ORIGINAL RESEARCH

Effects of Catheter Tracking Management on Urinary Tract Function and Infection Rates in Patients With Spinal Cord Injury

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ABSTRACT

Context • Patients with bone-marrow injuries, such as spinal cord injuries (SCIs), usually have urinary dysfunction, changes to the urethra's anatomical structure, and pathophysiological changes of the urinary system, which can lead to urodynamic changes. If a patient receives improper treatment, repeated infections of the urinary system can easily occur, causing hydronephrosis and damage to renal function.

Objective • The study intended to explore the effects of catheter follow-up management for patients with SCIs on the function of the bladder and the urinary tract and on urinary tract infections (UTIs), selecting antibiotics reasonably according to a bacterial culture and drug sensitivity test.

Design • The research team designed a randomized controlled trial.

Setting • The study took place at the Hebei Cangzhou Hospital of Integrated Traditional Chinese Medicine (TCM)-Western Medicine (WM) in Cangzhou City, Hebei Province, People's Republic of China.

Participants • Participants were 92 patients with SCIs who were treated at the hospital between January 2020 and December 2021.

Intervention • The research team randomly divided participants into an intervention group (n = 45) and a control group (n = 47). The control group received routine treatment, while the intervention group received catheter follow-up management.

Outcome Measures • At baseline and postintervention after six weeks of treatment, the research team: (1) examined participants' bladder function, (2) examine urodynamic indexes including measurement of the maximum bladder volume, maximum urethral closure pressure, maximum urinary flow rate, and maximum detrusor pressure, and (3) assessed participants' QoL using the World Health Organization Quality of Life Questionnaire Abbreviated (WHOQOL-BREF).

Results • Improvements in bladder function, urodynamic indexes, QoL, and UTIs occurred in both groups. The intervention group's: (1) total effective rate for bladder function was 91.11%, which was significantly higher than that of the control group ($P = .022$); (2) maximal bladder volume, urethral closure pressure, and urinary flow rate were 365.59 ± 54.43 ml, 81.19 ± 8.8 cmH_2O, and 18.60 ± 2. 43 ml/s, respectively, and were significantly higher than those of the control group (all $P = .000$); (3) maximal detrusor pressure was 47.48 ± 5.64 cmH_2O, which was significantly lower than that of the control group (p=0.000); (4) scores on the WHOQOL-BREF's subdimensions and total score were significantly higher than those in the control group: psychological, 17.92 ± 1.55; physiological, 30.30 ± 1.82; independence, 22.43 ± 1.40; social relations, 16.82 ± 1.32; environment, 21.19 ± 1.85; and total score, 110.02 ±16.64 (all $P = .000$); (5) incidence of urinary tract infection was 17.78 which was significantly lower than that of the control group ($P = .003$). The distribution of bacterial species in the UTIs of the intervention and control groups wasn't significantly different ($P = .869$). The two bacterial groups were Escherichia coli and Enterococcus. Drug sensitivity tests showed that the Escherichia coli were less susceptible to gentamicin, levofloxacin, and piperacillin than to ciprofloxacin, and the Enterococcus were less susceptible to gentamicin, ciprofloxacin, and levofloxacin than to piperacillin.

Conclusions • For patients with SCIs, catheter follow-up management can be helpful in restoring the function of the bladder and urinary tract, can improve patients' QoL, and reduce their rate of UTIs. Clinically, medical practitioners should select antibiotics reasonably according to a bacterial culture and drug-sensitivity test (*Altern Ther Health Med.* 2023;29(3):104-109).

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Spinal cord injury (SCI) is a kind of pathological change that damages the spinal cord's structure and function. Patients with SCIs have impaired micturition function due to pathological reflex changes, such as muscle tension or sensory abnormality.There is a primary center of urination reflex in the spinal cord, and the spinal cord is also an important channel for the senior center to conduct downward and control urination reflex.

Patients and their families strongly press for the recovery of limbs and organs, which makes it extremely urgent to carefully implement urine control management.[1] Welk et al found that the recovery of bladder function is a long process, which increases the pressure on patients and their families.[2]

SCI's causes are various and irreversible, which can lead to abnormal motor, sensory, and autonomic nerve function below the injured plane, detrusor-sphincter dysfunction, and bladder and urethra dysfunction and can seriously affect patients' quality of life (QoL).[3]

Patients' bladder function restored thanks to appropriate urination., and continuous follow-up management. These can promote the recovery of patients' independent micturition function, improve patients' QoL, and reduce the pressure that patients and their families experience.

