Papers and Originals

Transurethral Resection*

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The one form of surgery which fully justifies the specialization in urology is probably transurethral resection. Though the principles of surgery and, in particular, haemostasis still apply, the technique differs considerably from any other operation.

This can be a very satisfying technique, once the surgeon has mastered the necessary manoeuvres to keep haemorrhage under control. A very wide variety of urological conditions can be treated by transurethral resection, from bladder tumours to prostatic hypertrophy, and though the resectionist may try to describe a routine procedure, the variety of problems that arise from one patient to another are such that no two cases are entirely alike, and there is certainly no risk of being involved in a monotonous routine. One of the most satisfying features of the operation is its completeness, as the magnification obtained by the optical system gives the operator the opportunity of extremely accurate surgery. The patient has the satisfaction of not having an abdominal wound and its associated discomfort, and is therefore able to move about and breathe easily immediately he recovers from the anaesthetic. In resection of the hypertrophied prostate it is possible to stop the operation and withdraw if the patient's condition is causing any concern. Having achieved haemostasis, the patient can be returned to the recovery ward for full resuscitative measures with very little delay.

The mortality from transurethral resection is now generally accepted as somewhere in the region of 1%, and even this figure probably includes a few patients who present a greater risk at operation than would be considered reasonable for open surgery.

Though the abbreviation T.U.R. has now been accepted on both sides of the Atlantic, the scholar of English will find the prefix "trans" unacceptable for an operation which is performed through the urethra and not across it. For this reason many attempts have been made to preserve the term "per-urethral resection" but, despite the greater accuracy of this terminology, popular usage demands the word "transurethral," which will be used in this lecture to avoid any ambiguity.

Indications for Transurethral Resection

The place of transurethral surgery is not just that of an alternative approach for a procedure which could be covered equally well by open surgery. Many of the conditions for which transurethral resections are indicated are either not possible by open surgery or the result achieved is so inadequate that the surgeon feels doubtful of the justification of his efforts. Trying to resect a fibrous bladder neck or a small adherent adenoma of prostate or even a neoplastic prostate by open surgery always leaves the surgeon with the feeling of doubt about whether he has removed enough to give the

patient relief of his obstruction. In these conditions no clear line of demarcation can be seen and the plane of cleavage cannot be presented, either to the enucleating finger or to the tips of the scissors in their attempts at blunt dissection. Resection of the sphincters in the neurogenic bladder is always a matter of trial and error, and can readily be achieved by the transurethral route, whereas at open surgery there is only one opportunity to assess how much should be removed and, thereafter, the surgeon has to resort to the less adequate measure of neurectomy.

Not infrequently the resectionist is presented with a patient in whom a false passage has been created somewhere in the region of the prostate gland. The disabilities from this false passage can be relieved by resecting the bridge of tissue between the posterior urethra and the false passage, and thereby saucerizing the area. This is perhaps an impossible procedure by open surgery, as is also the opening of all pockets of an extensively loculated prostatic abscess.

Although various instruments have been devised for taking biopsy specimens from bladder tumours, a procedure which is now accepted as an essential first stage in the treatment of any neoplasm of the bladder, none of these instruments will give as good a view or as satisfactory a biopsy specimen size for the pathologist as the use of the resectoscope. Small pieces of the bladder tumour will give a very poor representation of the grade of this growth, and none of these biopsy forceps provide any means of subsequent haemostasis. Even using a 24 Charrière resectoscope, which is the same size as most of the recognized biopsy forceps, a slice of tumour more than 0.5 cm. wide and 1 to 2 cm. long can be obtained. The area from which the biopsy specimen has been taken can then be coagulated so that there is little risk of a subsequent clot retention.

A well-fronced pedunculated tumour of the bladder can be fulgurated via the cystoscope, but if its size is 2 cm. in diameter or more the surgeon finishes with a nubbin of charred tissue projecting from the bladder wall, and in all probability the centre of this tumour is still viable. If the tumour is resected it can be removed in toto down to the flat surface of the bladder wall. The resectionist can be satisfied that he has destroyed the neoplasm completely unless it has infiltrated the bladder wall, and, furthermore, the operation is very much quicker.

