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Anatomical Aspects of Vesicoureteral Reflux

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1. The Prevesical Ureteral Sphincter

Until recently it was supposed that the circular muscle fibers of the ureter disappeared at the point where it entered the bladder wall, leaving only the longitudinal ones, which run slantwise into the ureteral meatus.
A recent detailed investigation made me to think in a different way. No doubt the ureter shows only longitudinal fibers in its parietal segment; however these are not an extension of the fibres bearing the same name in the extravesical ureter, but spring exclusively from the circular fibers of the ureter. In the segment adjoining the bladder,

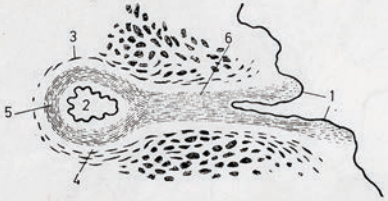

Fig. 1. Scheme of the prevesical ureteral sphincter: 1. Fibers proper of the ureter insert into the ureteral orifice. 2. Ureter upon penetrating into the bladder. 3. Extravesical periureteral sheath. 4. Waldeyer's space. 5. Prevesical ureteral sphincter. 6. Longitudinal fibers the continuation of sphincterial fibers

where it is about to enter the vesical wall, the ureter is composed solely of circular muscle fibers, which fact suggests the idea of a sphincter: the prevesical sphincter (Gil Vernet). On entering the bladder wall these circular fibers change direction, run lengthwise and all end at the labia of the ureteral meatus and the area of the vesical mucosa adjoining the meatus. Fig. 1 sketches this arrangement. In

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other words, the prevesical sphincter and the longitudinal fibers emerging from it to terminate by insertion into the ureteral meatus are two distinct components of a single anatomical structure. The two components combine to make up an anatomical and functional unit – the sphincteral system of the ureter's terminal segment, designed to control the flow of urine and prevent vesicoureteral reflux.

This sphincter lies in the segment of the ureter adjoining the bladder. It measures about 2 cm in length and is made up of very slender muscle fibers arranged in a regular pattern. Only the lowest ones change direction, run lengthwise, and compose the parietal ureter's own fibers, clustering about it. These fibers cross the detrusor urinae, continue inward, and unravel below the vesical mucosa, thus beginning the submucosan stretch. All these fibers and in the labia of the ureteral meatus and in the vesical mucosa adjoining the meatus.

This basic description is valid for all age-groups. Detailed illustrations appear in an article published by *Archivos Españoles de Urología* (1970).

2. Where the Ureter's own Fibers End

The ureter's own fibers end in the ureteral meatus. None of those fibers extend as far as the trigonum vesicae, the neck of the bladder, or the colliculus seminalis.

Fig. 2 shows a series of sagittal sections from the terminal part of the ureter supporting this statement. The appearance of the ureteral fibers, all longitudinal, very slender

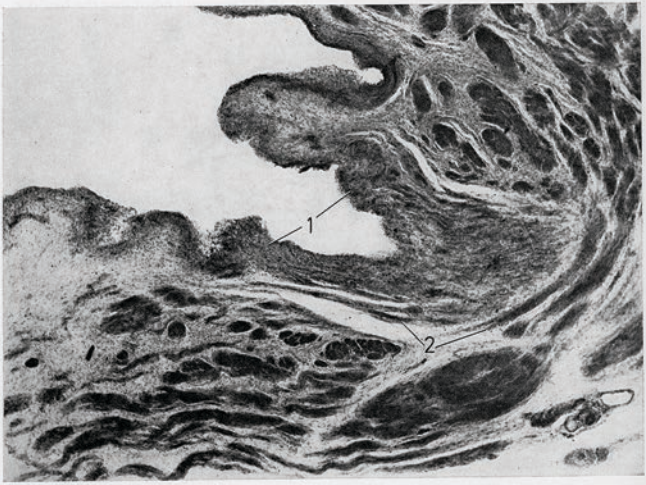

Fig. 2. Parasagittal cut that involves the ureteral orifice. 1. Fibers proper of the ureter inserting into the labia of the ureteral orifice. 2. Fibers of the ureteral sheath

with hardly any interfascicular tissue is in marked contrast to the thick fasces of the detrusor urinae, separated by a large amount of connective tissue. An open space intervenes between the two structures – that is, between the ureter's own fibers and the fasces of the detrusor: this is WALDEYER's cavity. Some fasces of the detrusor, in the shape of slender fascicles (GIL VERNET), approach the ureter. They belong to the periureteral sheath (Fig. 2).
In the sections adjoining the meatus it is possible to observe some very thin fibers which look ureteral and which enter the corium of the vesical mucosa. At the same time muscular elements belonging to the periureteral sheath emerge more noticeably. These will form the slanting segment of the sheath and the interureteral ring.