SCIs can cause increased, residual urine volume, so patients need mechanical urination, such as an indwelling catheter or other drainage device. In the past, medical practitioners have found that urethral catheterization can treat patients with SCIs and improve bladder function.

Urethral Catheterization

An indwelling catheter can improve urinary retention, but long-term placement of a catheter can destroy the urethra's sterility, causing urethral infection and increasing the incidence of urinary-system complications. Long-term indwelling and replacement of urinary catheters can cause the bladder to be unable to perform contractions and expansions autonomously and can reduce the bladder's urinary storage function, which is difficult to recover.[4]

Also, a long-term, indwelling catheter can easily induce bacterial breeding, lead to urinary tract infections (UTIs) and bladder-function damage.[5]Treating the urinary system of SCI patients as soon as possible is important to improving bladder function and preventing UTIs. Medical practitioners need urinary catheterization that has higher safety and is more conducive to the recovery of bladder function.

Medical practitioners consider intermittent urethral catheterization to be an effective measure for emptying the bladder of patients with impaired bladder function. However, due to the influence of individual drinking habits and diseases, individual differences exist in patients' urine production, which can lead to unsatisfactory results from intermittent urethral catheterization.[6]

Catheter Tracking Management

In recent years, clinicians have put forward a new intervention, catheter follow-up management, considering it to be better than conventional urethral catheterization.[7] Catheter tracking management can monitor bladder capacity in real time and adjust the timing and frequency of urinary catheterization according to the bladder's safe capacity, urination volume, and residual urine volume. It can reduce the number of blind urinary catheterizations, avoid long-term retention of urine in the bladder, and reduce the risk of UTIs. Strengthening urethral catheterization management is beneficial for improving patients' urination mode.

Controlling the daily intake and discharge of patients and providing adequate water replenishment is beneficial to the timely discharge of harmful inflammatory substances in the body, and combined with catheter tracking, can reduce the occurrence of UTIs. Bladder function training for patients is also beneficial to improving the coordination of the bladder detrusor and sphincter movement. The above measures jointly maintain bladder function and can reduce the incidence of UTIs.

Urinary control management monitored bladder volume before urination and postvoid residual urine volume in real time mastering urination rules. Adjust the urination volume, frequency and frequency to a stable state, and train and stimulate patients in accordance with normal physiological conditions, clipped catheter, when there is urination, then let go, adjust the amount of water, encourage patients to actively cooperate with the treatment, gradually improve the urination function. After the improvement of bladder function, the patient 's physical and mental pressure is also reduced.

Antibiotics for UTIs

In the course of treatment, medical practitioners should base treatment of UTIs on the actual distribution of pathogenic bacteria and should select drugs with relatively poor drug resistance as far as possible, avoiding selection based on prior empirical knowledge. If patients choose long-term treatment, they can choose oral antibiotics, but the types and quantities of such drugs are small.

Drug resistance is obvious in many outpatients.[8] The drug resistance of urinary tract bacteria and the types and quantities of drug-resistant bacteria show an increasing trend, which can cause patients' immunity levels to decline and can affect the sensitivity of antibacterial drugs. The strains of bacteria in UTIs and their drug resistance are constantly changing. Therefore, a urine culture and drug sensitivity test should occur as soon as possible to guide the correct use of drugs.

Current Study

At present, clinicians pay attention to the repair and maintenance of bladder function, but the complications in bladder function and UTIs after SCIs aren't completely clear.

Some studies[9] have found that catheter follow-up nursing mode can reduce the incidence of UTIs and improve bladder function in some patients, but no study has explored the clinical significance of catheter follow-up management for patients with SCIs.

The current study intended to explore the effects of catheter follow-up management for patients with SCIs on the function of the bladder and the urinary tract and on UTIs, selecting antibiotics reasonably according to a bacterial culture and drug sensitivity test.

METHODS

Participants

The research team designed a randomized controlled trial. The study took place at the Hebei Cangzhou Hospital of Integrated Traditional Chinese Medicine (TCM)-Western Medicine (WM) in Cangzhou City, Hebei Province, People's Republic of China. Potential participants were patients with SCIs who were treated at the hospital between January 2020 and December 2021. Selection of eligible patients according to the inclusion criteria by a competent physician and follow-up by outpatient and telephone.

Potential participants were included in the study if they: (1) had an SCI caused by trauma; (2) had a negative test for urine bacteria before the operation; (3) met the American Spinal Injury Association's (ASIA's) requirements for the: (B) Incomplete injury, partial preservation of sensation below the level of injury, complete loss of motion, (C) Incomplete injury, more than half of the key muscle strength below the injury level is less than 3, the legs can not leave the bed, or (D) Incomplete injury, more than half of the key muscle strength below the injury level is greater than or equal to 3 grade of SCI[10]; and (4) were between 18 and 60 years of age.

