

THE SURGICAL TREATMENT OF DIVERTICULA OF THE URINARY BLADDER.*

WITH THE REPORT OF A CASE AND A NEW DEVICE FOR FACILITATING THE
OPERATION.

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THE presence of a diverticulum of the bladder, when so situated that stagnation of its content is favored, is a constant source of danger to the patient if it becomes inflamed.

Of the various methods of treatment of this condition, the radical removal of the diverticulum by excision has given the best result. The report of fourteen cases thus operated upon can be found in literature, namely, those of Alexander (1884), Czerny (1897), Riedel (1903), Pagenstecher, Young (3 cases), Wulff, Von Eiselsberg (1904), Porter (1907), V. Eberts (1909), Kroiss, Zaaier, Brongersma (1911). To this number I wish to add the report of a case that has come under my own observation.

Male, aged thirty-eight. Measles, whooping-cough, and chicken-pox in childhood. At the age of twenty-eight the patient experienced two attacks of severe pain in the left abdomen and one attack in the corresponding part of the right side in the course of a year. These attacks were diagnosed as renal colic. He passed no blood in the urine, nor did he pass any calculi. At the age of thirty-one he had an attack of urethritis, which healed in three weeks. Nine months later he had an attack of gonorrhœa, which lasted for fifteen months, but finally healed completely. Urethral sounds were passed for a long time first by the attending physician, later by the patient. Four years previous to consultation the patient noticed thick whitish material in the urine at intervals of a few weeks. Occasionally he had spasm of the sphincter urinæ and could not quite finish the urination. He

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suffered no pain nor any other inconvenience. Now and then he noticed that on urinating in the morning he could pass urine again shortly afterward. During the last two years the whitish material in the urine has appeared at shorter intervals and has been more abundant, and the urethra has been somewhat sensitive. The condition grew worse since January, 1910, with frequent urination, and he was treated with irrigations of the bladder and instillations.

When the patient came under my care a general examination except that of the urinary tract was negative. The prostate was slightly enlarged, and an enlargement was felt in the region of the left seminal vesicle. Repeated examinations showed a residual urine of 200 c.c., which contained a great deal of pus and slime. There was no tenderness nor enlargement in the region of the kidneys or over the bladder. The urethra accepted a 29 F. sound. The bladder was irrigated daily and solution of nitrate of silver instilled. The urine cleared up considerably, but could never be kept entirely free from pus and shreds.

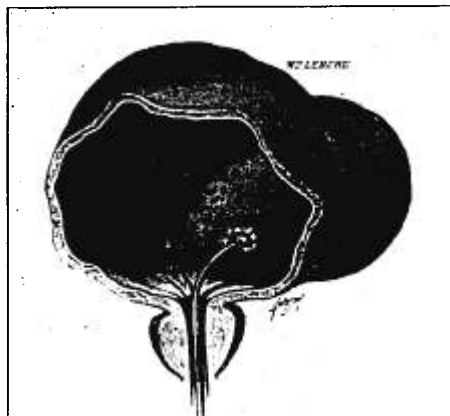
Cystoscopy.—After thorough irrigation of the bladder, 350 c.c. of a boric acid solution was left in the viscus and the cystoscope introduced. The bladder was found to be trabeculated, and there was evidence of cystitis. The left ureter could not be seen, but in that region was discovered a black hole. This opening (Fig. 1) was oval in outline with the lower border somewhat straighter than the upper. It was about 1 cm. in its longest diameter and its margin was thick, as shown in cut, with blood-vessels and radiating folds of mucous membrane curving over it. Whitish, thin shreds could be seen floating in and out of the opening. It was impossible to get the cystoscope into the opening. The left side of the posterior wall of the bladder was bulging forward (Fig. 2), and the right ureteral orifice was on a plane more posteriorly. A diagnosis of diverticulum was made and to verify this a radiograph was taken after introducing 400 c.c. of a 5 per cent. collargol solution into the bladder, a method first used by Volcker in radiographing the kidney pelvis. With the patient flat on his back the plate did not show anything abnormal, but with the patient turned about 35° the diverticulum showed up very well (Fig. 3). The radical removal of the sac was decided upon. In planning the operation the thought occurred to me that if the diverticulum could be distended inde-

FIG. 1.



Cystoscopic view of diverticular orifice.

FIG. 2.



Diverticulum distended by inflated rubber bag.

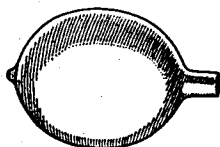
FIG. 3.



