THE TREATMENT OF THE BLADDER IN GUNSHOT INJURIES OF THE SPINAL CORD.

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THE question of the best method of dealing with the paralysed bladder after gunshot wounds of the spinal cord is ripe for discussion in the light of war-time experiences, and of certain researches carried out by Henry Head and Riddoch,* which were published in *Brain*, vol. xv, Parts 1 and 2, 1918. Before the war the profession seemed to be obsessed with the idea that very little could be done for these unfortunate sufferers. This was because the old teaching was largely based on inadequate observations and false assumptions. It was commonly taught:

1. That the bladder once paralysed was unlikely to recover.
2. That the "trophic" nerves to the bladder being damaged, cystitis and pyelitis were almost inevitable.
3. That "automatic" bladder was an extreme rarity (many authorities indeed stated that it could not exist).
4. That patients with injured spinal cords seldom recovered from their paraplegia.

These ideas need considerable modification as the result of war-time experience; I think it can be shown that these cases are not nearly so hopeless as was at one time thought, and that it is worth making every effort to secure for them a clean automatic bladder. Only by so doing can we do away with the chief cause of death, and enable these patients to live a reasonable life of comfort. In some favourable cases we can hope to see them recover from their paraplegia and take up their beds and walk.

The article of Head and Riddoch should be read and digested by all who are interested in the subject, but the following abstract will be convenient for the present purpose.

THE RESEARCHES OF HEAD AND RIDDOCH.

After gunshot injury of the spinal cord the bladder wall may suffer (1) overdistension and atony, and (2) cystitis and fibrosis, conditions which prevent the establishment of automatic bladder.

The paper applies to a third class where the bladder has not been allowed to become overdistended and has been kept comparatively clean. Even in this class there are exceptions when there is profound toxæmia from bedsores. In that case the cord does not sufficiently recover its tone to permit of "spreading reflexes," and consequent automatic flushing of the bladder.

If the bladder has been adequately treated what may happen after some weeks is—

1. To begin with there is occasional and fitful evacuation.
2. Later there is fitful evacuation with a certain amount of dirty residual urine. The catheter is still needed twice a day for lavage purposes.
3. Finally a regular automatic bladder is established, and the bladder empties itself partially or completely at regular intervals without a catheter.

This automatic action can be reinforced by peripheral extravasical stimuli such as swabbing the penis, tickling the soles of the feet, or the anus, or the abdominal wall, or by deep breathing.

The length of time before automatic action can become established is—

1. In partial lesions in fourteen days or more.
2. In total lesions in twenty-one to twenty-eight days.
3. In sacral lesions in three to four months.

Precautions needed to secure automatic bladder—

1. In washing the bladder no pressure must be used which would overstretch the weakened musculature.
2. Severe cystitis must be avoided which would cause degeneration of the musculature and fibrosis of the bladder wall.

When a bladder has learnt to empty itself automatically at a certain size it can be made to act at a smaller size by making use of "mass reflexes," such as tickling the skin of the abdomen or deep breathing. Even in a lesion of the cauda equina an automatic bladder once established could be made to respond more easily by the use of these reflexes. Combined with the detrusor response to these reflexes there is also an inhibitory response to the tonic action of the sphincter muscle when a catheter is not *in situ*.

* A leading article on these researches was published in the BRITISH MEDICAL JOURNAL on April 20th, 1918, p. 457.

Conditions which Influence the Action of an Automatic Bladder.

A. In the central nervous system: (1) Response to tension on the part of the detrusor muscle; (2) relaxation of the sphincter muscle; (3) extravasical "mass" reflexes. These hold good even in the complete absence of the spinal cord. The site of the lesion in the cord makes no difference.

B. Shock, fever, and other general states. Cystitis, septicaemia, fever tend to diminish all reflexes.

The "Mass" Reflex.

In a higher animal with an intact central nervous system the reflex response to a stimulus applied to the skin tends to be limited, well defined, and purposeful, and to exhibit a "local signature"; that is to say, the muscular response evoked by the stimulus tends to direct its action to the purposeful removal of that stimulus. The primitive mass flexor reflexes of the spinal cord are thus overshadowed and controlled by the higher functions of the brain.