Potential participants were excluded from the study if they: (1) also had diseases of important organs, such as the heart, brain, liver, or kidney; (2) had a history of mental illness; (3) had UTIs before the SCI; or (4) had urethral malformations, stones, or prostate disease.

There were 180 potential participants who met the requirements according to the inclusion criteria, and 92 patients were selected according to the exclusion criteria. Participants and their families gave written informed consent, approved by the Hospital Ethics Committee.

Procedures

Randomization. The research team randomly divided participants into an intervention group and a control group using the random number table method.

Operation. Admission for spinal cord injury due to trauma (incomplete injury), related surgery (debridement, laminectomy, spinal canal exploration and decompression) ,and after treatment need to place a catheter. Patients with spinal cord injury have the following conditions and need surgical treatment:

1. Open spinal cord injury should be early debridement.
2. Closed spinal cord injury patients, if the signs of nerve progressive deterioration, should be done as soon as possible laminectomy, spinal canal exploration and decompression.
3. Spine X-ray showed bone fragments in the spinal canal.
4. Uncertain complete spinal cord injury can be considered for surgical exploration.
5. Spinal cord injury, and cervical disc herniation vertebral compression fractures or fracture dislocation caused by spinal cord injury syndrome, after non-surgical treatment is ineffective.

Bacterial culture and drug sensitivity test. At baseline, the research team collected participants' clean urine for a bacterial culture, and conducted a drug sensitivity test using the improved Kirby-Bauer method.[11] The team purchased the drug sensitive paper was from Beijing Tiantan Pharmaceutical Biotechnology Development (Waltham, Massachusetts, USA).

The research team conducted the smear examination and bacterial culture with clean urine of local disinfection of urethral orifice or catheter orifice. According to the standard that the National Hospital Infection Management Committee established, if the colony count was >105 ml, the research team made a diagnosis of a UTI with reference to the microscopic white blood cell count.[12]

Intervention. The control group received routine treatment, while the intervention group received catheter follow-up management. Both groups received midstream urine bacterial smear and bacterial culture. After the bacteria were cultured, the main bacteria were subjected to drug sensitivity test. Both groups received midstream urine bacterial smear and bacterial culture. After the bacteria were cultured, the main bacteria were subjected to drug sensitivity test.

Outcome measures. At baseline and postintervention after six weeks of treatment, the research team: (1) examined participants' bladder function and urodynamic indexes[13] using the Leibury GBS002 urodynamic analysis device (Toronto, Ontario, Canada). including measurement of the maximum bladder volume, maximum urethral closure pressure, maximum urinary flow rate, and maximum detrusor pressure, and (2) assessed patients' QoL using the World Health Organization Quality of Life Questionnaire Abbreviated (WHOQOL-BREF).[14]

Intervention

Control group. The control group received routine treatment, during hospitalization using Catheter model F14-F16. catheter for sterile urethral catheterization, which the nurses changed once a week, injecting 10 mL of water into the balloon, and dipped a sterile cotton ball in iodophor sanitizer (Qingdao Hainuo Bioengineering Co., Ltd., Laixi, Qingdao, Shandong Province, China) every three days to disinfect the pudendum and keep it clean.

The medical staff instructed patients to drink plenty of water and to make a drinking-water plan. The total amount of drinking water needed to be about 1500 mL between morning and 8:00 pm, including food moisture, with the infusion patient reducing the amount of drinking water after that time as appropriate.

Intervention group. The medical staff implemented for patients in the intervention group measures for catheter

Table 1. Comparison of Demographic and Clinical Data Between the Intervention and Control Groups at Baseline

Group	n	Gender		Age, y Mean ± SD	BMI kg/m² Mean ± SD	Damage Plane on Spine				ASIA Grade		
		Male n (%)	Female n (%)			T1 to T12 n (%)	T10 to L3 n (%)	L1 to L5 n (%)	L3 to S1 n (%)	B n (%)	C n (%)	D n (%)
Intervention	45	27 (60.00)	18 (40.00)	38.93 ± 8.82	22.30 ± 2.16	11 (24.44)	14 (31.11)	12 (26.67)	8 (17.78)	18 (40.00)	17 (37.78)	10 (22.22)
Control	47	25 (53.19)	22 (46.81)	39.50 ± 9.14	22.17 ± 2.42	13 (27.66)	16 (34.04)	11 (23.40)	7 (14.89)	21 (44.68)	15 (31.91)	11(23.40)
t/χ^2		.434		-.304	.271	.367				.360		
P value		.510		.762	.787	.947				.835		

Abbreviations: ASIA, American Spinal Injury Association; BMI, body mass index.

tracking management on the basis of the control group, using aseptic intermittent catheterization and placing a portable bladder volumeter (BladderScan BVI 9400, American Ultrasound Diagnostic, Medtronic, Minneapolis, Minnesota, USA） at the patient's bedside to dynamically monitor bladder capacity. The medical staff provided a drinking-water plan for participants. During the treatment, the medical staff trained patients based their own conditioned reflexes to improve their bladder-storage function and activity.