Radiograph of diverticulum and bladder taken from left side.

pendently of the bladder, with the latter in a somewhat collapsed condition, it would materially lessen the difficulty of dissection by converting the diverticulum into a tense cyst and raising it higher up in the pelvis. To that end I had little rubber bags made (Fig. 4), which could be fastened securely with a silk thread to the ureteral catheter and wrapped around the latter, a tiny rubber band (*A*, Fig. 5) being slipped over to keep the bag, *B*, in place. When the bag is distended this rubber band is forced off and later

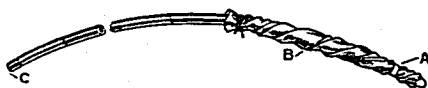
FIG. 4.



Rubber bag (actual size).

passed off by the urethra. The funnel-shaped part of the proximal end of the catheter is cut off (*C*, Fig. 5), in order to enable this end to be introduced backward through the distal end of the catheter carrying tube on the cystoscope. A Brown-Buerger cystoscope is used for the purpose. Fig. 6, *A*, shows the catheter with rubber bag being introduced into the mouth of the diverticulum, *B*. When the rubber bag is in the diverticulum, boric

FIG. 5.

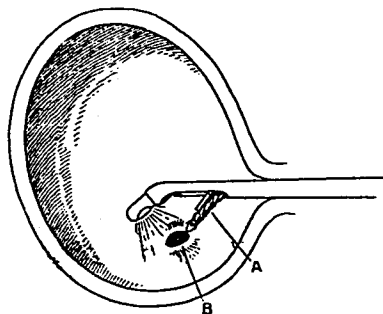
Rubber bag (*B*) tied to catheter and held by rubber band (*A*).

acid solution or normal saline is injected through the catheter into the sac until resistance is noticed. The corresponding amount of fluid is drawn off from the bladder. The bulging rubber bag can also be observed in the mouth of the diverticulum through the cystoscope. The number of cubic centimetres used will give the exact size of the diverticulum. When the latter is fully distended the proximal opening of the catheter is plugged by a thick, straight needle. The diverticulum in my case measured exactly 200 c.c.

Operation.—With 350 c.c. of a boric acid solution in the

bladder, the rubber bag on the ureteral catheter was introduced into the diverticulum through the cystoscope; 200 c.c. of boric acid solution was injected into the rubber bag in the diverticulum, while the corresponding amount was let out of the bladder, leaving about 150 c.c. or less of the solution in the latter. The distended diverticulum could be felt per rectum like a tense cyst. Ether anæsthesia. Through an incision 10 cm. long through the left rectus muscle, with the patient in the Trendelenburg position, the pelvis was entered extraperitoneally. The peritoneum was stripped off from the left side of the bladder and pelvic wall, and the tense wall of the diverticulum reached. The benefit of the

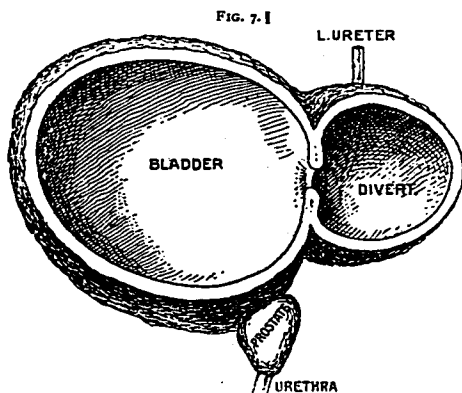
FIG. 6.



Catheter with rubber bag in cystoscope ready to be introduced into diverticulum.

rubber bag scheme was immediately appreciated. An attempt was made to dissect the diverticulum off from the peritoneum, but this could only be done half way around on account of the firm adhesions. The outer layer of the wall of the diverticulum was therefore cut through, and it could then be shelled out. The left ureter was found on the mesial side of the diverticulum being pushed to the right, and the left seminal vesicle was behind and underneath it. The diverticulum had somewhat undermined the trigonum, and it extended backward into the hollow of the sacrum and was adherent to the rectum. The rubber bag was now emptied, and on cutting through the neck of the diverticulum from the left side the bag with the catheter could be pulled out through the abdominal wound. The orifice of the left ureter was seen on the mesial wall of the diverticulum about 1 cm. from the

opening into the bladder (Fig. 7). The diverticulum was removed and the opening in the bladder sewed up with two layers of continuous formalized catgut sutures, the left ureter being implanted into the bladder through the same opening. Split tube drainage with gauze wick was left in the large extraperitoneal cavity, and the abdomen closed except for drainage opening. The neck of the bladder was dilated to 43 F. with a Kollman dilator and a retention catheter was left in the bladder. The extraperitoneal drain was removed on the fourth day. Frequent spasms interfered with the bladder drainage, and a posterior



Lateral view of bladder and diverticulum, showing position of left ureter.

urethrotomy was therefore made and a large tube put into the bladder. The neck of the bladder was found hard and fibrous and did not admit the tip of the forefinger. The patient made an uneventful recovery and left the hospital on the thirty-fourth day. Three weeks later I removed part of the fibrous neck with Young's¹ ingenious median prostatic bar excisor *per urethram* under local anæsthesia.