Size of Adenoma Suitable for Resection

Transurethral resection should not be regarded as an alternative for removing the adenomatous prostate. The benign hypertrophy of more than 30 g. is best removed by open surgery, as an easy plane of cleavage will be found. An adenoma of under 20 g. is much more readily treated by transurethral resection, as this size of gland is often difficult to enucleate and the more important part of the operation is a complete and accurate resection of the hypertrophied bladder neck. This leaves the 20 to 30 g. adenoma which represents the overlap between open surgery and transurethral resection, where both methods are possible and reasonable.

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Nothing is achieved to the advantage of the patient by the enthusiasm of the resectionist tempting him to tackle bigger and bigger prostates. On occasions, however, the resectionist may be called on to remove the large adenoma in a patient who has respiratory or cardiac complications, or in one who is so obese that retropubic prostatectomy may be something of an embarrassment.

Systemic Effect of the Operation

It is important to remember that transurethral resection is no less a procedure than open surgery. It may relieve the patient of the discomfort of an abdominal wound, and the operation may have a lower mortality than open prostatectomy, but nevertheless the result is identical, the amount of tissue to be removed is prescribed by the size of the gland and not by the mode of operation, and therefore the systemic effect will be identical, whether the gland is attacked by open surgery or by the transurethral route. Our physician colleagues may occasionally refer a patient with a note asking whether he would stand a small resection, implying that this is probably just little more than an outpatient procedure. This illusion must be corrected. Similarly, it is essential to remember that these patients will require the same standard of postoperative nursing care and the same duration of convalescence as the man who has undergone prostatectomy by open surgery.

Postoperative Relief of Symptoms

In the early stages transurethral resection earned a poor reputation for relief of symptoms. This was due not so much to inadequate resection but to the type of condition for which resection was performed. We know that we can promise a much better result for the prostatic patient presenting with symptoms of obstruction than for the one who presents with frequency of micturition. Bladder neck hypertrophy or fibrosis was the commonest condition for which transurethral resection was advocated in the early history of this operation, and this is the very condition which so often presents with frequency as its main symptom. This frequency is due to the hypertrophy of the muscle of the bladder wall, clearly demonstrated by trabeculation at the time of cystoscopy. Removal of the obstructing bladder neck does not alter the state of the bladder wall, and therefore the frequency will still persist. These patients should be carefully warned before operation that their frequency will take several weeks, if not months, to subside, even after the operation. In the same way as open surgery is less likely to give relief of frequency than obstructive symptoms, so the results of transurethral surgery must be anticipated in a similar light.

History of Transurethral Resection

The history of transurethral resection can be traced back over many years. In the early stages the operations were performed by ingenious instruments with hidden or retractable blades, resembling the old bistoury. There was no means of endoscopic viewing of the extent of the procedure, but Guthrie (1834, 1843), who was probably the first to try this method, claimed successes. Following Guthrie, further reports appeared in French literature from Civiale (1850) and Mercier (1856) and their writings of 100 years ago make very amusing reading today, when we can trace the bitter controversy between these two French surgeons, both of whom claimed to be the first to carry out this operation; neither of them missed an opportunity, either in their writings or their lectures, to make defamatory remarks about the other. Early this century Hugh Young (1913) developed the first (direct vision) punch

and tried to perform the operation of resection as an outpatient procedure. After the first few cases he had a disastrous haemorrhage and decided that this form of surgery should be reserved for the hospital inpatient. The punch was finally perfected by Gershom Thompson (1935) of the Mayo Clinic.

Advent of Electrosection

As soon as the potentials of surgical diathermy were appreciated, attempts were made to resect the bladder neck, using a loop very similar to the one we use today. The first effective diathermy resectoscope was McCarthy's (1933) electrotome. Cutting under water with a spark-gap diathermy was, however, an uncertain procedure as the current had to be turned to maximum in order to create an arc under water. This resulted in extensive dispersal of current and a widely necrotic area beyond the site of section.

I still remember vividly nearly 20 years ago the appearance of the capsule of a prostate which I had resected transurethrally, using an old spark-gap diathermy, some three weeks previously. This was in a patient who had a neoplasm of the rectum, but was also complaining of obstructive urinary symptoms. My general surgical colleague had asked that the patient's urinary symptoms be relieved if possible before embarking on the abdominoperineal resection. At the time of the subsequent excision of the rectum I had the opportunity of seeing the prostatic capsule and was astonished at the extent of the oedema that I had created by my previous resection. In the past 20 years the valve diathermy has been perfected, with the advantage of fine electrosection of tissues, even under water.

