ARTIFICIAL URINARY BLADDERS:

the present position

By DAVID ANNIS, Ch.M., F.R.C.S.Eng.

Liverpool Royal Infirmary

In order to divert urine from the bladder it has been the usual practice either to implant the ureters into the large bowel, or to bring them to the skin. During the last 40 years ureterocolic anastomosis has taken precedence over cutaneous ureterostomy and it has long been a standard operation in surgery. Throughout this period, however, there are to be found occasional reports of attempts to create an artificial bladder able to contain urine uncontaminated by contact with the exterior or with the bowel. It seems likely that by 1910 most, if not all, of the possibilities had been considered and some had been put to experimental and to clinical trial. Because of the technical difficulty of many of them they found no real place in surgery. However, with the advances in surgical technique during the last decade, some of these operations have been rediscovered and used successfully. Sufficient experience of some of them has now been gained to be able to give an interim report on their usefulness.

An artificial bladder may be created either to replace the urinary bladder entirely or to replace a part of the bladder in order to increase its capacity. This may be necessary because a part of the bladder has been removed, or because the bladder has become shrunken by disease.

Total Replacement of the Bladder

Total replacement of the bladder by some form of artificial receptacle may be considered as an alternative choice whenever ureterocolic anastomosis or cutaneous ureterostomy is contemplated. It is probable, however, that there is very little to justify the construction of an artificial bladder for many patients who have carcinoma of the bladder. In the series of 1,673 patients having ureterocolic anastomosis analysed by Jacobs and Stirling (1952) carcinoma of the bladder accounted for 1,181. Of these, 476 had palliative procedures. For many of the patients the prognosis is so poor that it may be that nothing more than ureterocolic anastomosis is called for. However, some tumours of the bladder requiring total cystectomy may yet

be of a low grade of malignancy and may not have infiltrated deeply into the bladder, and it is especially disappointing to see a patient who has such a tumour die from some complication of the ureteric transplantation without evidence of recurrence of growth. For these patients and for the younger patient who may be expected to have many years of life ahead of him it may be safer to direct the ureters into some form of artificial bladder, separate from the bowel content.

When the need for urinary diversion arises out of a non-malignant disease such as ectopia vesicae or because of neurogenic incontinence in children afflicted with spina bifida or other deformities, then some form of artificial bladder may be the most satisfactory arrangement. For many patients with neurogenic urinary incontinence ureterocolic anastomosis cannot be satisfactory because of associated rectal incontinence or sphincteric weakness sufficient to control the normal motion but incapable of holding back the fluid faeces that result from ureterocolic anastomosis.

Whilst these children remain incontinent of urine many of them are stinking, bedfast, and socially isolated, and in consequence their education suffers. An artificial bladder may make all the difference to them, for when they are dry it is possible to fit any necessary leg splints or supports so that they may get about unaided. Many of them may then take their place in ordinary schools. There are a sufficient number of reports to enable one to say that for neurogenic incontinence, an ileal bladder is most satisfactory and it has proved in many cases to bring a quite dramatic change in the outlook for these children.

For ectopia vesicae the choice between an artificial bladder and colonic transplantation of the ureters still remains. It is true that over the last 40 years some of these children have survived ureterocolic anastomosis for many years and many have passed beyond childhood, yet there has been a steady toll from complications of the anastomosis itself. Many of these children suffer chronic ill health and all develop some degree

renal damage and destruction as a direct consequence of the anastomosis. It remains to be seen whether the formation of an isolated artificial bladder will result in less renal damage over the years. The early reports suggest that it will.

There are other circumstances that preclude the implantation of the ureters into the colon. The rectum may have been removed together with the bladder in the operation of pelvic evisceration. A wet colostomy is rarely satisfactory. Again, with inoperable recto-vesicovaginal fistula, rectal continence cannot be achieved. Here, too, the ureters may be directed into an artificial bladder. Once urinary leakage ceases it is usually possible to prevent faecal soiling in these patients simply by giving an enema each day.

