can be overcome to a very large extent by haemolysis. The further testing of the A.O. Haemoglobin meter indicates that this is an extremely useful instrument, and though not as consistent as the two photoelectric instruments the difference is small, and is likely to be very small indeed with less-practised observers than the two involved in the present study.

The number of different methods of haemoglobinometry is so large that it was virtually impossible to compare more than a few at any one time. However, a fairly wide variety of types of method were represented, and the results would seem to support the following general conclusions. In a laboratory in which a large number of blood samples are handled and the observers are relatively skilled, a method based on a photoelectric colorimeter appears to be preferable to the other types of method investigated here. Under such conditions the time required for standardization and, if necessary, calibration of an instrument is small relative to the time it is in use. On the other hand, experience with the A.O. Haemoglobin meter shows that it is possible for a single whole-blood method to provide adequate results for the relatively unskilled observer who wishes to make an occasional haemoglobin estimation. It is also a suitable technique for field surveys where the more cumbersome instruments are impracticable.

Summary

Four laboratory technicians, with varied experience in haemoglobinometry, estimated the haemoglobin levels of replicated samples of four specimens of blood on two days, with seven different methods.

Two methods based on the use of photoelectric colorimeters gave the most consistent results, but one of the methods in which lysed whole blood is compared visually with a standard gave results which were almost as consistent, and which were better than those of any of the other methods. Skill in haemoglobinometry appeared to be of some importance in methods requiring dilution of fluids but of less importance in methods using whole blood.

A further limited examination of two of the methods (the E.E.L. Colorimeter and the A.O. Haemoglobin meter) over a period of three months in routine laboratory work confirmed that the E.E.L. Colorimeter gave more consistent results than the A.O. Haemoglobin meter, though the difference was small and the correlation between the two was extremely high ($r=0.99$).

For routine haemoglobinometry in skilled and practised hands a photoelectric colorimetric method is therefore recommended, but for survey work and use in general practice, and particularly for occasional use, the A.O. Haemoglobin meter, in which the estimation is made on whole blood, is adequate and probably preferable to any of the other methods investigated.

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Control of Infection after Prostatectomy

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It is always difficult to avoid infection after prostatectomy. Some surgeons believe it to be almost inevitable (Farquharson, 1962). For some time it had been almost invariably occurring in a surgical ward, and especially disturbing was the high incidence of infection by *Pseudomonas pyocyanea*. It is generally agreed that this is the result of cross-infection and as such largely preventable. In fact the incidence of infection by these bacteria could be regarded as an index of cross-infection in urological surgery. To deal with this problem an effort was made to reduce the infection rate by three measures: immediate or early prostatectomy in cases of acute retention of urine; the introduction of a new closed system of urine drainage; and the administration of the osmotic diuretic mannitol in the immediate post-operative period.

Material and Methods

The series includes all cases of prostatectomy performed in a general surgical ward, without special interest in urology, during the two years from September 1962 to September 1964.

During the first year the management of patients with prostatic obstruction was as follows. Those admitted with acute retention of urine were catheterized soon after admission and the catheter was connected by means of a sterile piece of rubber tube to a King's College Hospital drainage-bottle.

Continuous bladder-drainage was applied until the next "cold" operating session, which usually took place two to five days, sometimes longer, after admission, when retropubic prostatectomy was performed. After the operation the same type of drainage was continued. Bladder wash-outs were carried out every two hours or as often as necessary until no clots were present in the urine. Nitrofurantoin (Furadantin) or a combination of penicillin and streptomycin was given for five days post-operatively. During the operation intravenous dextrose 5% in water was administered and about one-third of the patients had blood transfusion. The catheter was usually removed four or five days after the operation. The management of cases admitted for elective prostatectomy was the same except that no catheter was passed before the operation.

The following modified regime was adopted in September 1963 and continued for the next year. Patients with acute retention of urine underwent retropubic prostatectomy within four hours of admission whenever possible. During the operation 2 pints (1,080 ml.) of intravenous dextrose 5% in water was given except in one-third of the patients, who had a transfusion of 1 pint (540 ml.) of blood instead of the same volume of the dextrose 5% solution. At the end of the operation the indwelling catheter was connected to a sterile Aldington type "C" bag of 1,500 ml. capacity (see Fig. 1).¹ This bag is made

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¹ Manufactured by Aldington Laboratories Ltd., Aldington Frith, Mersham, Ashford, Kent.

from polyvinylchloride sheeting with satin finish, and the tubing from crystal-clear polyvinylchloride. The connector for the catheter and the bung in the outlet tube are manufactured from polyethylene. The closed system of drainage arranged in this way needs to be opened only at the time of emptying the bag. To do this the bung in the outlet tube is dipped into 0.5% chlorhexidine in 70% alcohol for a few seconds, then removed with a sterile forceps and left in the same solution while the bag empties by gravity. When this is completed it is reapplied with the same forceps. There is no need for the nurse to scrub-up or wash her hands so long as these simple manipulations are carried out with a sterile forceps and non-touch technique.