When the spinal cord has been completely divided the lower end may, after some time, recover its tonic influence and reflex excitability. The reflexes, however, now assume a form in which they have lost to a great extent their "local signature," and the responses are widespread, ill defined, and purposeless. A stimulus applied to the skin of the leg or abdomen may now produce not only a violent flexor response of the leg but automatic emptying of the bladder and rectum, and excessive sweating. Injection of fluid into the rectum and bladder may also act as a stimulus and produce excessive sweating and a flexor response of one or both legs. Deep breathing will also produce automatic emptying of the bladder.

This type of reflex has been named a "mass reflex" to distinguish it from the normal type of reflex in animals with an intact spinal cord, which is a "type reflex with local signature." Extensor tonic reflexes which control the upright posture of the body appear to be centred in the mid-brain and pons. Flexor reflexes or spasms which permit sudden withdrawal of a limb from a painful contact are the oldest in the phylogenetic scale, and betray their primitive origin—that is to say, the reflex mechanism by which they act lies chiefly in the spinal cord.

When the cord is cut off from the brain intense pain and discomfort can not only evoke a withdrawal of the lower extremity but can also lead to definite visceral reflexes. Urine is passed, the rectum is emptied, and the sufferer sweats. This resembles the reflex of fear.

When the spinal cord is cut across and shock has passed away, the lower end of the cord regains its primitive reflex activity uncontrolled by any influence above the lesion, such as the reflex extensor tone taking origin in the pons and mid-brain. The only response now is a "nociceptive" reflex—a vast outburst of motor energy, not confined to the parts stimulated, overflowing into visceral channels, a profound shrinking away of the animal from harmful stimulation. Not only is the spread of the reflex activity greater than under normal conditions, but the receptive field from which it can be evoked is unlimited below the lesion in favourable cases.

This is the "mass reflex," which cannot occur under normal conditions of higher neural control, though it may occur under violent affective stimuli, as with the emotion of fear.

The great practical outcome of Head's work, apart from its enormous theoretical interest, is that he has shown how to make use of these mass reflexes in gunshot wounds of the spinal cord, in order to abolish the permanent use of the catheter. As it is in most of these cases the catheter that kills, this knowledge will undoubtedly save a great number of lives.

POSTULATES.

If, then, we consider the facts brought to light by Head, we see that the two postulates for obtaining an automatic bladder are:

1. The paralysed bladder must never be allowed to become overdistended and stretched—for if this is permitted the bladder muscle cannot recover its tone and automatic action is impossible.
2. The paralysed bladder must be guarded from severe infection—for if severe infection is permitted the muscle in the bladder wall is destroyed, and is replaced by fibrous tissue which is incapable of automatic contraction.

These two postulates must be used in determining the real and ultimate value of any method of dealing with the paralysed bladder in the first six or eight weeks following an injury of the spinal cord.

WAR-TIME PRACTICE.

During the war it has been the common practice to deal with the paralysed bladder in cases of gunshot wounds of the spinal cord by one of three methods: Either a catheter has been passed intermittently, or suprapubic cystostomy has been performed forthwith, or no catheter has been passed at all and the bladder has been emptied at frequent

intervals by massage and pressure applied above the pubes.

There is also a fourth method, which I have consistently used in these cases, which saves the surgeon's time, renders the nursing much easier, and leaves the patient in the most favourable condition for recovery—and that is the method of the "tied-in catheter."

This method, to my mind, is on the whole the most fool-proof, and is therefore the best fitted to render the patient a fit subject for the establishment of "automatic bladder."

I will begin by discussing the advantages and disadvantages of the first three methods, which have been so extensively employed during the war; the first two should, I think, be discarded, leaving the field for a final decision between the third and fourth methods.

1. *The Method of the Intermittent Catheter.*

A soldier is wounded in the spinal cord, and suffers as a consequence immediate paralysis of the bladder. A catheter is passed on an average twice in twenty-four hours on his way down the line. Under the conditions of warfare it was almost inevitable, with this method, that before a week was out, and by the time he arrived at a base hospital, the bladder had become severely infected and the urethra might be in an inflammatory and bleeding state, which rendered each successive catheter more difficult of insertion.