The patient has been well since and has gained in weight. The urine was cloudy for some time after the operation.

The inner surface of the diverticulum was smooth and of a dull greyish-red color; there were no trabecula in the sac. The epithelium was absent in places; muscular fibres were present in the wall.

RÉSUMÉ OF OPERATIVE METHODS IN THE FOURTEEN CASES RADICALLY OPERATED UPON.

Vaginal Route:—Alexander's² case: A diverticulum of the bladder protruded from the vulva. A stone was removed from the sac and the latter was ligatured at its neck and cut off. The woman recovered with a small fistulous tract.

Sacral Route:—Pagenstecher's³ case: Male, aged 33. Suprapubic cystotomy disclosed a diverticulum with its opening in the region of the left ureteral orifice. Drainage of diverticulum. Second operation: temporary resection of sacrum, removal of diverticulum, and transplantation of left ureter, which ended in the diverticulum, into the bladder. Recovery. Sacral scar painful. Sacral urinary fistula present when last seen.

Suprapubic Intraperitoneal Route:—Von Eiselsberg's case, reported by Wagner:⁴ Male, aged 48. No prostatic enlargement. Cystoscopy: trabecular bladder, diverticulum near summit on right side. Intraperitoneal excision of diverticulum, closure of bladder wound with catgut. Retention catheter. Recovery.

Riedel's⁵ case: Male, aged 61. Moderate prostatic hypertrophy. Partial prostatectomy. Continuation of symptoms. Later suprapubic cystotomy revealed a large diverticulum with large opening above right ureteral orifice. Bladder temporarily closed, then incision through right rectus muscle. Serosa over diverticulum incised and the latter dissected free, invaginated into the bladder, and removed. Diverticular orifice closed intra- and extravasically with catgut. Abdominal drainage of cavity, perineal drainage of bladder. Death.

Zaaijer's⁶ case: Male, aged 58. Moderate prostatic enlargement. Suprapubic cystotomy. An opening found to a diverticulum behind the interureteric bar. Trabecular bladder. Septum divided and margins sutured. Functional result poor. Second operation: Laparotomy. Suprapubic cystotomy. Peritoneum over diverticulum incised, the sac dissected free, pulled into the bladder, and cut off. Diverticular orifice closed intravasically. Perineal drain behind bladder. Abdominal incision closed. Cystotomy wound left open—drainage. Recovery.

Porter's¹⁰ case: Male, aged 34. Prostate moderately enlarged. Cystoscopy: Three diverticula. First operation, suprapubic drainage. Second operation, suprapubic cystotomy reopened and the orifices of the diverticula stretched. Drainage. Third operation, incision parallel with Poupert's ligament. Peritoneal cavity opened. Cystotomy wound reopened. The largest diverticulum was excised. Suprapubic drainage and retention catheter.

Later: suprapubic fistula keeps open if urethral catheter is not in place.

Suprapubic Extraperitoneal Route:—Czerny's⁷ case: Male, aged 30. Traumatic stricture of membranous urethra. Suprapubic cystotomy revealed a diverticulum with opening in the region of left ureteral orifice. Suprapubic drainage of diverticulum. Second operation: Diverticulum

removed extraperitoneally through a transverse incision of the left rectus. The left ureter terminating in the diverticulum was transplanted into the bladder. Opening closed with two rows of catgut. Suprapubic drainage, also urethral retention catheter, drainage of the extraperitoneal cavity through abdomen. Four months later left nephrectomy. Recovery.

Young's⁸ case: Male, aged 30. Urethral stricture. Cystoscopy. Two diverticula, one very large. Suprapubic extraperitoneal excision of both; right ureter in diverticulum was sewed into the bladder with a flap cut of mucosa. Drainage of bladder through a perineal urethrotomy. Drain of extraperitoneal cavity by tube behind prostate through perineum. Suprapubic fistula healed later after a Bottini operation on middle prostatic lobe. Cure.

Young's case: Male, aged 34. Cystoscopy. Small diverticulum in urachus caused by a fall. Suprapubic extraperitoneal excision of sac. Cure.

Young's case: Male, aged 63. Cystoscopy. Large diverticulum due to prostatic hypertrophy. Suprapubic extraperitoneal excision of diverticulum, perineal prostatectomy. Cure.

Wulff's⁹ case: Male, aged 34. Cystoscopy, diverticulum on right side. Incision parallel with Poupart's ligament; diverticulum opened extraperitoneally, cavity tamponed. Later diverticulum excised and communication with bladder closed. Retention catheter in bladder. Bladder sutures failed. Later edges of opening into bladder had to be freshened and sutured again. Patient when discharged had 150-200 c.c. residual urine.

