ANÆSTHESIA FOR UROLOGICAL SURGERY

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(Lecture delivered at the Royal College of Surgeons of England, April 1948.)

In urological surgery, the bladder and its attendant organs and passages demand the major part of the surgeon's attention, and as the nerve supply of those regions arises from a limited length of the spinal cord, it is to be expected that spinal analgesia will be called upon to play a regular part in anaesthetic methods for this special type of surgery. It is fitting therefore to consider the nerves which require to be blocked in the various operative techniques.

It is apparent that anatomists and physiologists have had some difficulty in deciding the exact origins of the varied nerve supply of the bladder, and if the views of some authorities are accepted, certain clinical phenomena are left unexplained. On the other hand, a patient search in odd places has furnished information which tallies with clinical results, and it is to this that definite reference will be made. First, however, there are the nerve origins upon which there is general agreement—
(a) the somatic nerve supply, travelling in the pudendal nerve with its origin in sacral roots 3 and 4, and supplying the external sphincter and the urethra as well as the genitalia in part; and
(b) the parasympathetic nerve supply with origin in sacral roots 2 and 3, and supplying the mucous membrane of the bladder and the remainder of the sphincter mechanism. Afferent sensory impulses travel in the fibres of both supplies, as well as efferent motor impulses.
The discrepancies appear when the sympathetic supply is under consideration, and it is here that leave is taken to quote authorities whose views agree with clinical findings. Riddoch (1921) pointed out that the sympathetic trunks do carry afferent impulses from the bladder, and that section of the spinal cord above the eleventh dorsal segment abolishes all vesical sensation. Learmonth (1931) presented evidence concerning the segments of the spinal cord with which the sensory fibres running with the sympathetic nerves connect. He described a case which showed that these afferent fibres may enter as high as the ninth thoracic segment. Ignoring the vague descriptions of some anatomy books on this topic, Quain records these origins:

Bladder
(a) Mucous membrane and neck of bladder—S. (i), 2, 3, 4.
(b) Overdistension and ineffectual contraction—D. ii, 12 and L.1.

Incidentally, it may be noted here that he also records:
Kidney and ureter—D. 10, 11, 12, and 13
Prostate gland—D. 10, 11, (12)
—S. 1, 2, 3 and L. 5.

Supported by these authorities, it may reasonably be accepted that there is a sensory nerve supply to the bladder and prostate with origins at least as high as the tenth thoracic segment, and when a spinal anaesthetic is chosen for urological work which involves distension of the bladder or cutting of the prostate gland, it is well to keep this unexpectedly high segmental origin in mind. There is a temptation to attempt such operations as litholapexy or transurethral resection of the prostate, using a ‘low spinal’ anaesthetic. The reasonable distension of the bladder which is likely to occur in each case and the insult to the gland in the latter will produce evidence in the form of a grunt or grimace that anaesthesia is not quite complete unless its level has reached this tenth dorsal segment.
It is less the concern of the anaesthetist that efferent impulses may have an even higher origin (Fig. 1).

Before leaving the anatomical aspects of urological surgery, the origin of the nerve supply to the skin areas through which the surgeon progresses to his target might be mentioned. These
areas are covered by a nerve supply from D.8-12, except for the genitalia which share a sacral outflow and also branches from the ilio-inguinal and lumbo-inguinal nerves.

Transurethral Procedures

For armed with some anatomical knowledge, consideration can be given to the methods of anaesthesia which are suitable for urology, and attention will be paid first to the out-patient. Most patients—male and female—attending a urological dispensary are examined by the skilled urologist without anaesthesia and little or no discomfort is experienced. But there are always some who do require anaesthesia, and their needs are met by a choice from (1) local analgesia, (2) spinal analgesia or (3) general anaesthesia.

(1) Local analgesia may be produced by the instillation into the urethra of one ounce of 1:500 nupercaine or of 2 per cent metycaine. The use of cocaine should be avoided as reactions from this drug are not uncommon in this region. Mild barbiturate premedication is worthy of consideration in view of the well-recognized antagonism between local analgesics and this class of drug.

