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Original article

Correlation between bladder compliance and the content of detrusor collagen fibers

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ABSTRACT

Objective: To explore the possible correlation between bladder compliance (BC) and the changes in detrusor collagen fiber content after bladder outlet obstruction (BOO).
Methods: Ninety healthy female Sprague-Dawley (SD) rats were enrolled in this experiment and divided into an experimental group and a control group randomly, using the randomizing table method, with 70 rats in the experimental group and 20 rats in the control group. Six weeks after BOO modeling was established, BC was evaluated through bladder testing. Bladder tissues were then fixed and embedded in paraffin. The tissues were cut into thin slices, followed by Masson staining and observation under a microscope.
Results: Compared with the control group, the BC of the experimental group rats increased, and the difference had statistical significance ($P < 0.05$); the content of detrusor collagen fibers of the rats in the experimental group increased significantly compared to the control group.
Conclusions: The content of detrusor collagen fibers increased significantly after BOO, and BC was higher.

1. Introduction

With the advent of a gray society, the incidence of benign prostatic hyperplasia has gradually increased in recent years. The major clinical manifestations in males are frequent urination, urgent need to urinate, urinary retention, etc. Many of the lower urinary tract symptoms caused by benign prostatic hyperplasia are caused by changes in bladder function resulting from bladder outlet obstruction (BOO). Clinical investigation indicates that approximately 1/3 of the patients with benign prostatic hyperplasia still have voiding dysfunction after the relief of the obstruction.[1] Therefore, the focus shifts from the prostate to the bladder. Some scholars believe that the increase of the content of collagen fibers in detrusor cells is one of the main causes of voiding dysfunction.[2] In this study, we observed the changes in the content of collagen fibers of rats after BOO, as well as the detrusor contractility, and discussed the correlation between the collagen fiber content and detrusor contractility.

2. Methods

2.1. The model of bladder outlet obstruction (BOO)

The BOO animal model was established by inserting a 1-mm epidural anesthesia catheter into the rat's bladder after anesthesia with 1% pentobarbital sodium and then performing partial ligation of the perineal urethra using 4-0 silk thread in the experimental group. The epidural anesthesia catheter can be pulled out easily. The anesthesia and operation were the same in the control group, but the urethral canal was not ligated.

2.2. Filling cystometry

The sutures were taken out, and a 1 mm epidural anesthesia catheter was inserted into the bladders of experimental group rats for cystometry after anesthesia with 20% urethane. The filling velocity was 12 mL/h, and the infusion was stopped when perfusion liquid was found flowing out from the urethral opening. Bladder leakage point pressure (BLPP) and bladder capacity were recorded.

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2.3. Masson staining

Rat bladder specimens were fixed with ethanol dehydration and embedded in regular paraffin. They were then sliced, stained, and observed under a light microscope. With the use of Masson staining, detrusor muscle fibers were stained red, collagen fibers were stained blue, cell nuclei were stained blue-brown, and red cells were stained brownish red.

2.4. Statistical analysis

Statistics were obtained using SPSS 17.0 software package. The measurement data are shown as $\bar{x}$ (SD), and the inter-group comparison was performed by using analysis of variance.

3. Results

3.1. Establishment of BOO model

Experimental group: Of the 70, 4 rats died of anesthesia, 2 rats died due to tight ligation, another 2 died of infection. Successful model was established in 62 rats, consisting of 48 in the unstable bladder group (DI) and 14 in the stable bladder group (DS). The modeling success rate was 75.61%. All the 20 rats in the control group survived.

3.2. Changes in BC

BC is the ratio of the increment of detrusor and the increment of bladder volume. According to the definition of the International Continence Society (ICS), it can be expressed as $C = \Delta V/\Delta P$. Of which, C is compliance, ΔP is the increment of pressure, and ΔV is the increment of bladder volume when pressure increases by ΔP. Bladder pressure measurement showed that all the BLPPs of the experimental group increased to a certain extent, and the differences of the BLPPs between the groups had statistical significance ($P < 0.05$) (Table 1). It was found that the experimental group could be divided into a high-compliance group (53 cases) and a low-compliance group (9 cases) (Table 1).