V. Eberts'¹⁰ case: Male, aged 32. Right-sided nephrectomy for pyelonephrosis. Urine continued cloudy—hence suprapubic cystotomy, which revealed a diverticular opening 2.5 cm. to the outer side of the right ureteral orifice; drainage of diverticulum. In a third operation the diverticulum was removed extraperitoneally through a suprapubic incision, aided by a finger in the diverticulum through the reopened bladder wound; opening closed with a purse-string suture. Suprapubic drainage of bladder. Drainage of extraperitoneal cavity through perineum. Cure.

Kroiss'¹¹ case: Male, aged 28. Cystoscopy; X-ray. Orifice of diverticulum 2.5 cm. behind and to the left of the left ureteral orifice. Large suprapubic cross incision to left of median line. Diverticulum removed extraperitoneally with the aid of the finger in the sac through a suprapubic cystotomy opening. The opening of communication closed with interrupted sutures. Suprapubic drainage of bladder. Extraperitoneal cavity tamponed and wound left entirely open. Recovery.

Brongersma's¹² case: Male, aged 61. Bladder trouble since age of 15. Prostatic hypertrophy. Cystoscopy. Diverticular opening to the left of left ureteral orifice. X-ray. Suprapubic extraperitoneal excision of diverticulum. Closure of diverticular orifice with catgut. Recovery.

The case of Péan,¹³ which by a number of writers has been grouped with the diverticula, seems to be a case of supernumerary bladder—an embryonal malformation—and is therefore perhaps better grouped with

the cases of Wolfier and Colzi (cit. by Schwartz¹⁴), and does not belong to the diverticula described in this paper. For the reason, however, that several writers have included the case, it is appended here.

Péan's case: Female, aged 15. Incontinence of urine since birth. A small sac was felt through the anterior vaginal wall, which communicated with the exterior through an 8 cm. long canal terminating 3 mm. below the normal urinary meatus. Péan dissected out the mucous membrane of the sac and canal and closed the defect. The sac communicated with the bladder. Cure.

Wolfier's case: Female, aged 12. Incontinence of urine since birth. Below the normal meatus was found a minute opening from whence came urine. No communication could be demonstrated between the bladder and sac. Both the urethral canals were forcibly dilated, and an anastomosis made between the bladder and sac with a specially constructed pressure forceps. The patient was "almost" relieved of her incontinence.

Colzi's case: In a young girl with incontinence of urine. An extra opening was found below and to the left of the normal meatus, from which dribbled urine. At operation it was found that this opening communicated with a sac into which ended the left ureter. The sac was extirpated and the ureter implanted into the bladder. Recovery.

Of other methods of treatment can be mentioned:

(a) Simple incision through the vaginal wall with drainage of the diverticulum.

Chaput's¹⁵ case: Female, aged 50. Tumor to right of cervix uteri thought to be fibroma. Incision through vagina revealed a vesical diverticulum containing large quantity of urine and mucopus. Communication with bladder could not be found. Drainage of bladder and diverticulum. Recovery.

(b) Establishment of a fistula by sewing wall of diverticulum to the skin of the abdominal wall.

Ljunggren's¹⁶ case: Male, aged 12 years. Ljunggren first made a fistula between diverticulum and abdominal wall. One year later he made an anastomosis between the bladder and the diverticulum. Cure.

(c) Perineal drainage of the bladder.

Burckhardt's case: (Cit. by Pagenstecher. The case was reported by Burckhardt, but not treated by him.) Male, aged 43. Cystoscopy. Diverticulum above right ureteral orifice. Perineal urethrotomy through which the bladder was drained. Death.

(d) Forcible stretching of the orifice of the diverticulum.

Guibal's¹⁷ case: Male, aged 68. Gonorrhœal stricture and prostatic hypertrophy. Suprapubic cystotomy. The bladder of the size of a hen's egg; the diverticulum held a quart and a half. The orifice of the diverticulum was forcibly dilated with the finger. Suprapubic drainage. Death.

Mumford's case: Suprapubic cystotomy with drainage of the bladder was first done, without relief. Later suprapubic cystotomy with stretching of the diverticular orifices with negative result. Finally the case was radically operated upon. (Reported by Porter, *loc. cit.*)

Langer's¹⁹ case: Male, aged 38. No stricture, stone, nor prostatic hypertrophy. Suprapubic cystotomy. Dilatation of the orifice of the diverticulum. Death.

(e) Curettement of diverticulum and closure of its margins with sutures.

Pousson's²⁰ case: Male, aged 78. Prostatic hypertrophy. Suprapubic cystotomy, three calculi. Middle prostatic lobe removed. A small diverticulum containing a calculus was curetted and edges of orifice freshened and united by sutures. Bladder drained. Cure.