When the ureters to be transplanted are grossly dilated and more particularly when there is only one remaining hydronephrotic kidney, it is especially dangerous to implant the ureter into the intact colon. The likelihood of thereby accelerating renal damage is considerable. There is a special place, here, for the construction of an artificial isolated bladder.

For an artificial bladder to be satisfactory it must allow of the accumulation of urine in sufficient quantity to prevent overfilling and yet it should require emptying only at reasonably convenient intervals. Especially is this important at night so that the patient may sleep without interruption. It should not require the use of a tube or catheter for drainage, because repeated catheterization usually results in infection ascending to the kidney, in many ways comparable to that which follows ureterocolic anastomosis.

Many ingenious efforts have been made to create a satisfactory artificial bladder. Probably the earliest attempt used the vagina as a urinary receptacle. The ureters were implanted into it and the orifice narrowed to gain some degree of continence. Indeed, this operation was devised before that of colonic transplantation of the ureters.

During the last 50 years two main lines have been followed. Some have attempted to construct a bladder using an isolated segment of the intestine. For this purpose lengths of colon, rectum and ileum have been used. The ileocaecal region has also been isolated and utilized as a urinary receptacle. These internal bladders have usually been brought to the surface and a stoma formed through which urine may drain or through which a catheter may be introduced at intervals. However, attempts have been made in a few instances to drain such a 'bladder' through the urethra and thereby to establish a normal means of micturition. Thus Pyrah and Raper (1955) have described an operation in which the ureters are

FIG. 1.—Total replacement of the bladder using an ileal loop.

implanted into an isolated length of ileum which is anastomosed to the divided prostatic urethra (Fig. 1). Their patients have achieved something very closely akin to normal micturition. Similarly, Giertz (in press) has anastomosed an isolated length of sigmoid colon to the prostatic urethra.

The second approach has been to concentrate upon methods by which urine may be rapidly and uninterruptedly carried to a simple stoma so constructed that it will not narrow at the skin surface. A watertight and comfortable collecting bag is applied over the opening. Here the surgeon is concerned with the construction of a satisfactory conduit. The artificial bladder is an external appliance.

Some of these operations have been done so infrequently that it is impossible to assess their worth. Where sufficient numbers have been done to give an indication of the value of the operation, too little time has passed to say anything of the long-term results. It is possible, then, to give only an interim report on the more frequently performed operations.

The Isolated Ileocaecal Bladder

Verhoogen reported one such operation in 1908 in which he used the stump of the appendix for catheter drainage and there have been a number of reports of similar operations using the ileal limb as the route of drainage (Fig. 2) (Gilchrist and Merrick, 1950; Gregoir and Van Wein, 1955; Moore, 1953). It was hoped that the ileocaecal valve would act to maintain continence and that

FIG. 2.—The isolated ileocaecal bladder.

the bladder could be drained intermittently by catheterization. A trial of this operation was reported by Bricker (1950). He abandoned the operation in favour of ileal ureterostomy with external collection of urine. It is now generally agreed that the preparation of an ileocaecal bladder may carry a high immediate mortality and that repeated catheterization for drainage results in infection ascending to the kidneys. Progressive renal destruction, pyonephrosis and stone formation have all occurred after this operation with a frequency probably no less than that following ureterocolic anastomosis. Moreover, it is now generally agreed that the ileocaecal valve and the peristalsis of the terminal length of ileum are usually inadequate to prevent leakage from the caecal bladder. Repeated catheterization may injure the ileal mucosa and bleeding may occur. Stricture at the ileocutaneous junction is a common sequel to repeated catheterization. The isolated ileocaecal bladder has proved to be unsatisfactory and it should not be used.

Artificial Bladder from an Isolated Length of the Pelvic Colon

The pelvic colon is isolated with its blood

supply intact and the continuity of the large bowel restored by end-to-end anastomosis. The upper end of the isolated loop is closed and the lower end brought out as a colostomy. The ureters are implanted into this isolated pouch. Although the pouch has a capacity roughly comparable to that of a urinary bladder there is no sphincteric mechanism at the colostomy. Urine drains freely through the opening into a flanged adhesive bag.

