Urinary diversion in children

JOHN E. S. SCOTT

From the Department of Surgery, University of Newcastle upon Tyne, Royal Victoria Infirmary, Newcastle upon Tyne

Scott, J. E. S. (1973). Archives of Disease in Childhood, 48, 199. Urinary diversion in children. A series of 60 children subjected to urinary diversion is described. Particular emphasis is placed on the long-term results of 41 ileal conduit operations. The upper urinary tract became dilated postoperatively in 9 children in whom it had been normal preoperatively, dilatation increased in 1 child with only moderate dilatation preoperatively, and the degree of dilatation remained unchanged in a further 9 children who had preoperative dilatation.

Operative and radiological findings suggested that stenosis of the ileal stoma or of the ureterointestinal anastomoses was not the cause of the upper urinary tract dilatation which appeared in most instances only after a period of several years.

Measurement of the pressure changes in the ileal conduit of 11 children selected at random showed that under normal circumstances intraluminal pressure remained low, but that obstruction of the stoma produced an immediate rise in pressure accompanied by strong ileal contractions. It is suggested that intermittent stomal occlusion caused by diversion appliances, clothing, or body posture may, by producing intermittent high pressure in the conduit, result over a period of years in gradual upper urinary tract dilatation.

It is suggested that ureteroileostomy should not be used as a method of controlling urinary incontinence in children with normal upper urinary tracts, and that careful regard should be given to the unsatisfactory results of this operation in some children with deteriorating upper urinary tracts. It is possible that a sigmoid colon conduit may be more satisfactory than an ileal conduit.

Diversion of the urinary stream plays an important role in the management of many congenital disorders of the urinary tract. Among the indications for this type of surgery are urinary incontinence, severe damage to the drainage system from the kidneys, and the necessity for removing the lower urinary tract when it is the seat of malignant tumours. The use of the colon for diversion is a practical proposition only in those children who have abnormalities which do not affect anorectal function, such as ectopia vesicae, epispadias with incontinence, or malignant disease. But even though it enables a child to develop control over the urinary stream, ureterosigmoidostomy has a bad reputation because, in the long term, biochemical disturbances and gradual deterioration in upper urinary tract function may occur in some cases, and, in general there is a preference for surface over intestinal urinary diversion. When the function of the anorectal region is abnormal, such as in neurogenic disorders of the sphincters or rectal agenesis, urinary diversion to the surface is obligatory. Since normal ureters will not reach the surface of the abdominal wall without risk of vascular insufficiency, it is necessary to interpose a length of intestinal tract to act as a conduit. Terminal ileum is most frequently used for this purpose after the method of Bricker (1950), but Mogg (1967) advocated the use of sigmoid colon. When there has been prolonged lower urinary tract obstruction and the ureters are dilated, tortuous, and hypertrophied, it may be possible to bring them to the surface directly as a cutaneous ureterostomy.

Thus the ultimate aim of urinary diversion in children is to control urinary incontinence and prevent progressive deterioration in the health of the upper urinary tract. It is, however, important to be certain that the operation will not damage a normal urinary tract and will result in improved function in the damaged urinary tract. The

Received 20 July 1972.
purpos of this paper is to examine these criteria in the light of results obtained in a consecutive personal series of 60 children subjected to urinary diversion, and to review recent reports on the subject.

Clinical material

22 of the children were male, and 38 female. The ratio of males to females was 1:1.7, which is somewhat lower than in other published series in which there were three times as many girls as boys (Livaditis, 1965; Cook, Lister, and Zachary, 1968; Eckstein and Boyd, 1969). The indication for operation, and the sex distribution are given in Table I which shows that the majority of children in the neurogenic group were girls. The 'other congenital anomalies' comprised 1 boy with gross congenital upper urinary tract dilatation and ureteric reflux without urethral obstruction, and 1 girl with a congenitally short, incompetent urethra and absent vagina. The children with ectopia vesicae were subjected to urinary diversion because their bladders were small and unsuitable for closure, because they had increasing dilatation of their upper urinary tracts, or because they were suffering from hopeless urinary incontinence after bladder reconstruction.

Table II shows the techniques used. Diversion by means of an ileal conduit was performed in 41 cases.