3.3. Masson staining

The bladder specimens of the control group rats showed that the space between the red-stained detrusor fascicles was filled with green-stained rich collagen fibers, with compact structure of bladder wall and rich collagen fibers under the mucous membrane (Fig. 1). The bladder specimens of the experimental group rats showed that the transverse fascicles were plump, the detrusor fascicles were disorderly and loose, the space between the fascicles was obviously wider, there was less collagen, and the volume of the fascicles was larger. The green-stained collagen between the fascicles was obviously less, as was that under the mucous membrane (Fig. 2).

Table 1
Comparison of the BLPPs and BCs in different groups ($\bar{x}\pm s$).

Group	BLPP cm H_2O	BC mL/cm H_2O
DI	40.467 ± 3.576*	0.117 ± 0.011*
DS	32.680 ± 1.774**	0.086 ± 0.026**
Control group	16.964 ± 1.738	0.061 ± 0.007
F value	473.364	277.940
P	0.002	0.013

Note: * Compared with control group, $P < 0.05$; ** Compared with DI group, $P < 0.05$.

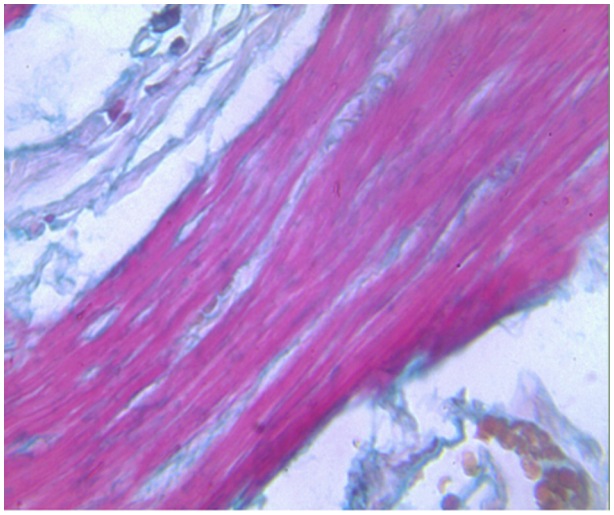

Fig. 1. Histopathological findings of the rats in the control group (Masson staining × 400).

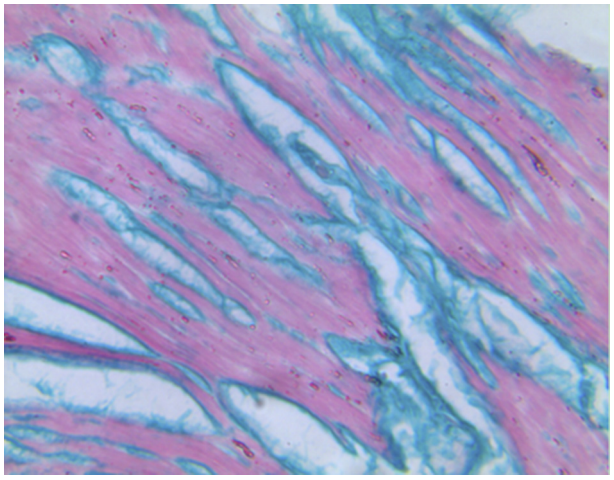

Fig. 2. Histopathological findings of the rats in the DI group (Masson staining × 400).

4. Discussion

4.1. About the animal model

There are many reports about the BOO animal model, adopting the same or different laboratory animals and modes, but the key point is to avoid to the greatest extent the influences on detrusor functions from non-obstruction factors. The most commonly adopted method is ligation, in which ligature of the urethra with silk thread causes artificial urethrostenosis, and then BOO. This method is easy, precise, and reliable, with lower operative strike on animals and a higher success rate.

In the modeling of this experiment, perineal – urethral ligation is adopted. Perineal – urethral ligation is easier to operate than the ligation of the bladder-neck urethra, causes less bleeding, and leaves a smaller scar. The operation does not require dissection of the pelvic cavity; avoiding nervous damage and pelvic pathologic adhesion and making the obstruction of the outflow tract steadier.[3] In addition, preliminary experiments prove that, compared with normal rats, the wet weight and volume of the modeling rats are significantly increased ($P < 0.05$), with reliable obstruction effect.