Although technically simpler than the isolated ileal bladder, the pelvic colon is not always sufficiently mobile to reach across to the right ureter at the pelvic brim. The surgeon who hopes to do this operation must first make certain that the pelvic colon is anatomically suitable. If it is found not to be so, some other form of artificial bladder should be fashioned.

Few of these operations have been done and no final assessment of their worth can be made.

Implantation of the Ureters into the Isolated Rectum: Proximal Colostomy

This operation was suggested by Kroenig in 1907. Pyrah (in press) has recently described his experience with it. The pelvic colon is divided and the distal opening is closed, thereby isolating the rectum with its sphincteric mechanism intact.

FIG. 3.—Implantation of the ureters into the isolated rectum.

The pelvic colon is brought out as a colostomy. The ureters are implanted into the isolated rectum (Fig. 3). Kinman *et al.* (1953) gave an account of their experience with the operation and they were of the opinion that it overcame the dangers of ureteric implantation into the intact bowel.

Levitsky (1953) performed a similar operation, but instead of bringing the sigmoid colon out to form an inguinal colostomy he mobilized it and took it behind the isolated rectum, through an incision in the posterior rectal wall and out through the anal sphincter. Continence of both urine and of faeces was achieved. Lowsley (1955) has described a somewhat similar operation in which the colostomy is brought out through the anterior part of the anal sphincter into the perineum. Equally good results were obtained.

It is, of course, essential to ensure that there is adequate rectal control before doing these operations. The obvious disadvantage of Pyrah's operation is that the patient must suffer the inconvenience of a colostomy in return for a continent artificial bladder. Pyrah, who favours this form of artificial bladder in certain patients, says that the management of the colostomy need not be of any great inconvenience to the patient and less inconvenient, he feels, than some forms of urine-draining enterostomy.

The operation has certain definite advantages: Firstly, it eliminates the need for a bowel anastomosis to restore intestinal continuity—an essential of all the other procedures using isolated lengths of intestine; secondly, the ureterocolic anastomosis is simpler, following the ordinary lines of ureterocolic anastomosis to the intact bowel.

Again, few operations of this sort have been done, but the early results are excellent. Complete isolation of the urinary stream with mucosa-to-mucosa anastomosis between ureters and rectum should offer minimal opportunity for renal infection and destruction.

Ileocutaneous Ureterostomy

This operation was first performed by Schoemaker in 1909. Recently it has been rediscovered and a considerable experience of its use has been gained, notably by Bricker (1954), Pyrah (1954), Cordonnier (1955) and Annis, Hunter and Wells (1954).

An isolated length of 8-10 inches of the terminal ileum is closed at its proximal end. The distal end is brought out on the abdominal wall in the right lower quadrant. An accurate ileocutaneous union is made so that the everted ileum projects about three-quarters of an inch from the abdominal wall. The ureters are implanted into the ileal segment as they cross the pelvic brim (Fig. 4). Urine is collected in a flanged adhesive bag

FIG. 4.—Ileocutaneous ureterostomy.

similar to that used by patients who have had an ileostomy for ulcerative colitis.

With a careful technique it is possible to secure an accurate mucosa-to-mucosa union between the ureters and the ileum. The projecting end of the ileal segment should be everted and sewn directly to a circular opening in the skin. Fibrosis and stenosis are thereby minimized.

A sufficient number of reported cases are available for an assessment of the method. Bricker (1954) was able to report the results of 106 of these operations, many of which were done five years earlier. Annis (*in press*) analysed the results of 58 ileal ureterostomies done during the preceding four years. At the annual meeting of the British Association of Urological Surgeons in Liverpool in June 1956, Wells (*in press*) incorporated these in an analysis of data on 212 patients operated on by members of the association.