(f) Invagination of diverticulum into bladder, freshening of margins of orifice, and closure intraperitoneally.

V. Eiselsberg's case. (Reported by Wagner, *loc. cit.*) Male, aged 58. Three diverticula demonstrated by cystoscopy. Laparotomy. One small diverticulum near the summit was invaginated into the bladder and the margins closed by sutures. The larger diverticulum could not be found. Death a few months later.

(g) New anastomosis between bladder and diverticulum.

Ljunggren's case, *loc. cit.* Cure.

(h) Enlargement of diverticular orifice by incision of the septum or crushing with forceps.

Young's case, *loc. cit.* Male, aged 66. Cystoscopy revealed two diverticula. Suprapubic cystotomy; incision of septa; suture of cut edges. Voluntary urination restored; patient well, but has 300 c.c. residual urine.

Zaaijer's case, *loc. cit.* Male, aged 58. Suprapubic cystotomy; division of septum; suture of cut edges; functional result poor. Later radical excision of diverticulum.

Serralach's²¹ case: Suprapubic cystotomy; several incisions in the margin of the diverticular orifice. Recovery. Functional result negative.

Lennander's case reported by Zachrisson:²² Male, aged 21 months. Retention of urine and cystitis came on after operation for phimosis. Suprapubic cystotomy disclosed a diverticulum. A fistula was established by sewing the bladder to the skin of the abdomen. In a second operation a strong silk thread was passed through the septum and the diverticular orifice and tied tight in order to cut through. In a third operation a strong curved forceps was applied to the septum and an opening was made by gradually tightening the forceps. Patient left hospital with 200 c.c. residual urine and cystitis. When seen 18 months after operation cystitis was still present. At postmortem, according to Lennander²³ the left kidney was found to have double pelvis with two ureters which ended in the diverticulum. The right ureter and the urethra were found in the bladder proper. Abscess in kidney.

(i) Suprapubic drainage.

Englisch's²⁴ case: Male, aged 60. Prostate somewhat enlarged, particularly the middle lobe. Diverticulitis. Suprapubic cystotomy; drainage of diverticulum for seven months; pain disappeared but diverticulum remained unchanged.

Strauss's²⁵ case: Male, aged 29. Frequent urination for years, worse

since age of 27. Suprapubic incision disclosed two thin-walled sacs communicating with the anterior wall of the bladder. Incision of sacs; drainage. Cure. Strauss describes this as a case of triple bladder—a congenital malformation. Englisch (*l.c.*) comments upon it as a case of diverticula of the bladder.

Fischer's²² case: Male, aged 75. Suprapubic cystotomy; drainage of diverticulum. Improved. Death one year later from uræmia, pyelonephritis.

Wright's²³ case: Male, aged 38. Suprapubic cystotomy revealed a hypertrophied bladder, with which communicated a diverticulum. The latter was four times the size of the bladder and its orifice of communication was near the right ureter. Drainage. Death.

(j) Perineal drainage of diverticulum behind the prostate.

Cholzoff's²⁴ case. Male, aged 26. Cystoscopy; diverticulum on left side. Suprapubic cystotomy and perineal incision; left ureter which terminated in diverticulum was transplanted into an opening made in the bladder; diverticulum drained through perineum; bladder stitched to skin suprapubically. In a second operation an attempt was made to remove the diverticulum, but without success. Through suprapubic cystotomy the mucous membrane at the neck of the diverticulum was then cut through and the edges closed with catgut; suprapubic drainage of bladder and perineal drainage of diverticulum. Sutures gave way and diverticular orifice reopened. In a third operation the suprapubic fistula was closed and an extraperitoneal fistula curetted. All urine passes through perineal fistula.

Etiology and Pathology.—By diverticula are meant those limited protrusions or bulgings of the bladder wall which only affect a small portion of the periphery of the latter.

Of the older writers Heister used the designation diverticulum; Morgagni, Saccus; Walther, hernia vesica; Cruveilhier, hernia tunicaire de la vessie. Of other synonyms can be mentioned vesica bipartiti; vesicæ accessorizæ; cystocele interna (Chopart); vesica supernumeraria, etc.

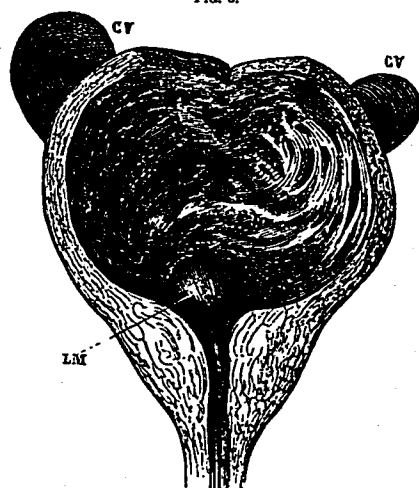
Englisch²⁵ divided diverticula of the bladder into those: (a) whose walls consist of muscular fibres and mucosa (Taschen); (b) whose walls consist of mucosa only (Zellen).