(2) Spinal analgesia provides an effective and easily applied method. A small dose of procaine, 60–80 mg. made up in heavy solution (0.3–0.4 c.c. of 20 per cent solution) is injected at the 3rd or 4th lumbar interspace with the patient sitting up. Remaining in this position, or comfortably reclined on the urological table at an angle of about 45°, only the sacral roots become involved. Somatic and parasympathetic afferents are blocked and as long as the bladder is not distended, cystoscopy and treatment of the bladder mucous membrane (S.(1), 2, 3, 4) can be carried out (e.g. fulguration of papilloma). The analgesia does not involve the kidney or ureter, and retrograde pyelography can be readily performed, the necessary sensation being retained in the kidney pelvis. As there is no sympathetic involvement no fall in blood-pressure ensues, and no pressor drug is given. It should be remembered that the
skin on the outer part of the soles of the feet is supplied by the sacral roots, and the patient should be warned of the woolly feeling in this area. The main sensory supply to the lower limbs and the entire motor supply are unaffected and the patient should have no difficulty in walking away at the conclusion of the examination. After resting for an hour, the patient is allowed to leave the dispensary, with a recommendation to take things quietly for the remainder of the day.

Extradural sacral block or caudal block provides a satisfactory analgesia, but the technique is less simple than for spinal analgesia, and great care must be taken to avoid too high a spread if pyelography is under consideration. Spinal analgesia demands no delay before it is effective, but caudal block requires 10-15 minutes to secure efficient results.

(3) There are patients for whom it is preferable to choose a general anesthetic even in an out-patient clinic, and their needs are well supplied by the use of intravenous pentothal. If the operative procedure or examination is at all prolonged, the patient will recover more quickly if the anaesthesia is maintained with gas and oxygen following pentothal induction, than if the pentothal is continuously administered.

Going on now to procedures which entail some overfilling of the bladder, namely litholapaxy and transurethral resection of the prostate, it has been shown already that the anaesthesia must be raised to the tenth dorsal segment when spinal analgesia is chosen. The subarachnoid injection is made with the patient again sitting up, choosing the 3rd lumbar interspace. One hundred mg. of metycaine [Gamma—(2 methyl-piperidino) propyl Benzoate Hydrochloride] in the form of 1 c.c. of 10 per cent solution, diluted to 2 c.c. with cerebrospinal fluid, are injected, and the patient is laid flat immediately, elevating the head and shoulders on a pillow. It is important to lay the patient down at once—otherwise the anaesthesia will fail to reach the desired segment. Some fall in blood-pressure is to be expected with this anaesthetic level, and the use of a pressor drug is advised, e.g. ½—1 gr. ephedrine
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hydrochloride, given intramuscularly at the time of the spinal puncture. Some prefer to await evidence of a fall in pressure before injecting the pressor drug, but there has been no occasion to regret its prophylactic exhibition. On the contrary, it has served to secure the desired maintenance of blood-pressure until such time as the surgeon has completed the resection and coagulated the bleeding points. The abdominal wall is well relaxed between the umbilicus and the pubis and it is easy to palpate the filling bladder and guide the surgeon as to its condition. A continuous record of the behaviour of the blood-pressure is advisable so that the operator may feel that his coagulation is carried out on a patient who is doing his best to bleed, as it were. The cutting-time in resection seldom exceeds 20–30 minutes, and unless bleeding is excessive the blood-pressure remains at a satisfactory level. On his return to bed, the patient is kept flat, with the usual pillow or two under his head, for a few hours.

When some contra-indication to the use of spinal analgesia exists in such cases, it is entirely convenient to carry out the litholapaxy or the resection under a general anaesthetic. The agents of choice are pentothal sodium intravenously accompanied by gas and oxygen. An intravenous saline drip is primarily established, pentothal is injected into the drip at appropriate intervals while a rich oxygen-gas mixture is also administered. A secure closed-circuit cyclopropane anaesthesia carefully screened from the source of diathermy provides a most satisfactory general anaesthesia for such operations, the blood-pressure being fully maintained in these circumstances.