The training indicated that patients should urinate once every 3 hours, and if the residual urine volume was: (1) 300 ml or less, they could change their catheterization frequency to one time every 6 hours; (2) less than 200 ml, they could adjust the timing to one time every 8 hours; and (3) was very small, less than 100 ml, and the bladder volume was greater than 250 m, they could stop follow-up catheterization measures. Bedside ultrasound is used to detect bladder residual urine volume after urination.

The medical staff paid close attention to the participant's micturition volume and residual urine volume during the six weeks of the study. Mastering the regularity of urination, that is, the amount of urine and catheter urination frequency and adjusting the micturition volume and frequency to a stable state. The medical staff also needed to provide follow-up with patients by telephone or in person after discharge from the hospital. If problems occurred in the participant's micturition status, the medical staff gave the patient guidance on urine control management again.

Outcome Measures

Bladder function and urodynamic indexes.[15] Maximum bladder capacity refers to the bladder volume measured when the patient feels strong desire to urinate during bladder filling and has to urinate. Maximum detrusor pressure refers to the maximum detrusor pressure in the standard urodynamic test process; and maximum urethral closure pressure refers to the difference between maximum urethral pressure and bladder pressure. The maximum bladder capacity (normal value of about 400 ml), the maximum urethral closure pressure (normal female 50-94 cmH_20, male 80-100 cmH_20), maximum urinary flow rate (normal value 20ml / s), the above three increased after the intervention on behalf of good urodynamic indicators, urination function; the maximum detrusor pressure (normal ≤ 50 cmH_2O). The decrease of this index after intervention represents good urodynamic index and good urination function.

A remarkable effect occurred when the participant was able to urinate automatically, with the residual urine volume being within the normal range. Improvement occurred when the participant could urinate automatically, and the residual urine volume exceeded the normal range. Ineffective urination occurred when the participant found it impossible to urinate automatically and had to use catheterization and an indwelling catheter for urination. Total effective = remarkable effect + improvement.

WHOQOL-BREF. The questionnaire has five subdimensions: psychological, physiological, independence, social relationships, and environment. The higher the score, the better the QoL.[16,17] The reliability and Cronbach 's α coefficients of the scale were 0.77 and 0.91, respectively.

Statistical Analysis

The research team used SPSS22.0 software (IBM, Amonk City, New York, USA） for the statistical analysis. The team: (1) presented the measurement data as means ± standard deviations (SDs) and compared that data using a *t* test, and (2) presented the counting data as n (%) and compared that data using the χ^2 test. $P < .05$ was considered to be statistically significant.

RESULTS

Participants

The study included and analyzed the data of 92 patients, with 45 participants in the intervention group and 47 in the control group. Table 1 shows the comparison of demographic and clinical data at baseline for the groups. The intervention group included 27 males and 18 females, with a mean age of 38.93 ± 8.82, and the control group included 25 males and 22 females, with a mean age of 39.50 ± 9.14. No significant differences existed between the groups at baseline.

Bladder Function Improvement

Table 2 shows that the intervention group's bladder function was significantly better than that of the control group ($P < .05$). The total effective rate of the intervention group was 91.11%, which was significantly higher than that of the control group, at 78.72% ($P = .022$).

Table 2. Comparison of Improvement in Bladder Function Between the Intervention and Control Groups Postintervention

Group	n	Remarkable Effect n (%)	Improvement n (%)	Ineffective n (%)	Total Effective Rate n (%)	*Z*	*P* value
Intervention	45	23 (51.11)	18 (40.00)	4 (8.89)	41 (91.1)	-2.293	.022[a]
Control	47	14 (29.79)	23 (48.94)	10 (21.28)	37 (78.72)		

[a]*P* = .022, indicating that the intervention group's total effective rate was significantly higher than that of the control group

Table 3. Comparison of Urodynamic Indexes Between the Intervention and Control Groups Postintervention