<table>
<thead>
<tr>
<th>TABLE II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary diversion: technique</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Ileal conduit</td>
</tr>
<tr>
<td>Ureterosigmoid</td>
</tr>
<tr>
<td>Colon conduit</td>
</tr>
<tr>
<td>Ureterostomy</td>
</tr>
<tr>
<td>(a) unilateral</td>
</tr>
<tr>
<td>(b) bilateral midline</td>
</tr>
<tr>
<td>(c) bilateral, with Yanast</td>
</tr>
<tr>
<td>(d) temporary</td>
</tr>
</tbody>
</table>

The 4 ureterosigmoidostomies included 2 children with ectopia vesicae and 2 with malignant pelvic tumours. Colon conduits were used in 2 children. One had had a ventriculoperitoneal shunt for hydrocephalus carried out previously, and it was found at operation that the terminal ileum was involved in a mass of adhesions around the catheter at the peritoneal end of the shunt. A coloneourethrostomy (Grant, 1964) for ectopia vesicae had been performed previously at another hospital in the second child, and on referral to the author there was gross dilatation of both sides of the upper urinary tract. Revision was achieved by excising the bladder and anastomosing the ureters to the colon conduit which had been constructed at the previous operation.

The majority of ureterostomies were constructed with a single 'trouser leg' stoma located in the midline between the umbilicus and symphysis pubis, a technique that produces a satisfactory stoma in a position where it is easy to fit a collecting appliance.

Fig. 1 shows the age at operation. 11 children were operated in the first year of life and the majority of these had ectopia vesicae. 63% were operated before the age of 5 years.

<table>
<thead>
<tr>
<th>TABLE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary diversion: state of upper tract at operation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Table III shows the state of the upper urinary tract at the time of operation. There were only 12 children in the spina bifida group whose upper tracts were normal, a measure of the author's reluctance to perform urinary diversion on the grounds of incontinence only.
A total of 39 (65%) children had dilated upper urinary tracts and of these 30 were bilateral. One child who had a ureterosigmoidostomy performed during removal of a malignant bladder tumour subsequently required conversion to an ileal conduit because of increasing upper urinary tract dilatation.

The immediate postoperative complications are shown in Table IV. There were 2 (3.4%) cases of intestinal obstruction requiring laparotomy for the division of adhesions. When the adhesions were divided in one of these cases a leak appeared from one of the ureteroileal anastomoses and it was necessary to refashion it. One child developed a faecal discharge from the ileal stoma on the third postoperative day but it ceased spontaneously after a further week. Two abdominal incisions dehisced; both were in babies with ectopia vesicae operated at the age of 3 months. Paramedian incisions had been used, and as a result of this disaster all subsequent children with ectopia vesicae were operated through oblique incisions in the left abdominal wall. There were no further instances of dehiscence. There were no deaths in the early postoperative period and none of the ileal conduits necrosed as a result of inadequate blood supply.

Table V shows the incidence of urinary infection,

TABLE IV

<table>
<thead>
<tr>
<th>Urinary diversion: immediate postoperative complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>Intestinal obstruction</td>
</tr>
<tr>
<td>Urinary leak</td>
</tr>
<tr>
<td>Burst abdomen</td>
</tr>
<tr>
<td>Faecal fistula</td>
</tr>
</tbody>
</table>

which was present preoperatively in virtually every case, the exceptions being those with malignant tumours. At each postoperative outpatient visit urine was sampled and the volume of residual urine measured by passing a sterile size 8 FG infant feeding tube into the ileal or ureteric stoma. Whenever this urine sample produced 100,000 or more organisms per ml on culture, it was assumed that a genuine urinary infection was present even though the child was not having symptoms. In view of the open nature of the drainage system and the fact that Gram-negative organisms usually reside in the small intestinal tract, it is unlikely that infected urine in an ileal conduit would produce symptoms. There seemed no advantage in obtaining urine specimens by the method advocated by Bishop, Smith, and Gracey (1971) since the metal sleeve, which they recommended should be passed into the conduit before introducing the catheter, would be as likely to contain urine from the distal part of the conduit as from the proximal, and thus be contaminated by it. 38 children developed a urinary infection postoperatively, though this occurred once only in 7 children. The remainder required continuous low-dose antibacterial drug therapy in order to prevent organisms reappearing in significant numbers in their urine.