Suprapubic Operations

Nowadays, suprapubic drainage of the bladder is usually reserved for the patient with retention of urine, and is most often only a temporary measure in the larger plan of fitting the patient for a subsequent prostatectomy. Most cases are suitably dealt with by local analgesic methods, a limited field-
block being employed as the method of choice in these often uraemic patients. It is impossible with such a technique to eliminate the sensation of the distended bladder, but the only discomfort which the patient need experience is the momentary pressure while the trocar is pushed into the bladder. A brief gas and oxygen or cyclopropane anaesthesia will meet these cases unsuitable for local methods.

More extensive suprapubic procedures, e.g. partial cystectomy, fulguration of tumours through the open bladder, may be dealt with under spinal analgesia, but are now most adequately anaesthetized by a light plane gas/oxygen/trichlorethylene or cyclopropane anaesthesia, the necessary muscular relaxation being secured with curare. When cyclopropane is used in the presence of diathermy the circuit must be securely closed and a damp anaesthetic screen should be interposed.

The operation for the extra-peritoneal removal of a low-placed ureteric calculus—an affliction which so often seems to attack the robust—is very comfortably executed under such an anaesthetic technique.

Probably one of the most extensive suprapubic, or rather abdominal, operations facing the urologist, often in a debilitated patient, is transplantation of the ureters, frequently accompanied by cystectomy. Spinal analgesia has probably most often been chosen, supplemented by a light highly oxygenated narcosis, and the technique is commonly successful. But a fair number of these patients operated upon under spinal analgesia are not so well after operation as one would expect—they exhibit pallor, a clammy skin, an anxious look, a rapid small pulse, listlessness and some abdominal distension. They may avoid some of these phenomena if a general anaesthetic is chosen, but they have to be retained in a fairly deep plane for some time. A further objection to spinal analgesia may come from the urologist, whose difficulties are increased by the contraction of the bowel.

As an alternative to the above, pentothal induction followed by a light cyclopropane narcosis has been found very successful,
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the relaxation being secured by the use of curare. Figure 2 shows the anaesthetic chart of an elderly lady of 70 years who had both ureters transplanted as well as a very radical cystectomy. The complete operation was performed in two stages, each of which took about two hours, much time being consumed in dealing with the many adhesions which remained after previous abdominal operations. The chart shows how well she endured the first operation, from which she made an excellent recovery. A similar technique was employed on the second occasion—one month later—with equal success except that some fall in blood-pressure accompanied the cystectomy at which there was a considerable loss of blood. The fall was arrested by the early start of a blood transfusion. It seems reasonable to suggest that no other anaesthetic technique would have suited this elderly patient any better.

While on the subject of transfusion, and remembering how often pre-operative and post-operative intravenous therapy are now in the hands of the anaesthetist, it should be emphasized that operations such as open fulguration of bladder tumours and nephrectomies for such conditions as hypernephroma often entail considerable loss of blood. This in patients who may have been suffering from a persistent haematuria can be a serious matter. Consequently all such cases should be typed for a blood transfusion which, thus premeditated and planned, can be speedily instituted should the need arise.

Kidneys and Ureters

Operations on the kidneys and ureters are preferably performed under general anaesthesia, the lateral position with elevation of the bridge or the use of inflatable kidney bags being an uncomfortable one for the conscious patient. When a unilateral type of spinal analgesia or a paravertebral block is used for some special reason, the block in either case should extend to the eighth dorsal segment. In paravertebral block, the nerve roots from D. 8 to L. 3 should be blocked with in addition deep injections on the lateral surfaces of the corre-
sponding vertebral bodies to render handling of the kidney-pedicle painless.

Continuous pentothal with gas and oxygen, pentothal followed by cyclopropane or cyclopropane and minimal ether give a satisfactory choice of general anaesthesia. The operation of nephro-ureterectomy for tuberculous kidney with ureteric involvement is a fairly severe one, and there would appear to be an increased liability to post-operative pulmonary collapse. A careful look-out should be kept and immediate treatment instituted should this complication occur. Finally in connection with operations for kidney tumours an X-ray examination of the chest should never be omitted.