All these reports and others indicated that, so far, the results are better than those obtained with any form of ureteric implantation into the intact colon.

The well-recognized complications of ureterocolic anastomosis—pyelitis, renal dilatation and hyperchloraemic acidosis—have occurred far less frequently in all the published series of ileocutaneous transplantation of the ureters. In our own series of 58 patients, clinically obvious pyelitis

FIG. 5.—Ileocystoplasty without ureteric transplantation.

occurred in only three patients, and in two there was some obstructive cause. In the third, an infected and dilated ureter was transplanted: pyelitis persisted for three weeks and then cleared and did not return.

Hydronephrosis following a direct mucosa-to-mucosa union between ureter and ileum occurred only very occasionally. Many dilated kidneys were reduced in size and a number of kidneys showing no radiologically demonstrable function before operation showed marked improvement.

Hyperchloraemic acidosis occurred much less frequently than after ureterocolic anastomosis. It was of only a mild degree and has not given rise to any clinical distress.

Within the limits set down earlier in this paper ileocutaneous ureterostomy appears, so far, to be a safe and satisfactory procedure and should replace ureterocolic anastomosis.

Partial Replacement of the Bladder

A bladder of intolerably small capacity may result from tuberculous or non-specific inflammation—the so-called interstitial cystitis—or it may be the consequence of partial excision of the bladder for tumour. In either circumstance it may be desirable to increase the capacity of the bladder by enlarging it with a segment of the intestine.

The most pressing problem arises in the patient who has had one kidney removed for tuberculosis and who has a small, healed and contracted bladder. The intramural fibrosis may also result in narrowing of the remaining ureter and pro-

FIG. 6.—Uretero-ileoplasty.

gressive hydronephrosis. Frequency of micturition is the troublesome symptom, but progressive renal distension is the danger to life. The small capacity of the bladder and the ureteric stenosis may be simultaneously corrected by the use of an intestinal segment—usually an ileal loop—interposed between the dilated ureter and the contracted bladder.

Two main types of operation may therefore be used:—

Ileocystoplasty without Ureteric Transplantation (Fig. 5)

There are a number of excellent reports of the use of this operation by Scheele (1923), Couvalair (1951), Cibert (1953) and Pyrah (1955).

Both the small and the large intestine have been used, but a segment of the terminal ileum seems most suited to the purpose because it has been found to retain its ability to contract and to empty vigorously in response to the stimulus of overfilling.

A length of 6-8 inches of the terminal ileum is isolated with its blood supply intact. The two open ends are then closed and the bladder is anastomosed to the centre part (Fig. 5). Occasionally it has been found that the stoma so formed has become plugged with intestinal mucus and for this reason it may be better to close the proximal end of the loop and anastomose the distal end directly to the bladder (Fig. 6).

FIG. 7.—Ileal sheet graft.

Tasker (1953) has described a technique in which the ileal segment is split along its anti-mesenteric border and the opened-out 'patch' of ileum is used to refashion the fundus of the bladder, and some excellent results of this operation have been recorded (Fig. 7).

Scheele's (1923) 'ring-plastik' is made by joining together the open ends of the ileal loop. The ring is then anastomosed to the fundus of the bladder.

It will be seen that there are a number of differing techniques and it is not yet possible to say which gives the best result. Taking the group as a whole, one can say that the early results are very satisfactory, but it is too soon for a proper assessment to be made. Many patients have been completely relieved of pain and intolerable frequency of micturition. Two minor inconveniences have been noted. Intestinal mucus is passed in the urine and very occasionally there may be difficulty in expelling it. Some patients find that they must wait for a moment after the main flow to pass a second smaller quantity of urine, in order to empty the 'bladder' completely.

Couvelaire and Cibert, both of whom have a wide experience of these operations, recommend that, for the tuberculous contracted bladder, part

of the thickened fundus should be excised and replaced by the ileal graft.

Uretero-ileoplasty

Where the contracture of the bladder has resulted in intramural occlusion of the ureter the bladder should be enlarged and the ureter re-implanted, by interposing a length of ileum between the dilated ureter and the bladder.