The former variety is also called congenital, the latter acquired diverticulum. Sugimura²⁶ following Aschoff unfortunately uses the terms true and false diverticula in the sense corresponding respectively to "taschen" and "zellen." Orth²⁷ understands by a false diverticulum a perivesical cavity that communicates with the bladder but that has none of the coats

of the latter; it is usually formed by a perivesical abscess that has ruptured into the bladder, and whose walls consist only of dense connective tissue. Such cases have been described by Targett and one reported by Billroth,⁸¹ Voillemier and Le Dentu (cit. by Englisch) used the names *cellules et poches*.

Fano⁸² calls both varieties *cellules vésicales*, and he mentions the following synonyms, *kystes*, *chatons*, *appendices*,

FIG. 8.



Diverticula symmetrically placed with regard to each ureter. (After Fano.)

poches, and *cavités accidentelles*. In his description Fano calls the small depressions little *cellules*, and the two large ones large *cellules* (Fig. 8). Civiale (cit. by Fano) distinguishes between *cellules contractiles* and *cellules non-contractiles* according to the presence or absence of muscular tissue in the wall of the diverticulum.

Targett⁸³ and Harrison⁸⁴ describe *sacculi* and refer to *pouches* as mere depressions. Hodgson⁸⁵ speaks of *pouches* and refers to the *sacculi* as merely the early start of the *pouch*.

Cases similar to the one reported by me in this paper have been described in recent German and French literature as congenital diverticula of the bladder.

The usage of the terms seems somewhat confusing and therefore in the following I apply the term diverticulum to both varieties, simply distinguishing the one with a coat of muscularis and mucosa as a "muscular diverticulum," and the other whose wall has mucosa only as a "mucous diverticulum."

Taschen (the muscular diverticula), according to Englisch, have certain seats of predilection, namely: (1) on the lateral walls of the bladder near the ureteral orifices; (2) toward the base of the bladder above the interureteric bar; (3) at the summit corresponding to the region where the urachus enters the viscus. They occur mostly singly, and most frequently near the left ureteric orifice, but two or more may be present in the same bladder. Englisch ascribes the reason for this predilection to anatomic causes. The longitudinal muscle bundles on both sides of the urethral orifice leave a space free, which is only covered by the circular and oblique muscle bundles—a locus minoris resistentia—and in case of intra-uterine obstruction to the outflow of urine, a diverticulum may develop at this weak spot. Englisch^{31 32} has repeatedly observed such obstructions in the new-born, often due to agglutination of the epithelial lining of the urethra. If the obstruction is merely of short duration the wall may just become pushed out a little at this spot, sufficient, however, to lessen its power of resistance. The further development may occur later in life, when again obstruction to free micturition arises, causing hypertrophy of the bladder wall and the formation of the diverticulum. Such development of the diverticulum may also take place without hypertrophy of the bladder wall. Where the diverticulum is congenital, the bladder is rarely found trabeculated. When a diverticulum is present in a hypertrophied bladder, trabecula may also be present in the diverticulum. Another seat of predilection is the top of the bladder. Two different types may develop here. The one consists of a dilatation of the vesical end of the urachus, which has remained patent. It has thin walls of circular and longitudinal muscle-fibres, and a mucous lining bearing more resemblance to a serous membrane. Its form is apt

to be cylindrical. The other type is a dilatation of the upper part of the bladder close behind the urachus; the formation of this Englisch explains as being due to the longitudinal muscle bundles immediately surrounding the region of the implantation of the urachus having thinner and wider meshes, while the circular fibres seem more strongly developed. The least frequent seat of the muscular diverticulum is above the interureteric bar, where they are found mostly in the presence of hypertrophy of the bladder in consequence of an enlarged prostate. The width of the diverticular orifice varies from 1 to 10 cm.; the thickness of the margin of the opening from 1 to 8 mm. The orifice may be circular or oval. This variety of diverticulum has been observed as large as six times that of the normal bladder.

Zellen (the mucous diverticula), according to Englisch, are of relatively common occurrence, as they come on in consequence of those disturbances to the outflow of urine, with which is connected hypertrophy of the muscular bladder wall—most frequently hypertrophy of the prostate. The depressions between the hypertrophied muscle bundles or trabecula correspond to the interstitial connective tissue. Early in its development the mucous diverticulum may have in its wall, beside the mucous membrane, the outer muscular layer of the bladder, but with the growth of the sac the muscle fibres are pushed aside and the wall consists of mucosa only, with muscle fibres around its neck and a little beyond. The width of the orifice of the diverticulum varies from 2 mm. to 2 cm. or more. In size these diverticula range from that of a pea to the size of the bladder or larger. It may occur singly or in large number; Englisch has seen a bladder with 40 diverticula, of which 28 contained calculi. This form does not show the regularity in distribution of the former variety. It is, however, mostly formed on the posterior wall from above the interureteric bar toward the summit, and on the side walls above the ureteral orifice toward the summit. It is rarely found on the anterior wall.