Equipment for Transurethral Resection

Resectoscope

The modern resectoscope (Fig. 1) is, in most respects, very similar to the original McCarthy electrotome, but with improvements in the moving parts and the quality of material used. Basically the instrument consists of a sheath constructed of insulating material, a water inlet, and a moving part carrying the diathermy electrode, which projects 2 to 3 cm. beyond the sheath and can be retracted just inside the sheath. Numerous designs of moving parts have been devised at various times, but most of these carry a spring. In some cases this will hold the electrode retracted, but in other cases the electrode is held in the extended or exposed position, which can be dangerous if the diathermy is inadvertently activated when the loop is out and perhaps touching the bladder wall. In the instrument demonstrated here there is no spring and the moving part has been reduced to minimal size with nylon roller bearings. This allows the resectionist to feel the contact of the electrode against the tissues, which is an essential part of the technique. Any form of spring inserted in the moving part will mask this

FIG. 1.—Modern resectoscope. (a) The wide-bore water inlet with tap. (b) Conventional lighting with rotatable Wappler pillar. (c) Diathermy cable, reversible to either side (Mitchell, 1958).

sense of contact between the electrode and the tissues. Lastly, and probably most important of all, is the optical system.

Telescope

The view obtained is described as foreoblique (Fig. 2). In most telescopes this is 15 to 20° away from a direct view. It is the same telescope as is used in the panendoscope for viewing the urethra. The field of view of these telescopes is between 30 and 40°, but the new wide-angle lenses are giving a field of view as much as 60°. When this telescope is rotated through 180° it gives the resectionist an overall field of view of twice the amount. In other words, the telescope with a field of 35° will, when the instrument is rotated through 180°, give him a field of 70°. Similarly, the modern telescopes with 60° wide-angle field will, when rotated, give a field of view of almost 120°.

FIG. 2.—Foreoblique view of resectoscope telescope. The angle of view is 30° from the straight and the field of view is 60°.

The conventional lens system of this telescope consists of an eyepiece, lens, and an objective lens. In addition there is a lens or prism to invert the image, and on either side of each of these lenses is a concavo-concave lens to increase the volume of light transmission. These lenses are separated by columns of air. In the new Hopkins lens system the glass and air is reversed so that the column of air is replaced by a solid rod of glass and the lens of the conventional telescope is replaced by an air space between the solid rods. This new lens system has three major advantages: there is a considerable increase in the volume of light transmitted, there is a reduction in the number of ghost images, and the minimal air space gives less trouble with moisture and dust being aspirated into the lumen of the scope.

System of Illumination

The conventional lighting system is still preferred by many resectionists to the new fibre illumination. Though the fibre provides much better illumination without the problem of failing bulbs, it has the major disadvantage that the pillar cannot be rotated on the telescope. Work is in progress to try to design a rotating collar for a fibre-light illumination, but so far efforts have not been rewarding, as there is such a high percentage of light loss at the junction point of the rotating collar.

Size of Resectoscope

The original McCarthy electrotome and many of the subsequent modifications were designed with a sheath 30 Charrière in size—that is, about 10 mm. diameter. In order to pass a sheath of this size the urethra inevitably had to be stretched, and many resectionists at this time advocated either internal urethrotomy to increase its calibre or a perineal urethrostomy, passing the resectoscope sheath through the perineum into the bulb in order to avoid the narrower part of the urethra. The incidence of urethral stricture, however, was

still somewhere in the region of 10%. The size of sheaths has steadily diminished and 24 is now used for biopsy, while a 26 Charrière is convenient for most bladder neck resections.

Even smaller sizes are made for use in children (16 Charrière—that is, 5 mm. diameter). Here the thickness of the sheath is an even greater problem, and it is hoped that carbon fibre sheaths might reduce the calibre of this instrument considerably. Though transurethral resection in a child is a rare operation, occasionally bladder neck hypertrophy can be such that this is the optimum means of removing the hypertrophied tissue.