Prostatectomy

The urologist has admitted, publicly as well as privately, that the anaesthetist is an important member of his team, most particularly in the surgical treatment of the prostate gland. Certainly these elderly patients presenting themselves for prostatectomy require every consideration if the best results are to be obtained. There are, broadly speaking, no less than five separate operative methods to consider—(1) transurethral resection (which has already been dealt with), (2) the Freyer operation, (3) the Wilson Hey technique, (4) the Millin retropubic extravesical approach, and (5) the method of prostatectomy with closure of the bladder as devised by Harris. To these we may have to add (6) vesico-capsular prostatectomy, described by Mr. Ogier Ward (1948). There is no evidence so far that this latter method calls for any special anaesthetic technique.

Some of the patients presenting themselves for prostatectomy are in good general condition and are ready for operation without much preliminary treatment. Others are the victims of an unrecognized overflow from a distended bladder and their renal mechanism has been thrown out of gear. Uremia has developed or is impending and most clinics therefore favour a period of suitable treatment before operation. Such
preliminary preparation may include, as already indicated, a temporary suprapubic decompression when this cannot be accomplished by means of an indwelling catheter. Local analgesia is usually satisfactory for the establishment of the suprapubic drainage when this is necessary. It is on the patient's first admission or during the above preliminary phase of treatment that the anaesthetist should have the opportunity of visiting and assessing his patient, and of instituting treatment to improve his operative chances.

In the assessment of the candidate for prostatectomy, attention should be paid to his general condition and appearance, and enquiry should be made into his habits and recreations. The elderly man who walks five miles, digs in his garden or enjoys a game of golf is usually in good form, irrespective of what may be heard with a stethoscope. Estimation of blood-pressure should accompany examination of the heart and chest, and a specimen of blood is taken for urea content. When the results of this examination suggest that the patient will be fit for operation in a few days, the time has come to begin the pre-operative build-up. Mild physiotherapy in the form of breathing exercises is begun, and a short course of strychnine is prescribed. It is given as a mixture containing m. 5 of liquor strychninae thrice daily, for a few days before the operation, and 1/30th gr. strychnine is added to the premedication one hour before going to the theatre. Following operation, gr. 1/60th strychnine is given hypodermically every four hours until the next day, when the oral mixture is resumed for a further three or four days. The benefits which follow the use of strychnine arise from the effects of this drug on muscle tone (Henderson). This improved tone results in support to the circulation and in increased production of carbon dioxide, which means a better respiratory excursion with improved return of blood through the large veins to the right heart. From here an increased pulmonary circulation is followed by improvement in the intake and output of the left heart to the systemic circulation. A higher muscle tone in the lower
limbs does much to obviate phlebothrombosis, a complication which has barely troubled our prostatectomy patients. So-called "delayed shock," occurring four to six hours after prostatectomy is a complication which proves troublesome in some urological units, but this feature is rare in my experience, and whatever part a careful anaesthesia and operative technique may play, it is to the use of strychnine that much of the credit should go. It is well recognized that post-operative shock is accompanied by a conspicuous decrease in muscle tone, whether general or spinal anaesthesia has been employed (Gellhorn). It is not unreasonable to take the view that the converse may be equally true—that maintenance of muscle tone will prevent the post-operative or "delayed shock".

Acknowledging the value of the pre-operative treatment described, and having made the necessary clinical examination of the patient, the final assessment of his condition is based upon (1) the state of his cardio-vascular system, (2) his psychological make-up, and (3) that intangible factor called the experience of the anaesthetist in sizing up his man. The behaviour of the renal system is indicated by the blood-urea examination, and after consultation with anaesthetist and physician, the urologist determines the operation to be performed.

It may be that the patient in poor condition cannot be sufficiently improved to warrant the performance of anything but a rapid enucleation of the gland. Such a technique, after the type of the Freyer operation, exposes the patient to a minimal operative procedure, short of condemning him to a permanent supra-pubic tube. The operation may be performed under spinal analgesia or under any straightforward general anaesthetic such as gas/oxygen/ether or cyclopropane and ether, experience favouring general anaesthesia as there is less danger of upsetting the cardio-vascular mechanism, an upset which may follow a severe fall in blood-pressure consequent upon spinal analgesia.