Fig. 2 shows the length of follow-up. 74% of the cases were operated more than 2 years ago. Fig. 3 shows the percentage of spina bifida children with normal upper urinary tracts subjected to urinary diversion per year. It is a measure of the author's increasing uneasiness about the merits of this procedure in children whose sole urinary tract disturbance is incontinence that 7 or more years ago 50% of the children with
spina bifida had normal upper urinary tracts whereas only 12% fell into this category 2 years ago.

Results

The late postoperative complications are given in Table VI. 11 (18%) children developed a

TABLE VI

<table>
<thead>
<tr>
<th>Organic</th>
<th>Ectopia vesicae</th>
<th>Spina bifida</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoma</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Stenosis</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Fistula</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Slough</td>
<td>3</td>
<td>9</td>
<td>2</td>
<td>14</td>
</tr>
</tbody>
</table>

There were 5 deaths in the late postoperative period, 2 of which were due to recurrent malignant disease. A further 2 children died of chronic renal failure between 2 and 3 years after urinary diversion, and 1 infant who had been subjected to a ureteroileostomy for ectopia vesicae died of uncontrollable sepsicaemia after laparotomy for late intestinal obstruction. It was interesting to note that a total of only 28 (47%) children had no postoperative complications of any kind.

The question of upper urinary tract dilatation and its relation to urinary diversion was examined in detail and the findings are set out in Table VII.

TABLE VII

<table>
<thead>
<tr>
<th>Organism</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ectopia vesicae</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Spina bifida</td>
<td>7</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

The preoperative radiological state of the urinary tract was known in all children and all but 4 had postoperative intravenous pyelography (IVP). Of these, one was operated recently and the remainder, who were subjected to cutaneous ureterostomy, died of progressive renal failure between 2 and 3 years after operation.

IVP was usually performed after an interval of 1 year from operation and again after an interval of 3 years. 14 cases with ileal conduits were subjected to a retrograde contrast medium study of the conduit.

There were only 11 children who had normal urinary tracts both before and after operation. 4 of them had ectopia vesicae and 7 spina bifida cystica. There were 37 with preoperative dilatation, of which 28 improved or disappeared postoperatively, but 9 remained unchanged. The outstanding feature, however, was that 10 children developed a significant increase in upper urinary tract dilatation postoperatively. 9 of these had a normal upper urinary tract before operation and all had been subjected to ureteroileostomy. When the time interval between operation and the onset of upper tract dilatation was examined, it was found that in the majority of cases dilatation did not begin until an interval of more than 2 years had passed. Others remained satisfactory for longer periods such as 3 or 4 years and one child did not develop her dilatation until 7 years had elapsed. Thus, in this series, the long-term outcome of urinary tract diversion, when assessed from the
Urinary diversion in children

Discussion

There are numerous published reports on urinary diversion in children using an ileal conduit, and virtually all of them mention the fact that some children had unsatisfactory results with respect to the state of their upper urinary tracts. Most of the reports do not stress this fact, though King and Scott (1962) pointed out that the greater the degree of prediversion upper urinary tract dilatation, the less the chance of improvement in the dilatation postoperatively. They also mentioned that in most instances, ‘deterioration of the collecting systems could not be traced to obstruction at the ileal stoma or at the site of ureteroileal anastomosis’. Because they thought that the dilated ureters were acting as an obstructing segment, they recommended anastomosing the ileal conduit directly to the renal pelvis. There was a high (52%) incidence of stomal obstruction in a series of 70 ureteroileostomy procedures published by Rickham (1964), but he claimed that only 1 child developed dilatation of the upper urinary tract. Smith, writing in 1964 and again in 1972, found that deterioration occurred in 10% of children whose upper urinary tracts were normal preoperatively, and in 25% of those with preoperative dilatation. 60% of the children in this latter group were unchanged. It is interesting that though the number of cases included in the second of these two reports was larger, the follow-up period was considerably longer and the number of unsatisfactory results significantly higher. Further series published by Logan, Scott, and Laskowski (1965), Fonkalsrud and Smith (1965), Bowles and Tall (1967), Cook et al. (1968), McCoy and Rhamy (1970), Malek, Burke, and DeWeerd (1971) all contained a small but significant number of children whose urinary tracts failed to improve or actually deteriorated after ureteroileostomy, and there is a strong impression that the longer the children were followed up, the greater was the number with unsatisfactory results.

