

SECTION OF SURGERY.

SPHINCTERIC CONTROL OF MALE BLADDER, AND ITS RELATION TO PROSTATECTOMY.

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THE exact muscular arrangement by which urine is retained in the bladder is a subject which formerly received much attention from anatomists and physiologists, and which now, owing to its increasing surgical importance, is attracting the attention of many surgeons.

From an anatomical point of view, the following muscles have to be considered:—

1. The internal sphincter vesicæ;
2. The external sphincter vesicæ;
3. The compressor urethræ muscle.

1. The internal sphincter vesicæ is composed of an ill-defined ring of involuntary muscular and elastic fibres surrounding the orifice of the bladder. According to Starling,¹ "careful dissection fails to show any thickening of muscle round the commencement of the urethra sufficient to constitute a sphincter. But the first part of the urethra is surrounded by a muscular coat, consisting of an inner longitudinal layer of fibres, and an outer thicker layer continuous with the inner and middle layers of the bladder." According to Reyfisch,² this internal

sphincter may be inhibited or set in contraction by voluntary impulses.

2. The external sphincter of Henle is composed of a few transverse fibres on the ventral surface of the prostate gland. This in man is the commencement of a sheet of striped muscle which surrounds the urethra to within an inch or so of the external meatus.

3. The compressor urethræ muscle. This is the name applied to a powerful muscular apparatus, of which the inner surface consists of longitudinal and circular unstriated muscles; the outer layer of striped muscle fibres, which are continuous above with the external sphincter of Henle, and surround the membranous urethra circularly and obliquely. This striped muscle is usually called the compressor urethræ muscle.

These muscles are, no doubt, from their position, all concerned in retaining urine in the bladder. Which is the important one to avoid injuring in the surgery of this region is a question which has provoked a good deal of controversy, different observers getting different results according to the methods employed. Now that a large number of prostatectomies have been performed, an opportunity has been afforded in man of deciding the question. The result has been that it has generally been accepted that the important muscle is the compressor urethræ muscle, and that, if incontinence is to be certainly avoided, the membranous urethra should be carefully left uninjured. This question is fully considered by E. Wood Raggles, in the *Annals of Surgery* for April, 1905, in which the following quotation from a paper of Freyer's is given: "It would thus appear that, after complete enucleation of the prostate, the prostatic urethra, deprived of its normal support, widens out in funnel fashion, and practically becomes part of the bladder cavity. It further

demonstrates that the true sphincter of the urethra (or bladder) is situated in the membranous portion of the urethra."

I myself, and I suppose the majority of surgeons interested in this region, felt quite satisfied that the important sphincter muscle was that surrounding the membranous urethra until the following surprising result was obtained in one of my own prostatectomy cases.

A perineal prostatectomy was done on a man, aged seventy-five, on March 8, 1905. Young's conservative operation was attempted. An incision was made in the membranous urethra, and the prostatic tractor inserted into the bladder. The prostate, however, did not enucleate nicely, and had to be removed in pieces, the prostatic urethra being largely destroyed. The mucous membrane of the bladder, however, was not injured. A double tube was inserted into the bladder, and continuous irrigation kept up for five days. The tubes were then removed, and I expected the patient to be constantly wet until the fistula closed. To my surprise this did not occur; the patient asked for the bed-pan the same evening, and passed ten ounces of urine through the fistula. This control continued until the fistula healed, and the urine came per urethram. In this case, the membranous urethra was open in its upper part; the prostatic urethra was largely destroyed; this control, which was almost perfect, must, therefore, have taken place by means of the internal sphincter. This observation, although only an isolated one, still made me seriously consider the question anew, and I resolved to try to find out, experimentally on animals, whether the membranous urethra was so important after all.

In the dog, the prostate is very like that of man, in fact a mesial section through the urethra, prostate and

bladder of a dog is extraordinarily like that of a child. The only apparent difference, microscopically, being the increased development of the glandular structure in the adult dog. In the commoner forms of monkey, the prostate is a small bilateral structure lying mostly on the posterior aspect of the urethra and not distributed so evenly all round the urethra as in the dog and man. I have not yet had an opportunity of dissecting this region in the anthropoid apes.

Dogs were used for the observations, and only the immediate results were considered. It is obvious that here, as in other parts of the body, the muscles left have considerable powers of adapting their function to take the place of those removed. This is one of the reasons that the ultimate perfect control, after prostatectomy in man, does not necessarily mean that the important sphincter muscle has been left uninjured.