Sterilization of Instrument

The sterilization of delicate equipment, such as endoscopic parts, including the telescope, has always been a problem. Immersion in antiseptic solution, such as chlorhexidine or glutaraldehyde, has the major limitation that they are totally dependent on thorough cleaning of the instrument. Any layer of coagulant allowed to dry on the surface of the instrument can protect organisms from such solutions. The use of formalin vapour or ethylene oxide again has the limitation that these gases do not penetrate the taps and other crevices on these instruments. Heat is the only reliable method of sterilization, but most endoscope telescopes will not stand the routine of the high-pressure autoclave. Many are constructed to withstand boiling, but there is little doubt that the agitation of the water and the fixation of the telescopes in the perforated boilable containers result in steady deterioration.

Pasteurization has been used at 80° C. for 5 to 10 minutes, but more recently the low-pressure autoclave, in which the instruments are subjected to steam at half an atmosphere pressure will effect an exact temperature control of 80° C. (Fig. 3). This will give adequate penetration of all the taps and joints of the instrument and will destroy all vegetative forms and even some spore forms of bacteria (Alder *et al.*, 1970). The total cycle is between 17 and 20 minutes from dirty trolley to clean trolley. The instrument is packed in a cardboard box with plastic foam layers cut to accept the various parts of the instrument. The protection of this instrument by foam is quite remarkable, and hospital portage has made "unintentional tests" by dropping these boxes without damaging the contents. The great advantage of this method of sterilization is that the instrument is sterile and ready for use at short notice, and the system of dry packed boxes fits very conveniently in the sterilization circuit of a theatre sterile supply unit.

FIG. 3.—Temperature of saturated steam at pressures below atmospheric. Under reduced pressure of half an atmosphere, steam can be developed at 80° C.

Diathermy Machine

The next piece of equipment required is an adequate diathermy machine. The wave form and frequency of the spark-gap diathermy will give excellent coagulation, even under water, but will not produce underwater cutting. A valve oscillator which can produce a pure sine wave of higher frequency is necessary. This will create an arc between the electrode and the tissues, even under water, and little surrounding tissue reaction will be seen at more than 1 mm. from the cut.

The hazards of diathermy are of particular importance in transurethral resection, as the current may be activated for as much as 20 minutes during any one resection (Mitchell and Lumb, 1960). If there is a fault in the application of the plate electrode, then the risk of a diathermy burn is much greater in transurethral resection than in most other forms of surgery. Many plate burns occur as a result of creases in the towelling covering the plate or unequal strength of the salt solution in which the towelling has been immersed. The latest recommendation of the British Standards Institution, shortly to be published, is the dry plate used directly against the skin with no electrode cream. This is usually applied to the thigh by means of Velcro strapping. Monitoring of the plate lead is also advocated, the cable having a double core, and it is therefore possible to have its own circuit, which, if broken, will trip an alarm and this will "howl" until the fault is corrected.

Water Supply

We have discussed the resectoscope and the diathermy machine. It now remains to say a word about the water supply. The primitive water container (Fig. 4), known as a Valentine jar, is still in use today, though it has been modified by improved methods of sterilization and the provision of a sterile cover in the form of a lid. Whether the sterile supply of water is by bottle or by overhead Rothwell piped system, it is still necessary to have a reservoir in order to control the head of pressure at which the water is delivered to the resectoscope (normally 60 cm.).

Isotonic Fluid

Sterile water is used for cystoscopy, but an isotonic non-electrolytic solution should be used for transurethral resec-

tion, as there is a risk of absorption of fluid when the veins in the capsule of the prostate are opened. Furthermore, many of these veins may be at negative pressure as a result of the position in which the patient is placed on the operating-table. In order to ensure a ready supply of irrigating fluid, should the tank run out, it is advisable to have two Valentine jars as shown (Fig. 5). One of these jars can be filled with sterile

FIG. 5.—Double Valentine isotonic fluid supply, with piped water from the enclosed Rothwell system. The concentrated solution to make up the isotonic fluid stands in the bottle on the table (Mitchell, 1969).

water, the other with the necessary isotonic solution, so that as soon as the resection is started the tap can be switched across to a 5% solution of dextrose.