The Aldington type "C" bag. Top inset shows details of the connector for the catheter, and the bottom inset the bung in the outlet tube.

During the six hours after the operation 2 pints (1,080 ml.) of mannitol 10% solution was given intravenously, followed by dextrose 5% at a slower rate until the next day, when the intravenous drip was discontinued.

The patients were given a sulphonamide combination (sulphatriad) or nitrofurantoin while the indwelling catheter remained *in situ*, usually four days. Catheter or mid-stream specimens of urine were sent to the laboratory for culture on alternate days while the patient was in hospital. No vasectomies were carried out in the series.

Results

During the first year 27 prostatectomies were performed. Eighteen patients were admitted with acute retention of urine and nine for elective surgery. All cases acquired infection in hospital, and 20 (74%) of them by *Ps. pyocyanea*. Only one patient was admitted with urinary infection, but during hospitalization different bacteria gained access into the urinary tract. Most of the cases developed a mixed infection by two or more bacteria. There was one death (4% mortality) caused by bronchopneumonia. This patient had acquired urinary

infection by *Escherichia coli* and *Ps. pyocyanea* while in hospital and developed secondary haemorrhages with clot-retention seven and nine days after the operation, which made it necessary to carry out bladder wash-outs under general anaesthetic. This may have contributed to his death. No post-mortem examination was made.

There were three patients with infected wounds; the patient who died had two secondary haemorrhages, and two patients had acute epididymitis, one of them bilateral.

The modified management was applied to 24 patients who had prostatectomy during the second year under study. Six patients were admitted for elective surgery and 18 with acute retention of urine. Of this latter group 14 underwent emergency prostatectomy and four had the operation postponed for periods varying from three days to two weeks.

Two cases were admitted with mild infection of urine, but no added infection occurred. Only two cases acquired infection while in hospital (8%), one of them by *Ps. pyocyanea*. The first of these two infected cases developed a subclinical infection by enterococci after the removal of the catheter. The second patient, a man of 84, acquired infection in hospital by *Ps. pyocyanea*; he came in with urine already infected by staphylococci and enterococci after having been catheterized at home by the district nurse. He had been bed-ridden for weeks, and on admission was suffering from emphysema, chronic bronchitis, and infection of both lung bases. He was regarded as unfit for operation, and an indwelling catheter was inserted. After two weeks his condition had improved a little and prostatectomy was carried out. At this time infection by *Ps. pyocyanea*, sensitive to tetracycline and chloramphenicol, was discovered. The infection was treated with these antibiotics and eliminated in a few days.

There was no mortality. No instance of wound infection or epididymitis occurred.

With the new management bladder wash-out was necessary in only one case. This patient was given hypotensive anaesthesia by a newly arrived anaesthetist. Some misgivings were expressed at the time regarding the possibility of delayed bleeding. Though the operative field appeared dry at the end of the operation, bleeding occurred a few hours later and a bladder wash-out was necessary.

The urine output during the six hours of mannitol-induced diuresis varied from 750 to 2,000 ml., with an average of 1,400 ml.

Discussion

Emergency or early prostatectomy for acute retention of urine shortens the period of catheterization, thus decreasing the risk of infection. This type of prostatectomy is feasible even in cases with some impairment of renal function, as shown by an abnormal blood urea (Wells, 1952; Beneventi, 1964), without the need of preliminary bladder-drainage or a two-stage procedure. Routine emergency prostatectomy has been found practicable in a peripheral hospital with the usual laboratory, radiological, and operating-theatre facilities. Assessment of the urinary system (by blood-urea determination and intravenous pyelogram) and of the other systems can be carried out as well in three to four hours as in three days. Only in those exceptional cases where associated medical conditions require longer treatment does a period of catheterization become necessary, with the consequent risk of infection. The only case of infection by *Ps. pyocyanea* in the second part of the series occurred in a patient whose operation had to be postponed for two weeks.