In the dog, the prostate can be readily exposed below the bladder by a vertical incision through the lower part of the abdominal wall at the side of the penis. The insertion of the rectus muscle of that side being detached as far out as is necessary to admit the finger to the pelvis. The urethra below the prostate can then be separated from the rectum and the prostate drawn up into the wound. The ease with which this can be done appears to depend on the age of the dog; in some the prostate is on a level with, or even slightly above, the pubis, in others it lies deep in the pelvis. From a considerable number I have examined, it would appear that the older the dog the higher is the position of the prostate with regard to the pelvis. It appears to me also that, if senile hypertrophy takes place, great enlargement might occur without producing any symptoms, because of the freedom of the prostate to expand without compressing the urethra, or en-

croaching on the bladder. The question of hypertrophy of the prostate in the lower animals can only be incidentally referred to here. On a future occasion I hope to deal with it more fully.

Experiment 1.—The prostate was exposed by an incision as described above. The urethra was divided transversely a little below the apex of the prostate, with the object of stitching it to the anterior abdominal wall. To aid in this, and to render it functionless, this piece of urethra was slit up into the prostatic structure, and stitched to the edges of the wound, which was then closed. The following morning the dog made efforts at micturition, but was unable to pass water. A catheter was passed through the prostate and the urine drawn off. After this the dog passed water apparently quite normally, so far as control was concerned, the only difference noticeable was a slight difficulty in cutting off the flow. So that, when only passing a small quantity of urine at a time, after the custom of the dog, a slight dribble took place for a few seconds. This, I think, could to a large extent be accounted for by the fact that the prostate had retracted into the depths of the wound.

Experiment 2.—In order to confirm the first experiment, the prostate and membranous urethra were similarly exposed in another dog. The membranous urethra was quite isolated. An incision was made across the posterior surface of the prostate and into the prostatic tissue, so as to make sure that all the nerves and vessels passing down to the membranous urethra were divided. The muscle fibres surrounding the urethra were then divided, leaving practically only the mucous membrane intact; in fact it appeared quite likely that the urethra might necrose.

The result of this experiment completely confirmed the first, for the dog had perfect control, and micturition was

perfectly normal. It now remained to find out whether this control lay in the prostate or above it.

Experiment 3.—In a third dog, the membranous urethra was cut across as before, and the prostate removed in slices until the entire structure was taken away, with the exception of a small piece on the posterior aspect, which was left to give a fastening to a rubber drainage tube put in to convey the urine to the surface. I was under the impression that, anteriorly, I had injured the bladder sphincter, which was relaxed and open. This relaxation possibly was accounted for by the depth of the narcosis, as by mistake a larger dose of morphia had been given hypodermically, previous to the administration of the anæsthetic, than had been intended.

I had already ascertained that the entire prostate could be sliced away with a moderately distended bladder without the urine escaping. This in itself did not seem conclusive, as the manipulation and stimulus of cutting possibly caused a spasm of the internal sphincter. The result of Experiment 3 was almost exactly the same as that of Experiment 1. There was no incontinence. When the dog was allowed to run about with the bladder distended by the urine of six or eight hours there was apparently some difficulty in cutting off the flow, more dribbling took place between the acts of micturition than in the first experiment. This difficulty of stopping only lasted a few seconds, and seemed to occur when the dog passed water with a full bladder; afterwards, when taken out for a run, micturition seemed perfectly normal.

The dog was chloroformed ten days after the operation, and the bladder, *post-mortem*, contained about two ounces of urine.

The above experiments demonstrate clearly that, in the

dog, the important muscle, which retains the urine in the bladder, is the internal sphincter vesicæ.

Von Zeissel³ has shown, in curarised animals, that the internal sphincter hinders water injected into the urethra from flowing into the bladder, and that stimulation of the nervi erigentes relaxes this sphincter and allows the flow to take place.

Finger,⁴ referring to these experiments of von Zeissel, says that "the anatomical conditions in beast and man are quite different, in beasts the mechanism of the closing of the bladder is according to its anatomical arrangements purely involuntary, in man, on the other hand, it is capable of being decidedly influenced through the will." This statement does not appear to be correct for all animals. I have already pointed out the anatomical similarity between dog and man. In the dog at least, among the animals, micturition is not, "purely involuntary." Many dogs can voluntarily retain their urine for twelve or more hours. This voluntary control is, of course, developed in house dogs, but I have also seen it in sporting dogs that have had no previous training in this respect. Of course that which is true in the case of the dog must also, if possible, be shown to be so in man.