Targett²² describes sacculi as protrusions of mucous membrane through the muscular coat of the organ in consequence of some mechanical obstruction to the outflow of urine. They occur mostly singly, but two or three may be present. If two are present they are often symmetrically placed with regard to each ureter (Fig. 8); such a case is also reported by Sugimura.²³

They have narrow mouths and may occur at any part of the bladder except the trigone, but are most frequently met with toward the base. The explanation may be that the felting of the muscular fibres is here most interrupted by the entrance of the large vesical arteries. Targett demonstrated a specimen in which the right ureter terminates in the sacculus, owing to its formation at the spot where the ureter perforates the vesical wall, and the gradual shifting of its orifice.

Pouches, according to Targett, consist of an irregularly shaped protrusion of all the vesical coats more or less thinned by distention. They have wide mouths, and not infrequently result from the pressure of a vesical calculus.

Harrison³⁴ gives as causes for the formation of sacculi (1) intra-uterine, (2) obstacles to micturition, (3) traumatic. He describes pouches as mere depressions in the most dependent portion of the bladder in which the whole thickness of the wall is involved.

Buckston Browne³⁵ suggests the following division: (1) the ordinary sacculi, (2) the post-trigonal pouch, and (3) the post-prostatic or trigonal pouch. Both the latter varieties usually hold calculi. Browne reports cases of post-prostatic pouches of considerable size containing calculi.

Hodgson³⁶ explained the formation of pouches as follows: In cases of long-continued obstruction to free evacuation of the urine, the bladder becomes gradually dilated as the amount of residual urine increases in quantity, and the muscular coat is hypertrophied in proportion as the impediment to free micturition progresses. As the musculature becomes hypertrophied, the fibres gather into bundles between which are seen depressions of the mucous lining when the viscus is contracted. If the obstruction continues to advance, the residual urine to accumulate in larger quantities than is consistent with further general dilatation of the viscus, and the muscular coat begins to act with increased power, the efforts to micturate unavailing to expel the whole of the fluid forward cause the expulsive force to act on the bladder. The residual urine now dilates the little depressions by degrees into pouches, which become larger and larger as the disease progresses, until they may attain even the size of a man's fist. This process extends over a long course of time. Internally, each pouch is lined with the displaced mucous membrane; exter-

nally, its wall is formed by submucous fibrous tissue, thin and dilatable when the sac is small, hard, gristly, and resistant for the most part when large. In addition there is a peritoneal covering where this membrane is reflected. Generally speaking the size of the pouches is in inverse ratio to their number, being either small and numerous or large and few.

Young⁸ found that in all of the cases that had come under his observation, either operated upon by him or seen post mortem, the walls of the diverticula contained muscle in varying degree, even in those due to obstruction late in life.

The largest diverticulum on record is that reported by Warren Greene.⁴⁰ Male, aged 84. Prostatic hypertrophy. Post-mortem revealed a hypertrophied bladder communicating through an opening on its left side with a diverticulum which held about one gallon of limpid urine. There was no muscular tissue in the wall of the diverticulum.

The following interesting case of Holmes⁴¹ is included here because it shows that a mucous diverticulum may also form in utero. In a newborn, otherwise well-built boy was found a protruding belly. Death in eight days. Postmortem showed great defect in the musculature of the belly. The kidney substance, particularly on the left, had greatly disappeared, and the ureters were distended and tortuous. The bladder consisted of two sacs, of which one had the ureteral orifices and the urethra, which were patent. The wall of the bladder proper was greatly hypertrophied—three times thicker than normal. The second sac, occupying the right side of the pelvis directly under the skin, was round and of the size of the bladder, with which it communicated through an opening half an inch wide. Its wall was thin and had not a trace of muscle fibres. Cause of death said to be obstruction to urination.

The conclusions, in regard to the etiology, to be drawn from the foregoing are that both the muscular and the mucous diverticula may form before birth and also that they may both develop later in life; but in either instance they are formed in consequence of some obstacle to the outflow of urine.

The presence of muscle in a large diverticulum does not seem to be a proof of the congenital origin of the latter, as maintained by Englisch and others, because muscle tissue has been found present in large acquired diverticula. The termination of one of the ureters in the diverticulum is by some

considered a proof of the anomaly being congenital. The specimen demonstrated by Targett, however, shows the ureter terminating in a diverticulum due to obstruction to micturition caused by an enlarged prostate.

