td>—</td>
<td>Valvectomy only</td>
<td>Diverticulectomy and bladder neck resection</td>
<td>5 yr</td>
</tr>
<tr>
<td>5. 8 yr</td>
<td>Enuresis</td>
<td>+</td>
<td></td>
<td>Posterior urethral valve</td>
<td>—</td>
<td>Valvectomy only</td>
<td>Diverticulectomy and bladder neck resection</td>
<td>5 yr</td>
</tr>
<tr>
<td>6. 5 yr</td>
<td>Dysuria, enuresis</td>
<td>+</td>
<td></td>
<td>Congenital perineal membrane stenosis</td>
<td>Left hydronephrosis</td>
<td>—</td>
<td>Diverticulectomy and urethral dilatation</td>
<td>6 yr</td>
</tr>
</tbody>
</table>

he has had no symptoms during the past year. The two children whose diverticula were not removed have been observed for three years and, although they still have occasional urinary incontinence, they have no residual urine and remain free from infection. Two children (Cases 4 and 5) had posterior urethral valves, which were removed by transurethral resection. Although the diverticula were not excised, urinary infection has been eradicated. One continues to have bed-wetting. These children have been followed for 5 years and in neither case has the diverticulum shown any tendency to increase in size. The remaining child in this group (Case 6) had congenital perineal membrane stenosis which was treated by urethral dilatation. The diverticulum was removed because it was compressing the lower end of the adjacent ureter. Further urethral dilatation was required a year later, and for the past 5 years there has been no recurrence of symptoms.

Seven children showed no evidence of infravesical obstruction (Table II). Diverticulectomy was performed in three of them. In Case 7, the earliest in the series, the diverticulum was removed because we thought at that time it was the correct treatment. In Case 8 the diverticulum was large and did not empty, and in Case 9, the diverticulum had produced ureteral obstruction (Figs. 3 and 4). This latter child developed infection of the urinary tract after operation, and this has recurred several times during the past 4 years. In four children the diverticula were not removed (Cases 10 to 13). One of these children (Case 10) has multiple diverticula which empty at the end of voiding. There has been no urinary infection and the diverticula have not increased in size during the past 4 years although the child continues to have nocturnal and diurnal incontinence of urine (Fig. 5). Two children with solitary diverticula (Cases 11 and 12) have been followed for 4 years and the diverticula have not increased in size. A girl (Case 12) had infection of the urinary tract with Escherichia coli which resisted treatment with sulphamethazine, oxytetracycline, and chloramphenicol and was eventually eradicated by a combination of sulphamethazine and streptomycin. This child remains symptomless although the other child (Case 11) who had no infection still has urinary incontinence.

The last child (Case 13) had an infected aperistaltic megaloureter on the left side with hydronephrosis and non-function of the left kidney. A diverticulum on the right side of the bladder was not removed. Ure-
teronephrectomy was performed 3 months ago and the child has had no further dysuria or pyuria.

**DISCUSSION**

**Incidence**

Eight cases were discovered during routine investigation of 487 children whose only complaint was persistent bed-wetting. In four of these patients no abnormality was found apart from the diverticulum, and it seemed unlikely that this could have been the cause of bed-wetting. This finding suggests that diverticula may easily remain unrecognized and that they occur more frequently than is generally supposed.

**Diagnosis**

The technique described for voiding cystograms has been of considerable value in demonstrating pathologic changes in the bladder, urethra and ureters. This technique is advisable for we have found that some diverticula can be demonstrated only during voiding. The post-voiding roentgenogram will show whether the diverticulum is capable of emptying. It should be emphasized that the presence of contrast media in the bladder after voiding is not necessarily an indication of the presence of true residual urine because it may have come from the diverticulum or from the ureters. To estimate the true residual volume in such cases the patient should be asked to void again and an additional roentgenogram made.

Excretory urography is advocated by many as the most useful method of detecting anomalies of the urinary tract. While this procedure is essential for the diagnosis of abnormalities in the upper portion of the urinary tract, it will often fail to demonstrate lesions in the bladder and urethra, e.g., bladder diverticula which only appear during voiding. Campbell obtains a voiding cystogram as soon as the excreted dye has filled the bladder. We have tried this on several occasions but found that poor contrast made it difficult to define abnormalities of bladder and urethra, and it is more difficult to detect vesicoureteral reflux. For these reasons we have abandoned this technique.

In the majority of cases sufficient information will be gained from an excretory urogram and a voiding cystogram to avoid the necessity for diagnostic urethroscopy or cystoscopy. Cystoscopy will usually reveal the orifice of a diverticulum, but this may be easily overlooked if it is small or if severe cystitis is present.
Infravesical Obstruction and Diverticulum of the Bladder

The association of infravesical obstruction and diverticulum of the bladder in children is well substantiated, but we believe that a diverticulum can also occur in the absence of obstruction. In seven cases we were unable to demonstrate evidence of obstruction in spite of careful investigation. Young and Davis and Hyman were unable to demonstrate evidence of infravesical obstruction in four boys. Infravesical obstruction as a factor in the etiology of diverticula of the bladder has possibly received undue attention. When a diverticulum is accompanied by obstruction of the urinary tract, the probability of diagnosis is increased, for symptoms of urinary obstruction or infection often develop and lead to investigation. When symptoms are absent or functional in origin, as in bed-wetters, the investigations necessary for a diagnosis may never be made.