This state of affairs has two important implications: firstly, urinary diversion through an ileal conduit, when carried out solely because of urinary incontinence, will produce a significant number of children with gradually deteriorating upper urinary tracts, and secondly, the use of ileal conduit urinary diversion in children with dilated upper urinary tract is no guarantee that the dilatation will improve.

Bad results in surgery immediately suggest bad operative technique. But there is a remarkable uniformity in the techniques described by different authors, and it seems that if a technical error is responsible for the bad results, then it is common

<table>
<thead>
<tr>
<th>Stoma</th>
<th>ileal</th>
<th>ureteric</th>
<th>Conduit</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

were revised because of stenosis caused by epithelialization or because of fistula formation. Four conduits were revised; one was the coloneourethrostomy previously mentioned, the second was an ileal conduit in a baby who had developed late postoperative intestinal obstruction, and two further ileal conduits were explored because of increasing upper urinary tract dilatation. The conduit in one of these children was undoubtedly too long and it was therefore shortened and new ureteroileal anastomoses constructed. A similar operation was carried out in the second case so that wide junctions between the ureters and the ileum were established. It is interesting to note that the original ureteroileal anastomoses in both these children seemed to be patent and that it was easy to pass a probe through them. Furthermore, IVP performed one year after the revision operations did not reveal improvement in the upper urinary tract dilatation.

A nephrectomy was performed in one child for a functionless dilated kidney which had failed to improve after urinary diversion, and a cystectomy was carried out in another child because of persistent infection and discharge in the residual bladder.

TABLE VIII
Urinary diversion: revision procedures

The revision procedures that were necessary in this series are shown in Table VIII. 13 stomas
to operations carried out in many different centres and by many different surgeons. Furthermore, a technical error should cause early rather than late malfunction in the urinary drainage system.

If gradual dilatation of the upper urinary tract is not due to a technical error in the operation, then it might be due to gradual stenosis of the ileal stoma or the ureteroileal anastomoses. That the former can cause obstruction in the drainage system is clear, but under these circumstances the ileal conduit, as well as the upper urinary tract, becomes dilated and elongated, and the condition responds rapidly to revision of the ileal stoma. The latter would produce dilatation of the upper tract only, but the fact that retrograde contrast medium examinations of the ileal conduits show free flow from the conduits into the ureters is against this explanation. Moreover, anastomotic stenosis was not found in the cases re-explored in this series and reanastomosis did not significantly improve the dilatation.

It seems that the cause of this complication must be sought elsewhere. Smith (1972) postulated that the pressure created by peristalsis in an ileal segment might be greater than the pressure produced by the bladder and that this might be responsible for upper tract decompenstion. Minton, Kiser, and Ketcham (1964) carried out a manometric study of ileal conduits and found three predominant types of peristaltic pattern with pressures ranging from 10 to 100 mmHg and correlated these findings with the presence of infection but not the state of the upper urinary tract. In an attempt to find a cause for ureteric dilatation after ureteroileostomy, pressure measurements were obtained from the ileal conduits of some of the children in the present series.

Pressure changes in the ileal conduit. Pressure changes were recorded in 11 children selected at random. A size 8 FG infant feeding tube was passed into the conduit to a depth of approximately 5 cm. This size catheter was selected because it was easy to manipulate into the conduit; finer tubes tended to become caught in mucosal folds. It was noted that the catheters did not obstruct any of the ileal stomas and urine flowed out freely around them. The catheters were connected to a Statham bridge transducer whose signal was amplified by a SE Laboratories (Engineering) Ltd. multichannel amplifier and recorded with an ultraviolet trace.

Recording was continued for 20 to 30 minutes to determine whether there was spontaneous activity in the ileal conduit. The baseline pressure varied between 0 and 10 cm water in all cases except one where it was 15. The only changes in pressure which were noted during this phase were caused by respiration and arterial pulsation, except in one child who produced spontaneous contractions with a low amplitude of between 10 and 20 cm water pressure, a duration of between 4 and 6 seconds, and a frequency of 10 to 14 contractions per minute (Fig. 4).