Endoscopy Position

The position of the patient for transurethral resection is important. The leg stirrups (Fig. 6) provide a suitable angle of flexion for the thigh without tilting the pelvis or flexing the lumbar spine. These leg stirrups can be adjusted to take patients of any size from a man of 6 ft. 6 in. (198 cm.) to a young child, and since the introduction of this shape of leg stirrup the incidence of postoperative backache has been reduced considerably.

Technique of Transurethral Resection

Resecting the Prostate and Bladder Neck

A detailed description of the technique of transurethral resection is beyond the scope of this lecture, but Fig. 7 will show the surgeon's position while manipulating the instru-

FIG. 4.—Simple Valentine reservoir.

FIG. 6.—Leg stirrups giving a suitable position for transurethral surgery (Mitchell, 1955). With acknowledgements to Messrs. Chas. F. Thackray Ltd., Leeds.

FIG. 7.—Position of surgeon's hands holding the instrument for transurethral resection. The instrument, in fact, can be operated single-handed when it is necessary to control the cut with a finger per rectum.

ment. The cables can be seen carried away from the operator at a convenient level. In Fig. 8 the instrument has been rotated through 180° and the resectionist is attempting to cut the anterior aspect of the prostate. Briefly, the procedure is to extend the loop as far as possible, and then withdraw the sheath so that the loop is just beyond the neck of the bladder (Fig. 9). The first cut is usually made in the region of 11 o'clock, and the next cut deep to that will usually expose the capsule of the prostate (Fig. 10). This can be recognized by the criss-cross fibres, as opposed to the fluffy appearance of the adenoma of the prostate. Resection proceeds by cutting between the capsule of the prostate and the adenoma, which then gradually falls medially, while at the same time the bladder neck opens widely.

The most important part of the technique is to ensure that any bleeding vessel is immediately controlled by coagulating with the button electrode. Two or more powerful bleeding vessels can make it very difficult indeed to arrest the haemorrhage, because even though the button may be in contact with one bleeder, the powerful jet of blood from the other two bleeding vessels can create a swirl of completely opaque fluid and no view can be obtained. In the left-hand diagram of Fig. 11 the right lobe has fallen medially, the resection having been carried down between the capsule and adenoma as far as 5 o'clock. In the diagram on the right both lateral lobes have been resected, leaving the posteromedial part of each lobe in the midline. This remaining part of the gland can usually be resected with little further bleeding.

Much delay can be caused by repeatedly cutting the same vessel as the depth of resection increases. This problem can be avoided by keeping the resection between the capsule and the adenoma so that the adenoma falls medially and the vessels are divided and coagulated at the depth of the capsule itself.

Sometimes bleeding will be inaccessible because it is behind a small tag of tissue remaining. The resectionist is then justified in making a further cut before completing the haemostasis, so that he can expose the exact bleeding point. Having

FIG. 8.—Similar position to that shown in Fig. 7 with the instrument rotated to 180° .

FIG. 9.—Position of the beak of the resectoscope and the loop during the stages of transurethral resection.

FIG. 10.—In the left-hand diagram the first two cuts are made at 11 o'clock. In the right-hand diagram a small amount of bleeding has occurred as further cutting proceeds with the lobe of the prostate falling medially.

coagulated every possible bleeding point, the resectionist will then go over the prostatic bed a second time, turning off the water flow so that even the smallest bleeders can be identified and coagulated. He will never under any circumstances allow the bleeding to get out of control. To continue cutting without stopping all bleeders as they appear is asking for trouble, and haemorrhage still remains the greatest source of anxiety to the surgeon practising transurethral resection.