By this method there is grave danger to life from cystitis and pyelitis, and the bladder wall becomes stretched from overdistension, its wall being paralysed, and the catheter not being passed often enough or regularly enough to secure that the bladder wall is not overstretched.

A few weeks after arrival at a base hospital pyelitis sets in and is often fatal, or if fatal pyelitis is avoided the urine becomes ammoniacal and a phosphatic stone grows in the bladder. Even if these dangers be avoided the result of the overstretching and the sepsis is to render the bladder wall a fibrous envelope, which loses for ever its power to contract automatically, so that permanent catheterization becomes a necessity.

Even were the conditions for the frequent passing of a catheter in war time more favourable than they are, it is my impression that many surgeons are not familiar with the importance of adequate urethral irrigation before the passage of a catheter.² Had this method been more widely known and practised it is my impression that severe cystitis would have been to a much greater extent avoided and prevented. This method, then, offends both the postulates assumed at the head of this section, and should be discarded.

2. *Immediate Suprapubic Cystotomy.*

This, a second method, was suggested by Thomson Walker.³ He advised this method without apparently having practised it in any of his cases before publishing—at least, so I gather if I read his paper rightly. This was, I think, unfortunate, as suprapubic cystotomy was widely used in certain of the clearing stations by surgeons who were not already practised in the most recent methods of suprapubic cystotomy with a mushroom drain, and who were not sufficient masters of modern methods of irrigation of the bladder and in the use of urinary antiseptics by the mouth to secure a clean condition of the urine after operation. The great advantage of this method, if performed at once, is that it does prevent overstretching of the bladder muscles—a very important point.

But it seems to me that it renders the dressing and nursing of these cases even more difficult and time-consuming than they are with the first method, and it certainly tends to make more difficult the avoidance of bedsores and the keeping of the skin of the abdominal wall healthy. This is true if suprapubic shields or ordinary dressings are used, but not to the same extent if a mushroom tube is used as a drain, so as to prevent the leakage of urine on to the skin.

Suprapubic cystotomy, then, saves the time of the surgeon but not that of the nurse, and is not really of great benefit to the patient, for it has been my experience that severe cystitis is the rule rather than the exception in these cases, with consequent pyelitis or formation of stone in the bladder. But a greater objection is that if "automatic bladder" becomes established it is still very difficult to get the suprapubic fistula to heal soundly and permanently, as the suprapubic opening remains the easiest way for the urine to find its outlet in automatic

action, rather than the urethra guarded by the spastic hypertonic sphincter muscle.

This method, then, conforms with the first postulate but offends the second postulate, and I think it should be discarded in favour of one of the last two methods.

3. *The Method of Mechanical Expression.*

The third method was, I believe, first widely adopted in France in 1917, and has been largely used ever since. It consists in expressing the contents of the distended bladder through the weakened sphincter by means of pressure and massage applied above the pubes to the bladder through the abdominal wall. Some men are accustomed to aid this expression by means of a gloved finger in the rectum. The great advantage claimed for this method is that it is said to conform with the second postulate, and that it does diminish the danger of sepsis. It is stated that if no catheter is passed the urine will always remain sterile. All the same I am not yet convinced that this is an accurate statement, and I believe that if the actual state of a series of bladders so treated were to be ascertained, it would be found that many had become infected through the blood stream and kidneys.

On the other hand, if this method is not to offend the first postulate it needs to be carried out at least four times a day, and this means a great application of time and patience on the part of the surgeons and nurses, and it also means that the massage must never be omitted or forgotten for any length of time. Otherwise the bladder muscle will become overstretched by distension, and the muscle will be unable to recover its tone.

If it can be proved by actual results that automatic bladder does become established in a proper proportion of cases so treated, then I think this will turn out to be the method of choice. At the same time, any one adopting this method will have to be prepared to be absolutely regular in his attendance, and, if the case is passed down the line, to see that the massage is not neglected on the way but is continued by all the other men into whose hands the case will fall.