Then, 20 ml sterile normal saline solution were run into the ileal conduit through the catheter via an intravenous infusion set. At the same time, the stoma of the ileal conduit was compressed digitally so as to prevent the saline from being immediately evacuated. The object of this investigation was to determine whether the isolated length of ileum would contract under conditions simulating stomal obstruction. One child complained of colicky abdominal pain as a result of the fluid infusion but none of the others experienced any discomfort. There was an immediate rise in baseline pressure in all the children though the magnitude of the rise varied from child to child, being as low as 15 to 20 cm in some, and as high as 50 to 60 cm in others.

This rise in baseline pressure was accompanied by slow contractions which produced, in 7 cases, pressures ranging from 65 to 125 cm water. One child had a sustained high baseline pressure

![Fig. 4.—Tracing of pressure changes in ileal conduit when draining freely.](http://adc.bmj.com/content/48/3/199)
of 50 cm with no contractions and 3 others had contractions generating pressures of 30 to 40 cm only (Fig. 5a and b). The frequency of the contractions varied from 1 to 18 per minute, though the mean was approximately 10 per minute. With the exception of the child already mentioned who developed abdominal colic, not even the strongest contractions produced any form of subjective sensation. So long as the stoma was obstructed the contractions continued unabated, though this condition was not maintained for longer than 10 minutes in any of the children. As soon as the stoma was released, fluid ran out around the catheter with the result that the baseline pressure in the conduit fell and the contractions diminished in amplitude and frequency.

It is clear from these recordings that under normal circumstances, ureteroileostomy provides a low pressure drainage system for the kidneys, and the early results of this operation are compatible with the experimental findings. However, the gradual dilatation of the upper urinary tract which occurs in some cases in the long term in the apparent absence of a mechanical obstruction suggests that at times the low pressure system may become a high pressure system. The recordings show that if the ileal stoma is obstructed, there is a rapid and marked rise in the intraluminal baseline pressure in the conduit accompanied by a series of strong contractions which generate pressures at least twice as high as the maximum generated by a normal ureter. A close examination of children with ileal conduit urinary diversions while wearing their urinary collecting appliances and their clothes shows how easily the stoma might become obstructed intermittently by the pressure of underpants, skirts, trousers, nappies, or orthopaedic apparatus. Similarly, the stoma might become obstructed at night if the child were to sleep in the prone position. This intermittent increased pressure within the ileal conduit acting over a long period of time might eventually produce ureteric dilatation.

**Conclusion**

Though the early results of ureteroileostomy were encouraging, there is increasing evidence that this method of urinary diversion causes a significant number of unsatisfactory results when used in children who are followed over a long period of time. In particular, the incidence of postoperative dilatation in normal urinary tracts is, in the author's opinion, sufficiently high to contraindicate ureteroileostomy as a method of controlling urinary incontinence. The penial urinal is satisfactory for this purpose in most boys, and the advent of electrical sphincter pacemakers may improve the outlook for both sexes. In circumstances where the upper urinary tract is already dilated and urinary diversion is contemplated in order to prevent further deterioration in renal function, cutaneous ureterostomy has proved satisfactory in this series. The operation of pyeloileocutaneous diversion advocated by King and Scott (1962), Holland et al. (1967), and Skoglund and Ansell (1968) may produce more direct drainage of the renal pelvis, but if the hypothesis put forward in this paper is correct, intermittent high pressure in the ileal conduit will affect the renal tubules immediately since the cushioning effect of the ureters is eliminated.

There is one alternative which deserves further consideration, namely the use of colon as a urinary conduit instead of ileum. The physiological characteristics of colonic motility might theoretically be more suitable. Moreover, when taken out of...
continuity as, for example, in the operation of oesophageal replacement, a length of colon becomes peristaltically inert. It is clear that further investigation of this possibility should be undertaken.

References


Correspondence to Mr. J. E. S. Scott, Department of Surgery, University of Newcastle upon Tyne, Royal Victoria Infirmary, Newcastle upon Tyne NE1 4LP.