Often in these cases nephrostomy or ureteros-tomy has been done as an emergency measure to preserve failing renal function, and in a number of patients the use of the ileal bridge has resulted in rapid closure of these unpleasant fistulae.

Wells (in press) has recently reported an analysis of 56 uretero-ileoplasties done by members of the British Association of Urological Surgeons. The early results of this operation are excellent. Renal function is usually improved or, at least, maintained and a number of patients have been able to exchange disabling frequency of micturition for something closely akin to normal micturition.

Summary

There is a place in surgery for the construction of an artificial receptacle to replace the bladder as an alternative to ureterocolic anastomosis or to cutaneous ureterostomy.

It is especially useful for patients with non-malignant diseases where the outlook for life is good. Ureterocolic anastomosis cannot offer these patients a sufficient chance of trouble-free survival. It seems likely, from the early reports, that an isolated intestinal bladder will be more satisfactory. Where there is associated rectal incontinence, ureterocolic anastomosis is completely contraindicated. An isolated intestinal bladder is especially useful in these cases. Certain selected patients undergoing cystectomy for carcinoma vesicae may benefit from the construction of an artificial bladder.

The various types of artificial bladder, with both internal and external drainage, are described and their value assessed.

The operations for partial replacement of the bladder, particularly those using isolated segments of ileum, are described and their value is assessed.

I am indebted to Miss Barbara Duckworth for the excellent line drawings.

BIBLIOGRAPHY

- ANNIS, D., HUNTER, W. R., and WELLS, C. A. (1954), *Brit. J. Surg.*, **42**, 290.
 BRICKER, E. M., and EISEMAN, B. (1950), *Ann. Surg.*, **132**, 77.
 BRICKER, E. M., BUTCHER, M., and MACAFEE, C. A. (1954), *S.G.O.*, **99**, 469.
 CIBERT, J. (1953), *J. Urol.*, **70**, 600.
 CORDONNIER, J. J. (1955), *J. Urol.*, **74**, 789.

Continued on page 77.

latter points, however, could not be confirmed. Puberty occurred before the age of 14½ years in 91 per cent. of the present series and the mean height of the 101 females who developed anorexia nervosa was 63.80 inches (S.D. 3.07), which did not differ significantly from the mean of the standard heights, which was 61.92 inches (S.D. 2.58) (Kemsley 1952). The cause of obesity during adolescence may well be an imbalance of the endocrine function. At the same time there does not appear to be sufficient evidence that anterior pituitary deficiency is an aetiological factor in anorexia nervosa, although it is probable that hypofunction of the anterior pituitary occurs soon after the disease is established. The clinical manifestation of this is the early appearance of amenorrhoea in the majority of cases.

When the duration of the disease is known, it appears that there is a significant difference in the rate of weight loss in fatal and non-fatal cases. From the figures available, the non-fatal cases lose weight at the rate of 1.25 per cent. of their body weight per month, in contrast to the fatal cases which lose 3.5 per cent. of their body weight per month. The rate of weight loss, however, is inconstant, except possibly in the early stages of the disease. This is true particularly in the non-fatal cases of long duration, where the rate of weight loss diminishes or even ceases after a varying period of time. This is one of the factors which accounts for the lack of a simple relationship between the duration of the disease and the maximum amount of weight lost. There is no doubt, however, that cases which lose weight rapidly in the early stages often die, but how this rate of weight loss compares with that in non-fatal cases over the same period of the disease is still to be determined.

Throughout this work the return of normal menstruation has been taken to signify the end of the disease. From the available figures it appears that the weight of patients at this time is significantly lower than normal. Amenorrhoea therefore, is not only an early symptom in the majority of cases but the return of normal menstruation is an early sign of recovery, often occurring before the patient has regained her standard weight. If any error has been incurred by taking return of men-

struation to denote the patient's return to normality, it is probably only slight, tending to underestimate the duration of the disease.