4. *The Method of the "Tied-in" Catheter.*

It now remains to discuss a fourth method, which I have employed consistently throughout the war in dealing with these cases. I was first led to employ it as it seemed to me to save the surgeon's time, to render the nursing far less arduous, and to add immeasurably to the comfort of the patient. The advantages are that there need be no bleeding urethra, no stretching of the bladder, that sepsis is of the mildest description and easily controlled, that the urine can be kept acid so that stones do not form, and pyelitis is less likely to supervene. The skin of the back cannot be soiled with urine, so that there is one less predisposing cause of bedsores, and the surgeon has to pass a catheter at most twice a week.

If the soldier can be steered through the first six to eight weeks of his disability, and if the bladder has not been stretched and has not become too septic, and if in other respects the patient's general condition is good and free from sepsis (bedsores, lung troubles, or other wounds), then it will be found that automatic flushing of the bladder becomes well established, and the need for further catheterization and lavage can be largely if not wholly dispensed with, to the utmost satisfaction of doctor, nurse, and patient. I can describe this method best if I append some instructions I drew up for the information of other surgeons in a military hospital.

GUNSHOT WOUNDS OF THE SPINE.

A Good Method of Dealing with the Paralyzed Bladder by the "Tied-in" Catheter.

Assemble the following articles:

1. An irrigating tin with rubber tubing and glass nozzle attached. Boil these.
2. A No. 9 or No. 10 (English scale) rubber catheter. Boil this.
3. A bottle containing oxycyanide of mercury—1 part in 30 of water.
4. An antiseptic lubricant—namely, tragacanth 2 parts, glycerin 20 parts, oxycyanide of mercury 1 part, distilled water 100 parts. To be put up in a tin squeezer tube.
5. A small safety-pin, two pieces of silk or tape, a narrow piece of strapping.

Fill the irrigator with two pints of water at 100° F., and add two drachms of the oxycyanide of mercury solution. Irrigate the urethra with this solution, so as to cleanse it before passing the catheter.² Lubricate and pass the catheter, and make sure the eye

is lying snugly in the bladder. Fix a safety-pin in the catheter, tie a piece of tape to each end of the pin, and carry these along the sides of the penis, and fix them there with strapping. This strapping should be just tight enough to control the tapes, and yet not so tight as to cause oedema of the prepuce. The tied-in catheter should be left draining into a bottle all the time so that the bladder never becomes distended—a most important point. The bladder can be irrigated with the oxycyanide of mercury solution (one drachm in one pint) twice a day. Be careful not to hold the irrigator higher than six inches above the level of the penis, so as not to force the bladder muscles; run in two ounces only of the lotion at a time, and then allow it to flow out again into a dish. Repeat this manoeuvre five or six times. If the urine is very purulent, and especially if it is alkaline, irrigate four times a day. If the urine is acid, give this mixture by the mouth six-hourly:

Hexamine	5 grains
Acid sodium phosphate	30 grains
Water	to 1 ounce

If the urine is alkaline give six-hourly:

Boric acid	15 grains
Ammonium benzoate	15 grains
Water	to 1 ounce.

Remove the catheter every fourth day, irrigate the urethra and tie in a fresh one. If this is not done the catheter may get blocked and the bladder stretched, and it may even give rise to perineal abscess.

By tying in the catheter several objects are gained:

1. Time is not wasted by passing a catheter frequently.
2. The urethra is not damaged by the constant passing of a catheter.
3. The bladder muscle is not overstretched, so that automatic bladder can be established in a few weeks' time.
4. It is easy to carry out lavage, the urine remains clean, and pyelitis and stone are prevented.

In any lesion of the spinal cord above the cauda equina, if the bladder muscle is not allowed to become overstretched, an "automatic bladder" becomes established in from three to six weeks' time, or occasionally in a little longer time. If "automatic bladder" has become established at the end of three or four weeks the catheter should be removed altogether, and simply introduced once or twice a day for lavage purposes. The hexamine mixture should be continued, and the patient's urination and urine watched.

The patient can learn to induce automatic flushing by tickling the skin of his abdomen, or by deep breathing ("spreading reflex"). When automatic bladder has become completely established, the catheter and lavage are entirely given up, but the mixture is continued indefinitely.

If surgeons would adopt this method they would be surprised to find how simple it is compared with such methods as suprapubic cystotomy or intermittent catheterization.

SUMMARY AND CONCLUSIONS.