The Wilson-Hey method leaves no time for pre-operative
development, and spinal analgesia is the anaesthetic of choice with a certain well-defined proviso. It is that the anaesthetic effects are limited to a level which does not permit of a fall in blood-pressure of more than 30 mm. Hg at the close of the operation. A serious fall of blood-pressure in old men is followed by cardio-vascular and nervous disturbances, such as thrombosis, which may occur immediately or subsequent to the operation. Wilson Hey states that too much emphasis cannot be laid upon this blood-pressure question. He favours the use of 1.4 c.c. heavy Nupercaine injected at the third lumbar interspace and the patient is laid flat. Whenever light anaesthesia reaches a point mid-way between the symphysis and the umbilicus, the patient is tilted with the feet downwards so that anaesthesia never reaches the umbilicus. At the same time an intramuscular injection of methedrine (1 c.c.) or its equivalent is given. If the initial blood-pressure is unduly low, e.g. 85 mm. Hg, the surgeon makes use of a local anaesthetic for the suprapubic incision when full anaesthesia has reached no higher than the groins. In such cases there should be no descent of the blood-pressure at all, indeed the pressure ought rather to be higher at the close of the operation than at the beginning.

For the retropubic operation, Magill, writing in Millin's book "Retropubic Urinary Surgery" expresses a preference for intermittent pentothal sodium along with gas and oxygen. The amount of pentothal is limited to 1 gm. The main advantage claimed for this method is the early co-operation of the patient in breathing deeply for the avoidance of post-operative pulmonary complications. Although advocating spinal analgesia as a useful alternative if expert general anaesthesia is not available, Magill cites the tendency of spinal analgesia to cause post-anaesthetic detrusor weakness with the absence of the desirable "vis a tergo" which keeps the bladder empty and minimizes the tendency to clot formation. Learmonth in the article previously quoted reminds us that the parasympathetic is in control of micturition.
Before leaving the choice of anaesthesia for the retropubic operation, attention must be particularly drawn to a short note by Rowbotham in the journal "Anaesthesia" on "Haemostasis in Prostatectomy". Vaso-constriction and contraction of the prostate bed are obtained by paralysing the parasympathetic supply to this region, thus allowing unrestricted action of the sympathetic. This is achieved by the use of spinal analgesia which affects only the sacral segments, including of course the parasympathetic fibres connected with them.

Forrester has skilfully adapted this observation to extend the usual "low spinal" to include the lumbar segments up to the third, leaving the sympathetic origins in the upper two lumbar segments undisturbed, and yet obtaining sensory anaesthesia of the skin and subcutaneous tissues in the suprapubic region. The exact technique is very important as the limitation of the upward spread is the secret of success. He makes use of the fact that the nerve supply to the adductor muscles of the thighs arises mainly from L. 3—the patient's legs are raised and the knees placed together after the spinal drug has been injected. Whenever motor paralysis involves L. 3, the knees begin to separate. The patient is then tilted into the reverse Trendelenburg position, and though sensory paralysis is often adequate, a small amount of pentothal, sufficient to produce sleep, is introduced into the drip which is set up routinely in these cases. It is claimed for the method that it produces haemostasis without an accompanying fall in blood-pressure.

Finally, there is the choice of anaesthesia for closed prostatectomy. Following careful pre-operative measures as already indicated, premedication is limited to omnopon gr. ½ and atropine gr. 1/100th. Some younger patients receive scopolamine gr. 1/150th instead of atropine, but scopolamine is unsuitable for elderly patients generally. It may be said at once that general anaesthesia has been consistently employed, as it is easier to ensure maintenance of blood-pressure than under spinal analgesia, and in addition the blocking off nume-
ous afferent and efferent impulses interferes with the maintenance of muscle tone whose importance has already been discussed.