In common with the findings of other writers (Ryle 1936), a proportion of cases remained underweight for a varying number of years after the periods had returned to normal. It might be thought that these would be more prone to relapse than those of normal weight, but in the 5 cases studied there was no evidence of this.

Conclusions

1. Patients who develop anorexia nervosa are frequently overweight before the onset of symptoms.
2. There is no direct relationship between the duration of the disease and the maximum amount of weight lost.
3. Fatal cases lose more weight and do so more rapidly than those that survive.
4. Patients are frequently below their standard weight when the periods return to normal.
5. The patient's weight a varying number of years after recovery from anorexia nervosa does not differ significantly from normal.

Acknowledgments

I am grateful to the physicians of the Middlesex Hospital for allowing me to study their cases.

This work formed part of a thesis accepted for the degree of D.M. at the University of Oxford.

BIBLIOGRAPHY

- BROSIN, H. W., and APPELBACH, C. (1941), *J. clin. Endocrin.*, **1**, 272.
- DECOURT, J. (1946), *Paris med.*, **36**, 249.
- DECOURT, J., and MICHAUD, J. (1949), *Sem. Hop. Paris*, **25**, 3343.
- FENWICK, S. (1880), 'On Atrophy of the Stomach and on the Nervous Affections of the Digestive Organs,' p. 98, London, J. A. Churchill.
- GEE, S. (1907), 'Medical Lectures and Aphorisms,' 2nd ed., Ch. 6, London, Hodder and Stoughton.
- GULL, W. W. (1874), *Trans. clin. Soc. Lond.*, **7**, 22.
- KEMSLEY, W. F. F. (1952), *Ann. Eugen., Lond.*, **16**, 316.
- MORTON, R. (1694), 'Phthisiologia, or a Treatise of Consumptions,' p. 4, London, S. Smith and B. Walford.
- OSGOOD, E. E. (1938), *Endocrinology*, **23**, 656.
- RYLE, J. A. (1936), *Lancet*, **ii**, 893.
- SHELDON, J. H. (1937), *Lancet*, **i**, 369.
- WHYTT, R. (1768), 'The Works of Robert Whytt,' p. 598, Edinburgh, T. Becket and P. A. De Hondt.
- Details of the cases quoted from the literature may be found in the author's D.M. thesis (Oxford, 1954).
- COUVELAIRE, R., (1951), *J. Urol. med.*, **57**, 530.
- GILCHRIST, R. K., MERRICKS, J. W., HAMLIN, H. H., and RIEGER, I. T. (1950), *S.G.O.*, **90**, 752.
- GREGOIR, W., and VAN WIEN, A. (1955), *Acta. Urol. Belg.*, **23**, 72.
- JACOBS, A., and STIRLING, W. B. (1952), *Brit. J. Urol.*, **24**, 259.
- KINMAN, F. M., SAUER, D., HOUSTON, V. T., and MELICK, W. F. (1953), *Arch. Surg.*, **66**, 531.
- KROENIG, (1907), *Zbl. Gynak.*, **31**, 559.
- LEVITSKY, V. (1953), *Amer. J. Surg.*, **85**, 91.
- LOWSLEY, O. S., and JOHNSON, T. H. (1955), *J. Urol.*, **73**, 83.
- MOORE, T. (1953), *Lancet*, **i**, 1176.
- PYRAH, L. N., and RAPER, F. P. (1955), *Brit. J. Surg.*, **42**, 337.
- PYRAH, L. N. (1954), *Ann. roy. Coll. Surg. Engl.*, **14**, 169.
- SCHEELE, K. (1923), *Beitr. z. Klin. Chir.*, **129**, 414.
- TASKER, J. H. (1953), *Brit. J. Urol.*, **25**, 349.
- VERHOOGEN, J. (1908), *Ass. Franc. d'Urol.*, **12**, 362.

Bibliography continued from page 59—David Annis, Ch.M., F.R.C.S.Eng.