3. The Periureteral Sheath

In the segment adjoining the bladder and the parietal segment the ureter runs inside a tunnel known as the periureteral sheath. The two structures are separated by an area of lymphatic cells, described by WALDEYER in 1892.
The periureteral sheath comprises two segments, the extravesical and the intravesical, which are simply two different parts of a single structure. It serves to protect the ureter to it, hold in place, and to facilitate its movements in the terminal segment.
The extravesical segment encases about 2 cm of the ureter's length. Its fibers emerge from the detrusor, run upwards, and end at the adventitia of the ureter (Fig. 3).

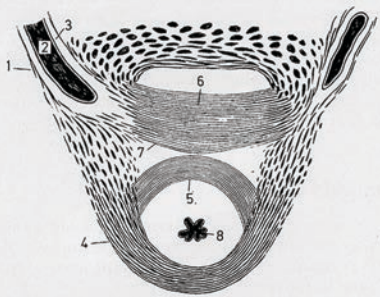

Fig. 3. Scheme periureteral sheath. 1. Extravesical periureteral sheath. 2. Ureter. 3. Waldeyer's space. 4. Loop of the detrusor. 5. Trigonal loop. 6. Interureteral ridge. 7. Oblique portion of the periureteral sheath. 8. Vesico-ureteral orifice

The intravesical segment exhibits more complexity. All its fibers also emerge from the detrusor. Some of them run horizontally and meet those from the other side midway, to form the interureteral ridge. Beyond this ridge other fibers run slantwise to meet those from the opposite side in the middle of the trigonum. All these fibers occupy only the posterior half of the trigonum.

4. Dynamic Interpretation of the Ureteral Musculature

To understand how this musculature works we must admit that the prevesical ureteral sphincter and the longitudinal fibers emerging from it and ending in the ureteral meatus make up an anatomical and functional unit. They relax to allow the passage of urine into the bladder; afterwards they contract, cause closure of the parietal ureter and withdrawal of the meatus, and thus prevent reflux.

If the longitudinal fibers of the parietal ureter were a continuation of the fibers bearing the same name in the extravesical ureter, they would have to contract at the same time, thus causing withdrawal of the meatus at the moment when urine is passed into the bladder and not after. If we assume that these fibers emerge from the sphincter and therefore form an integral part of the sphincteral system, then everything falls into place: closure of the terminal ureter and withdrawal of the meatus are caused by the same muscular structure, the ureteric sphincteral system. Endoscopic examination shows that urine brought along by the ureter empties into the bladder at regular intervals. The column of urine shoots out forcefully as an ejaculation, after which the ureter closes and the meatus withdraws. It seems clear that urinary ejaculation is brought about solely by contraction of the extravesical ureter's musculature: it is the end of the peristaltic wave which begins with a systolic phase in the musculature of the renal pelvis.

Thus the normal prevention of reflux is largely the work of the ureteric sphincteral system.

A subordinate factor preventing reflux is the crosswise segment of the parietal ureter and the segment below the mucosa. At the moment of micturition an increase in bladder pressure closes the ureter by coapting its walls. The technique for preventing reflux consists in the opening of a channel below the mucosa by ureterocystostomy.

The ureter and neighbouring structures must be in a normal state for the walls of the ureter to coapt perfectly. Edema, congestion, inflammation, or sclerosis cause reflux in some cases and ureteral ecstasis in others.

5. Vesicoureteral Reflux

The dynamic interpretation of the sphincteral system adjoining the bladder fits in with the findings of pathologic anatomy; including the hypertrophy of the sphincter and the longitudinal fibers emerging from it in cases of vesicoureteral reflux, where these muscle fibers swell up in the compensatory phase.

Fig. 4 shows a deictic example in a five-year-old child. Congenital and progressive obstruction of the bulbus urethrae caused dilation of the whole of the lower urethra, the vesical neck, and the bladder, and vesicoureteral reflux appeared. This figure shows a horizontal section of the ureter adjoining the bladder. The mucosa is normal and there is extensive hypertrophy of the ureter's own musculature, which forms a solid mass. The muscular fasces are arranged in a circle, looking like a hypertrophied sphincter.