There are certain criteria which govern the choice of a general anaesthetic for the elderly subjects undergoing this operation. These include—(1) induction should be pleasant, rapid and smooth, avoiding cardio-vascular strain; (2) maintenance should be reasonably free from toxicity, especially as far as kidney function is concerned, and the agent should permit of flexibility in the achievement of the various anaesthetic levels required; (3) recovery should be, for the same reason, as smooth as induction, reasonably rapid and free from sequelae as far as possible. Too rapid a recovery is apt to produce restlessness and efforts to get out of bed—presumably the indwelling catheter induces a desire to empty the bladder in the confused period of recovery, (4) the patient's blood-pressure should be fully maintained—(a) for the surgeon's benefit so that he may see the bleeding at its most active and so control it by his stitching, and (b) for the patient's benefit—for the reasons already emphasized earlier, viz. disturbances of cardio-vascular and nervous systems.

To meet these criteria, a minimal pentothal induction (often no more than 0.2-0.3 gm.) is followed by cyclopropane. To this is added a small amount of ether; recently, curare in moderate dosage has been used on many occasions instead of adding ether. These additions to the cyclopropane usually result in a peaceful awakening on return to bed. Robbins12 has also emphasized the importance of the barbiturates in reducing the cardiac arrhythmias attributed to cyclopropane—a reduction enhanced by the addition of a small quantity of ether. The above combination has resulted in the almost total elimination of these potentially serious irregularities. Much is gained by sending the patient away from theatre with the anaesthetic eliminated to the point of reappearance of muscle tone, e.g. his abdominal muscles should no longer be relaxed, and his jaw should be firmly elevated by the tone in his own
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Mortality = 3.6%. Tubarine cases not included.
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jaw muscles. Ordinary air should gradually replace the anaesthetic mixture in the circuit, as the presence of atmospheric air in the alveoli and bronchiolar and bronchial tree is a good defence against a patchy form of atelectasis which may grow to a larger collapse of the lung. It is noteworthy that Magill emphasizes the importance of adequate breathing in the avoidance of pulmonary complications. Sequelæ after this method of anaesthesia are infrequent and the patient is commonly found reading his paper on the morning following his prostatectomy. Tracings of blood-pressure recorded during operation show that the criteria demanded in this direction are fully met and a typical tracing is reproduced in Fig. 3. A statistical review of 165 cases operated upon under various anaesthetics brings evidence of reasonable results. Many of the operations of earlier date were done under gas/oxygen/ether or closed ether, and the inclusion of these does not seem to prejudice the statistics as presented in Table I, but clinically the patients are in better shape after the more modern techniques. Attention is specially directed to the complete absence of clinically recognizable post-operative pulmonary collapse, for which some credit would appear to be due to strychnine.

The figures presented in Table II are taken from the recent Presidential Address by Mr. W. W. Galbraith to the Urological Section of the Royal Society of Medicine.18 It is with Mr. Galbraith that my experience in anaesthesia for Urological Surgery has been gained, and I would like to conclude by paying this tribute to him for his encouragement and consideration, and for his very early recognition of the importance of co-operation between surgeon, physician and anaesthetist, especially in prostatic surgery.

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2. Learmonth, J. R. Brain, 1931, liv, p. 147 et seq.
8. Wilson Hey. Personal communication to Mr. Galbraith.

DEVICE FOR THE DETERMINATION OF ADEQUATE TIDAL VOLUME UNDER ANÆSTHESIA

By R. P. Harbord, M.D., D.A.

DURING anaesthesia with curare it is not always a simple matter to be sure of an adequate tidal volume because this is judged either by respiratory movements, which vary with the individual, or by the excursions of the reservoir bag. Bags are not all the same size; moreover, spherical alterations are difficult to assess and the visible excursions vary according to the quantity of gas contained.

When respiratory movements are diminished it would be fallacious to judge efficiency of breathing on facial colour changes, because cyanosis may not appear if the subject is breathing an excess of oxygen. In such circumstances carbon-dioxide may accumulate. Theoretically, when the tidal volume falls below about 500 c.c. respiration ought to be aided.