We believe there is a group of children in whom diverticula develop in the absence of infravesical obstruction and in whom symptoms are either absent or of a nature which does not usually demand investigation. Often these children do not have infection of the urinary tract. The sole etiologic factor in this group is probably a congenital defect of the musculature of the bladder. Since diverticula can occur without infravesical obstruction, it is possible that the occurrence of such obstruction in association with a diverticulum is coincidental. Some factor other than obstruction would appear to be essential, for diverticula are rarely found in children with obstruction of the urinary tract. Burns et al. reported 81 cases of obstruction of the bladder neck in children and only three had diverticula of the bladder.

The most common sites of infravesical obstruction are posterior urethral valves and obstruction at the bladder neck. In the past 5 years we have seen 39 children with urethral valves but only five children with obstruction of the bladder neck. Posterior urethral valves are most easily diagnosed with voiding cystograms.

The diagnosis of obstruction at the bladder neck is made frequently on insufficient grounds and the criteria for diagnosis are poorly defined. We believe that true residual urine should be present, and a voiding...
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Fig. 5. Voiding cystogram (Case 10). Multiple diverticula are present but there is no infravesical obstruction.

cystogram should show narrowing or a filling defect due to contracture of the bladder neck. We admit that a minimal degree of obstruction at the bladder neck may exist without true residual urine and without symptoms of obstruction of the urinary tract, but it is questionable whether surgical treatment is necessary. When in doubt, cystourethroscopy is advisable, although this examination by itself may be misleading. The presence of trabeculation will be useful confirmatory evidence of an obstructive lesion.

Urinary Infection

Kretschmer stated that 82% of all patients with diverticula of the bladder had infection of the urinary tract. Our experience has been different, for only 4 of 13 children had infection. We believe that urinary infection is more often related to infravesical obstruction than to the presence of a diverticulum. A diverticulum is only likely to become infected when it is large and does not empty. In the present series only two children had diverticula which failed to empty and although one diverticulum was large, infection was absent in both children. Urinary infection was present in four children and in each instance the diverticulum emptied readily. Two of these children had obstruction of the urinary tract from posterior urethral valves, one had an infected aperistaltic megaloureter with hydronephrosis, and one had bilateral ureteral reflux with pyelonephritis.

Size of the Diverticulum

Kretschmer held the opinion that many diverticula become smaller if infravesical obstruction is absent, while Ward believed that they must inevitably increase in size. Seven children in the present series have been observed for 3 to 6 years without apparent change in size of the diverticula. One child has multiple diverticula. Three of the children had no initial obstruction of the urinary tract, while in four it has been removed.

Treatment

When an infravesical obstruction is present, it should be corrected, but we are less certain that all diverticula should be removed. In some cases it is debatable whether diverticulectomy will relieve symptoms. In deciding treatment of a diverticulum, the following points merit consideration:

The Ability of the Diverticulum to Empty: Large diverticula which fail to empty during voiding should be excised, for if infection is not already present, it is likely to occur. Small diverticula and those with a wide orifice usually empty satisfactorily and in such cases removal of the diverticulum may not be necessary.

The Presence of Infection: Urinary infection may be eradicated by antibiotics provided there is no obstruction at the bladder neck, ureteral reflux or residual urine in the diverticulum. The only girl in the series had recurrent infection of the urinary tract which was eventually eradicated by antibiotic therapy without removal of the diverticulum.

The Position of the Diverticulum: A diverticulum which obstructs the lower end
of the ureter should be excised. Occasionally a large diverticulum may require removal when it interferes with emptying of the bladder.

Multiple Diverticula: Multiple diverticula usually empty satisfactorily and do not require treatment.

Calculation Formation: The occurrence of a calculus in a diverticulum is rare. The calculus should be removed with the diverticulum.

Operative Technique

The operative technique used in diverticulectomy is similar to that employed with adults. The intravesical technique described in detail by Young and Davis is preferred when the diverticulum is small, retrovesical, or subtrigonal in position. An extravesical approach is equally satisfactory in children for the bladder is easily accessible.

Every effort should be made to preserve the ureter when it opens into or adjacent to the diverticulum. In a few cases it may be necessary to reimplant the ureter into the bladder. This should be done if diverticulectomy does not relieve ureteral obstruction completely.

SUMMARY

Thirteen children with diverticulum of the bladder are described. Twelve were boys and one a girl. The children form two groups—those with infravesical obstruction and those with no obstruction.

Eight children with diverticulum of the bladder were among 487 children investigated for persistent urinary incontinence.

The incidence, pathology, symptoms, signs, diagnosis and treatment of diverticula of the bladder are discussed. In eight cases the diverticulum was not removed. The results of treatment are reviewed.

Acknowledgment

We are grateful to the Consultant Staff of the Royal Belfast Hospital for Sick Children for permission to study the patients.

We wish to thank Miss Deirdre Capper, Chief Radiographer, and her staff in the Radiology Department for their co-operation in making the radiographic studies.

We are also indebted to Dr. Orvar Swenson of the Boston Floating Hospital for Infants and Children for permission to include two patients in this study.

REFERENCES

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