Where the ureter enters the vesical wall it is very small, whether in a normal state or a pathologic one. It corresponds to the lowest part of the ureteral sphincter, at the exact point where the very slender muscle fibers in their circular arrangement carry on as longitudinal fibers (Fig. 5).

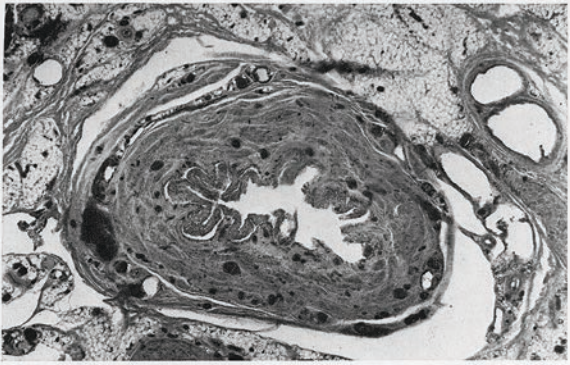

Fig. 4. Prevesical ureteral sphincter hypertrophie

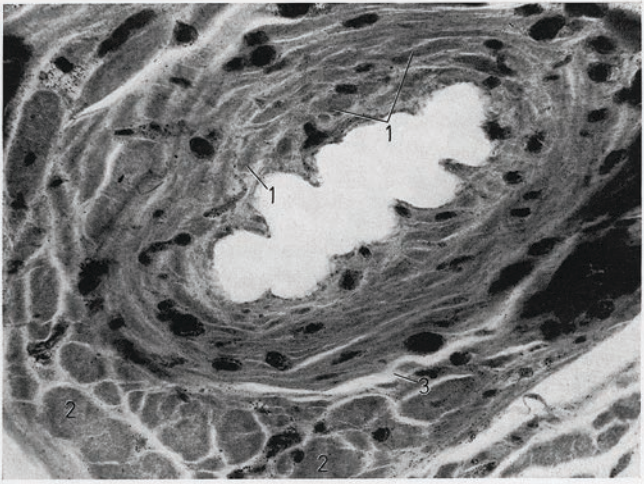

Fig. 5. Ureter where it enters the vesical wall. 1. Circular fibers carrying on as longitudinal fibers. 2. The periureteral sheath. 3. Waldeyer's cavity

Sections taken from the ureter where it passes through the bladder wall appear dilated, as if apersistently stronger vesical pressure had stretched the ureter. This is the first phase of an active reflux brought about during micturition by a sudden increase in vesical pressure. The musculature of the parietal ureter itself, made up of longitudinal fibers that emerge from the sphincter, appears much hypertrophied. It shows the struggle which the sphincteral system has put up to prevent reflux and looks as though intravesical pressure had finally got the better of it.

In short, morphologic examination of the ureter's terminal segment reveals an active ureteral reflux occurring at the moment of micturition. This would certainly have disappeared had the urethral blockage been removed.

Meticulous examination using the method of histotopographic sections during the autopsy of patients who suffered from vesicoureteral reflux, would indubitably give a great deal of insight into such problems. Direct study of the lesions is the best way of understanding them. Knowledge will be increased by exhaustive study of our cases rather than by increased numbers of the cases we study.

Summary

In the segment adjoining the bladder the ureter is made up of circular fibers, which suggest the idea of a sphincter: the prevesical sphincter. These circular fibers enter the bladder wall, change direction to run lengthwise, then all end at the labia of the ureteral meatus and in the area of the vesical mucosa which adjoins the meatus.

This means that the prevesical ureteral sphincter and the longitudinal fibers emerging from it to end in the ureteral meatus are two different parts of a single anatomical structure designed to control the flow of urine and prevent vesicoureteral reflux. When urine shoots into the bladder they relax and allow the urine through; after the ejaculation they contract, causing the parietal ureter to close and the meatus to withdraw so that reflux is prevented. Thus the main factor preventing reflux in the normal person is the ureteric sphincteral system.

A subordinate factor preventing reflux is the slanted segment of the parietal ureter and the segment below the mucosa. During micturition increased vesical pressure closes the terminal ureter by coapting its walls. But in order for this to happen the tissues of the ureter and neighboring structures must be normal. The technique for preventing reflux consists in opening a passage below the mucosa by ureterocystostomy.

The dynamic interpretation of the sphincteral system adjoining the bladder fits in with the findings of pathologic anatomy, hypertrophy of that system in cases of vesicoureteral reflux at the compensating stage. The case we have cited exhibits extensive hypertrophy of the ureter's own musculature, which forms a solid mass as though the sphincter had hypertrophied in its struggle to prevent reflux.

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