One of the most important measures to prevent infection is an effective closed system of drainage. We found the King's College Hospital drainage apparatus difficult to sterilize, and practically impossible to keep sterile once the bottle had been emptied. No perfect system of closed drainage has yet been

devised, but the introduction of the new urine-bag is believed to have been an important factor in the marked fall of the infection rate during the last year. This bag has also been found very effective in preventing urinary infection in patients having abdomino-perineal excisions of rectum or other operations when periods of continuous urine drainage of up to one week are necessary. We are also using it to collect the bile drained through a T-tube after exploration of the common bile-duct.

Bladder wash-outs are well known to involve risk of introducing infection. While they were found necessary in most of the early cases, the introduction of mannitol made it possible to discontinue them. It is impossible to obtain perfect haemostasis after prostatectomy. There is always some oozing blood in the immediate post-operative period, but this will stop spontaneously in a few hours if haemostasis is adequate. The good flow of urine obtained with an infusion of mannitol has prevented the formation of clots and obstruction of the catheter, making wash-outs unnecessary. We have found that the six hours following the operation are the most critical in this respect and have limited the administration of mannitol to this period, though it could be continued longer if necessary.

Mannitol, an osmotic diuretic, overcomes the physiological post-operative antidiuresis. It is being extensively used for prevention of acute renal failure after certain surgical operations, but this is a rare complication of prostatectomy. As pointed out above, we use it mainly to obtain a good flow of urine, which will prevent clots blocking the catheter. To avoid water-depletion a fluid load of about 1,000 ml. is given during the operation.

Intravenous urea has been used with a similar purpose (McKelvie, 1962). We felt reluctant to administer urea in case of obstruction of the urinary tract. From experimental evidence Bounous *et al.* (1960) concluded that "it might be considered unwise to utilize urea in patients who have marginal or reduced renal function." Comparative studies by Rabelo *et al.* (1962) have shown mannitol to be preferable to urea as an osmotic diuretic.

Some form of antibacterial "cover" was given to all patients in the series while the catheter was *in situ*. It certainly did not prevent infection during the first part of the series, and it is doubtful whether it had any influence on the infection rate during the second part. I have in the past seen two cases of fatal bacteraemic shock due to superinfection by resistant micro-organisms while the patients were on broad-spectrum antibiotics.

Summary

The high incidence of urinary infection after prostatectomy, especially by *Ps. pyocyanea*, was markedly reduced by the adoption of three measures: immediate or early prostatectomy whenever possible, the introduction of a new closed system of drainage, and the use of the osmotic diuretic mannitol in the immediate post-operative period.

I wish to thank Mr. E. B. Z. Masterman, under whose care the patients were admitted, for allowing me to treat them and for his encouragement. I am also grateful to the laboratory, radiological department, operating-theatre, and nursing staff for their help and co-operation.

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Value of Prophylactic Antibacterial Therapy in Instrumentation of Urinary Tract

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In the practice of urology instrumentation of the urinary tract is necessary in both diagnosis and treatment. That this carries a risk of infection is well documented, but the evidence as to the extent of this risk, and to whether it can be reduced by prophylactic antibacterial therapy, is scanty and to some extent contradictory. For this reason it was decided to carry out a controlled trial with an antibiotic given before instrumentation of the urinary tract. The antibiotic chosen was demethylchlortetracycline (Ledermycin), which, like the other tetracyclines, is absorbed rapidly from the gastro-intestinal tract, has a wide spectrum of antibacterial activity, is excreted in the urine, and has few side-effects. Demethylchlortetracycline is excreted more slowly than the other tetracyclines, thus maintaining an adequate serum and urine level for up to 48 hours after a single oral dose.

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Material and Methods

Most of the patients who took part in this survey were attending the urological clinic of the London Hospital; a few were in-patients. Patients who agreed to take part in the survey were instructed to provide a midstream specimen of urine, the specimen being collected in a glass jar after careful cleansing of the genitalia with cetrimide. In order to avoid a bias in either the test or control groups towards more or less extensive procedures the patients were allocated into categories depending on the anticipated type of instrumentation.

Appropriate information about the patient was recorded on standard forms so that it could later be coded and analysed on punched cards. The forms for consecutive patients in each category were numbered consecutively, and the treatment for each patient was provided in four red capsules enclosed in an envelope attached to the form, so that no confusion in