Hypotensive Anaesthesia

One of the most valuable advances in recent years has been the development of hypotensive anaesthesia. The ideal level for resection is about 80 mm. Hg systolic. To reduce the blood pressure below this level gives a clear field but, on the other hand, it is difficult to identify all the cut vessels. Careful

FIG. 11.—In the left-hand diagram the lateral part of the bladder neck resection has been completed on the patient's right side and the first two cuts have been made on the left side. In the diagram on the right the dissection between the lateral lobes of the prostate and the capsule has been completed and the lobes have fallen medially, ready for the final stage of resection.

haemostasis is essential, and even what appeared to be merely petechial spots must be touched with the coagulating button. Here it is essential to have the services of an anaesthetist who is experienced in hypotensive anaesthesia. If the blood pressure can be retained steadily at the level of 80, conditions for resection are perfect. The unfortunate surgeon who is provided with a patient whose blood pressure is oscillating over a range of 20 mm. Hg or more—say from 80 to 100 systolic—will find himself in considerable difficulty. One minute the field will be clear, the next minute the vessels in all directions will be oozing sufficient blood to obscure the view. If the resectionist is uncertain of his anaesthetic colleague's ability to maintain a steady hypotension he is far safer to ask for a normotensive anaesthetic.

Complications

Haemorrhage

Haemorrhage is undoubtedly the most alarming complication of this form of surgery, and so often it is the last cut that is said to create the torrential bleed.

Venous bleeding can often be more alarming than arterial, as the water pressure may be sufficient to equalize the flow of blood from the cut vessel. Even when the cut vessel is identified it may not be easy to coagulate as the prostatic venous plexus in the capsule has some large sized veins. Just occasionally the resectionist may have to use traction on a Foley balloon catheter, but before adopting this last resort he should make sure (1) there is no persistent arterial bleeding (2) only gentle traction is exerted, and (3) the traction must be released within four hours. If this measure fails, the bladder must be opened and haemostasis achieved by direct inspection of the resected area.

Perforation of Prostatic Capsule

The next complication is perforation. The commonest cause of perforation in the prostatic resection is the failure on the part of the resectionist to appreciate how the midline moves as the resection proceeds (Fig. 12). Within the first few cuts on the right side the bladder neck will begin to open up and the midline anteriorly will move across from 12 o'clock to 1 o'clock and even further. When the resectionist has completed the right lobe he will then turn his attention to the left lobe and may possibly start at about the same level as he started on the first side. If his next cut is made at about 1 o'clock he will be resecting an area where he has already made a previous bite and this will be sufficient to penetrate the wall.

FIG. 12.—As the resection proceeds on the right side the bladder neck opens so that the midline moves from 12 o'clock in diagram A to nearly 2 o'clock in diagram E, the position of the midline being indicated by the arrow.

Otherwise, perforation of the prostatic capsule is probably due to failure to recognize the difference between the capsule and the adenoma.

Perforation of Bladder Wall

Resecting bladder tumours can be even more difficult than resecting the prostate, as the flow of fluid causes the target to recede steadily as the bladder distends. The resectionist will therefore try to make the most of the empty bladder, but in so doing he must avoid the risk of cutting across a fold of the bladder wall, with the consequent perforation.

Recognition of a Perforation

Diagnosis of a perforation is sometimes difficult. The resectionist may see a hole with a cobweb appearance beyond. He may even see fluid flowing into the hole, floating particles identifying the direction of the flow of the fluid. He may find that he is not obtaining an adequate return of fluid when the bladder is irrigated with the evacuator to remove the pieces. If much fluid passes through the perforation into the retroperitoneal area the patient's general condition may cause some alarm to the anaesthetist. If a perforation is suspected at operation it is always safer to put in a suprapubic drain.

Delayed Recognition of a Perforation.—There is very little to be lost, beyond the surgeon's own dignity, in having to make a suprapubic stab to evacuate extravasated fluid, but there is a considerable amount to be lost in the condition of the patient if the perforation has been missed. Then, as the patient recovers from the anaesthetic, his pulse rate, the rigidity of his abdomen, and his complaints of abdominal pain will very quickly alert the surgeon to the fact that he has created a perforation, with extravasated fluid. This patient will have to return to the theatre immediately, and a suprapubic stab drain will have to be inserted. It is rarely necessary to suture the site of perforation unless there has been gross destruction of the prostatic capsule.

Delayed Perforation.—Occasionally a perforation can give symptoms only after a week or 10 days. Presumably the explanation of this is a necrotic area of bladder wall or prostatic capsule which has separated some days later. In these cases the consequences are usually mild and quite often prolonged catheter drainage is all that is necessary.

Conclusion

This is not intended as a comprehensive lecture on how to perform transurethral surgery, nor have the complications been described in more than the briefest detail, but the principles and potentials of this form of surgery have been outlined.

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