I have tried to show that the subject of the treatment of the paralysed bladder after gunshot injuries of the spinal cord is ripe for discussion and needs further consideration.

My own feeling is that the methods of intermittent catheterization and of suprapubic cystotomy are inadvisable, and should be discarded. I think that in the hands of a careful worker the third method of mechanical expression of the bladder is likely to be the best method if it can be proved by end-results that it does not diminish the chances of automatic action. This method is likely to ensure a more or less clean bladder, but will it ensure an automatic bladder?

I feel that until this question is settled the method of the "tied-in" catheter is on the whole the best and most "fool-proof" method, and is likely to lead to the highest percentage of recoveries. By recovery I mean the establishment of a clean automatic bladder. If we can obtain a clean automatic bladder we give the patient a chance of living until he may reach the period of possible recovery from his paraplegia.

This paper has been written in the hope that it will induce other workers to bring forward the results of their cases, so that a comparison of the different methods may be attempted in the future.

REFERENCES.

¹Head and Biddoch, *Brain*, vol. XV, Parts I and II, 1918. ²Frank Kidd, *Common Diseases of the Male Urethra*, 1917, pp. 39-40. ³Thomson Walker, *Lancet*, February 3rd, 1917, pp. 173-179.

REMARKS ON CHEST WOUNDS.

FROM A PHYSICIAN'S NOTEBOOK.

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The following notes on gunshot wounds of the chest, which I have been asked to publish, were jotted down from time to time as the observations occurred. They represent experiences gained on the Western front at all stages, from the regimental aid post to the base hospital in England, mainly, however, at the casualty clearing station. If sometimes I may be adventuring opinions on matters surgical, I plead in extenuation that after working with Duval, Gask, J. Anderson, J. E. H. Roberts, and most particularly and intimately with Lockwood, my surgical colleague at No. 36 Casualty Clearing Station, I have seen thoracic surgery in the making.

The retreat of the Fifth Army (to which I was then consulting physician) in March, 1918, and the rapid advance of the Fourth Army from August 8th to November 11th, impressed upon me the results when military exigencies prevented the application of the surgical principles we had learnt previously. Duval's famous dictum, "the general rules of surgery must be applied to wounds of the lungs," came home at those times with additional force.

In the early stages of chest wounds the physician's first work is to help the surgeon to select cases which require, and are fit for, immediate operation or resuscitation. He has to decide at once with the surgeon and radiographer (1) whether the patient needs immediate operation. If so, why? (2) Can the patient stand immediate operation? If not, why not?

Indications for Immediate Operation.

These are by now pretty well agreed upon. Briefly, they are as follows:

1. Haemorrhage.
2. Injuries of the diaphragm.
3. Open pneumothorax (traumatopnoea).
4. "Stove-in" chest.
5. Retained missiles, bone, and clothing.
6. Early acute infection.

If one or more of these reasons for operation exist, a prolonged physical examination of the chest is unnecessary and inadvisable, unless there is doubt whether the patient will stand an operation.

Cause of Unfitness for Operation.

The patient may be unfit for operation owing to

- Intrathoracic injuries.
- Severity of the external or complicating wounds.
- Loss of blood.
- Collapse or shock due to cold and transport.

It is the physician's province to decide as to the intrathoracic injuries, and he must form a definite opinion on the following points:

Is there a sufficient degree of

- Pneumothorax,
- Haemothorax,
- Collapse of lung,
- Laceration or haematoma of lung,
- Injury of heart, pericardium, or great vessels,
- Injury of diaphragm,
- Injury of vertebrae or spinal cord,

to account for the severity of the symptoms? Radioscopy and radiography are almost indispensable in order to reach a correct conclusion on these points, but it will sometimes happen that a patient's condition will not permit of immediate x-ray examination. When this is so, the question is rendered easier rather than harder. The patient is unfit for any immediate operation save one of the following:

- Immediate and rapid operation for the arrest of visible haemorrhage from the chest wall or thorax.
- Arrest of haemorrhage from coexisting wounds.
- Aspiration for relief of pneumothorax (usually valve pneumothorax).
- Aspiration for relief of haemothorax.
- Temporary closure of open pneumothorax.

Apart from one of these procedures, there remains nothing else to be done than to resort to measures for resuscitation of the patient.