Leedham-Green,⁵ by filling the living human bladder with an emulsion of bismuth, and then taking a radiograph of the pelvis, demonstrates that the full bladder is spherical, that is, that the internal vesical sphincter remains closed, and not, as held by Finger, pear-shaped owing to the pressure of the distending fluid causing the internal vesical sphincter to relax, and allowing the prostatic urethra to distend down to the compressor urethræ muscle. The views of Finger, which are so well known, and so generally accepted, because they explain many phenomena which occur in pathological

conditions of the urethra and bladder, I need not deal with here, as they have recently been so fully gone into by Leedham-Green⁶ in his recent paper in the *British Medical Journal*.

Oppenheim and Löw,⁷ at the clinic of Professor Finger, have carried out similar experiments to Leedham-Green's on the living bladders in apes, having ascertained that they were analogous to those in man. They obtain results supporting Finger's theories.

This ingenious method of investigating the shape of the living bladder is open to the criticism that a certain amount of irritation is produced by the injection of the opaque fluid, whether a catheter is used or not. This may cause a slight spasm of the sphincter muscle, and obscure the result, particularly in the case of one of Leedham-Green's radiographs, which shows a metal bougie *in situ* with the bladder distended.

Again, in the case of the apes, the fact that a certain amount of anæsthesia was necessary possibly accounts for the fact that the internal sphincter is relaxed in the distended bladders.

Conclusions.—In order to prove absolutely that in man the internal sphincter vesicæ is the important muscle, it will be necessary to obtain observations on all cases of surgical interference with this region, particularly in young patients that have not reached the complication of an enlarged prostate, for, in such cases, the action of the internal sphincter must be considerably interfered with, particularly in those in which there is much intra-vesical enlargement. This interference possibly accounts for the symptom, frequently seen in cases that have not reached complete obstruction to micturition—namely, inability to retain the urine if a sudden desire to pass water takes place. When this condition arises, very likely the

compressor urethræ muscle develops increased activity to counteract the symptom.

After prostatectomy, the control of micturition is usually somewhat abnormal at first, but quickly becomes apparently quite normal. This is probably owing to the compensatory powers of the compressor urethræ muscle. Whether the internal sphincter acts after supra-pubic prostatectomy is a point which no doubt will soon be ascertained by autopsies on patients some years after the operation. But it seems quite incorrect to argue, from operations on patients with enlarged prostates, that the chief sphincter of the bladder normally lies in the membranous urethra.

The foregoing experiments were carried out in the School of Physiology in Trinity College, Dublin. I have to express my best thanks to Professor Thompson, King's Professor of the Institutes of Medicine, for placing the resources of the department at my disposal, and for many courtesies extended.

REFERENCES.

- ¹ Text-book of Physiology, edited by E. A. Schäfer.
- ² Virchow's Archiv, 1897. Bd. CL. S. 111.
- ³ Archiv f. d. ges. Physiologie, 1893. Bd. 53.
- ⁴ Die Blennorrhoe Sexualorgane, 1905.
- ⁵ Centralblatt für die Krankheiten der Harn- und Sexualorgane. Bd. XVII., Heft 5. Ausgegeben am 31. Mai 1906.
- ⁶ Brit. Med. Journal. August 11, 1906.
- ⁷ Centralblatt für die Krankheiten der Harn- und Sexualorgane. Bd. XVII., Heft 2. Ausgegeben am 22. February 1906.

MR. T. E. GORDON considered the communication one of the most important which had been laid before the Academy for some time. The experiments appeared to be conclusive as far as they went and as far as it was possible to draw inferences with regard to human physiology from the anatomy and physiology of the dog.

MR. JAMESON JOHNSTON said it had been difficult for him to account for the complete control after suprapubic prostatectomy. He could not conceive that the internal sphincter could exist after the amount of manipulation which it had to undergo, and he thought the amount of damage done to the bladder wall would prevent the internal sphincter from acting again.

MR. GUNN said that in cases where the prostate had been removed by the suprapubic method, and where he thought the internal sphincter was either destroyed or taken away, good control had been got. He believed that the compressor urethræ muscle was the most important to leave behind when interfering with the bladder.