In my own case it is possible that the fibrous changes in the neck of the bladder have been the slow cause of the trabeculation of the viscus and of the formation of the diverticulum. The trabeculation of the bladder proper, the absence of trabecula in the diverticulum, and the shape of the orifice of communication would rather be in favor of the view that the diverticulum has originated late in life. The almost straight lower margin of the diverticular orifice suggests that that shape has been determined by a hypertrophied bundle of muscle, and that the formation of the diverticulum therefore has taken place secondarily to the trabeculation caused by the obstacle to urination. If that is the case the vesical end of the ureter has simply become gradually shifted into the diverticulum in the course of its development by pressure. The anomaly, however, may have been congenital in the sense regarded by Englisch.

An entirely different view is taken by Pagenstecher, who considers the muscular diverticulum an anomalous embryonal development—due to a superabundance of tissue. There are apparently no better proofs for the theory advanced by Pagenstecher than for the former.

Inflammation is a grave complication in case of diverticulum. Cystitis may be primary and extend into the sac, causing diverticulitis or *vice versa*. Most diverticuli have thin walls and little if any power of contraction. If the sac is dependent and the orifice of communication with the bladder small, stagnation is favored, and with inadequate drainage the pathologic process is progressive. Peritonitis or pelvic abscess may follow diverticulitis, and thrombosis of vessels may occur as reported in a case by Murchison.⁴³ A large diverticulum may compress surrounding organs and cause damage, particularly to the ureters, and in consequence to the kidneys, causing hydronephrosis, later by ascending infection pyelo-

nephritis and pyonephrosis. Calculi are at times found in the diverticula and cases of new growth in the sac have been reported by Targett,⁴⁴ Young,⁴⁵ and Perthes.⁴⁶

Symptoms.—A diverticulum may be present in the bladder without giving rise to symptoms, and it may be accidentally discovered postmortem. There is no pathognomonic symptom of this disorder, but the most characteristic one is perhaps that the patient after urination feels as if the bladder had not been completely emptied, and he is able almost immediately to repeat the act, voiding a considerable quantity. This is explained by Hodgson in the following way: The orifices of the vesical pouches are bounded on all sides by bundles of muscular fibres, very much hypertrophied. When the bladder is filled with fluid the hypertrophied muscle bundles are flattened out over the surface, and the orifice of the pouch is rendered patulous. As the urine is being expelled, the general muscular coat performs active contraction, its fibres aggregate themselves into separate bundles, which are gradually approximated to each other, those of them which bound the orifices of the pouches acting as sphincters and shutting up a certain quantity of urine, which is poured into the pouches in the reaction backward of the expulsive force due to the obstruction in front. Thus the diverticulum is filled with urine and its neck is simultaneously closed by contracting muscle bundles. After the urine has been evacuated from the bladder the contracting muscular coats relax and the urine confined in the diverticulum flows out.

Sometimes there is painful urination, particularly in large diverticula. In several instances tumor has been felt above the symphysis or per vagina or rectum. However, it is with the advent of complications, especially inflammation, that a diverticulum gives rise to symptoms. Cystitis and diverticulitis is the most frequent complication and is accompanied by the usual train of symptoms, *i.e.*, painful and frequent micturition of turbid, sometimes stinking, urine. Hæmaturia may appear early before diverticulitis is present, due, perhaps, to circulatory disturbances from distention. In my own case

there was early in the history a diverticulitis of a more chronic type, with periodical discharge of large quantities of slimy pus, followed later by an acute exacerbation. Sometimes, in a case of long standing, the secondary kidney disorder may overshadow the bladder trouble.

Diagnosis.—The introduction of a catheter immediately after the patient has urinated will usually disclose a considerable quantity of residual urine. By the aid of the cystoscope the opening into the diverticulum may be found, and a ureteral catheter may be introduced into the latter to roughly estimate the depth. If the opening into the sac is sufficiently large, the cystoscope can be introduced through it and the interior of the sac inspected. The diverticulum may be measured with my rubber bag as described above, and then palpated bimanually while distended. Radiographs taken in lateral and frontal view, after filling the bladder with a 5 or 10 per cent. collargol solution, are of the greatest value, especially where cystoscopic examination cannot be carried out.

Prognosis.—According to Englisch the mortality rate in cases of diverticulitis is 83.1 per cent. The results of palliative treatment and operative treatment other than radical operation have not been encouraging. In the fifteen cases radically operated upon there has been one death.

Sex.—Most cases of vesical diverticula reported have occurred in males, but there are several cases of diverticula in females on record. A very large diverticulum was found postmortem in a woman 59 years old, reported by Hofmohl.⁴⁷

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