Group	n	Maximum Bladder Volume (ml) Mean ± SD	Maximum Detrusor Pressure (cmH_2O) Mean ± SD	Maximum Urethral Closure Pressure (cmH_2O) Mean ± SD	Maximum Urinary Flow Rate (ml/s) Mean ± SD
Intervention	45	365.59 ± 54.43	47.48 ± 5.64	81.19 ± 8.83	18.60 ± 2.43
Control	47	320.01 ± 55.76	61.19 ± 7.02	67.70 ± 9.11	16.04 ± 2.81
t		3.965	-10.299	7.207	4.665
P value		.000[a]	.000[a]	.000[a]	.000[a]

[a]*P* = .000, indicating that the intervention group's maximum bladder volume, maximum urethral closure pressure, and maximum urinary flow rate were significantly higher and its maximum detrusor pressure was significantly lower than those of the control group

Urodynamic Indexes

Table 3 shows that postintervention the intervention group's maximal bladder volume, at 365.59 ± 54.43 ml; urethral closure pressure, at 81.19 ± 8.8 cmH_2O; and urinary flow rate, at 18.60 ± 2. 43 ml/s, were significantly higher than those of the control group (all *P* = .000), while the group's maximal detrusor pressure, at 47.48 ± 5.64 cmH_2O, was significantly lower than that of the control group (*P* = .000).

Quality of Life

The scores for the WHOQOL-BREF's subdimensions and total score weren't significantly different between the groups at baseline (data not shown). Table 4 shows that postintervention the intervention group's scores for the five subdimensions and the total score were: psychological, 17.92 ± 1.55; physiological, 30.30 ± 1.82; independence, 22.43 ± 1.40; social relations, 16.82 ± 1.32; environment, 21.19 ± 1.85; and total score, 110.02 ±16.64. All of that group's scores were significantly higher than those of control group (*P* = .000 for all scores).

UTIs and Bacterial Species

Table 5 shows that six participants in the intervention group experienced a UTI during the study and that the group's incidence of UTI was 13.33%. In the control group, 18 participants had a UTI, and the incidence of UTI was 38.29%. The intervention group's UTI incidence was significantly lower than that of the control group (2 = 7.431, *P* < .05). The distribution of bacterial species in the UTIs of the groups wasn't significantly different (*P* = .869). Escherichia coli and Enterococcus were the main species.

Drug Susceptibility

The research team assessed 12 strains of Escherichia coli and 7 strains of Enterococcus for drug susceptibility to nine

Table 4. Comparison of Quality of Life on the WHOQOL-BREF Between the Intervention and Control Groups Postintervention

Subdimensions	Intervention Group n = 45 Mean ± SD	Control Group n = 47 Mean ± SD	*t*	*P* value
Psychological, points				
Baseline	6.12 ± 0.54	6.23 ± 0.70	-0.841	.402
Postintervention	17.92 ± 1.55	13.12 ± 1.15	16.918	.000[a]
Physiological, points				
Baseline	6.89 ± 1.10	6.91 ± 1.16	-0.085	.933
Postintervention	30.30 ± 1.82	25.52 ± 1.73	12.915	.000[a]
Independence, points				
Baseline	8.13 ± 1.15	8.40 ± 1.09	-1.156	.251
Postintervention	22.43 ± 1.40	18.20 ± 1.37	14.646	.000[a]
Social Relations, points				
Baseline	9.10 ± 1.00	9.25 ± 1.06	-0.698	.487
Postintervention	16.82 ± 1.32	13.32 ± 1.55	11.636	.000[a]
Environmental, points				
Baseline	10.82 ± 1.72	11.04 ± 1.80	-0.599	.551
Postintervention	21.19 ± 1.85	19.02 ± 1.90	5.547	.000[a]
Total Score, points				
Baseline	41.72±8.82	41.90 ± 8.94	-0.097	.923
Postintervention	110.02 ± 16.64	90.01 ± 14.54	6.149	.000[a]

[a]*P* = .000, indicating that the intervention group's scores on the WHOQOL-BREF's five subdimensions and total score were significantly higher than those of the control group

Abbreviations: WHOQOL-BREF, World Health Organization Quality of Life Questionnaire Abbreviated.

Table 5. Distribution of Bacterial Species in the Urinary Tract Infections (UTIs) of the Intervention and Control Groups

Type of Bacteria	Intervention Group n = 45 n (%)	Control Group n = 47 n (%)	Fisher Exact Test	*P* value
Escherichia coli	4 (50.00)	8 (36.36)		
Enterococcus	3 (37.50)	4 (18.18)		
Staphylococcus aureus	1 (12.50)	2 (9.09)		
Klebsiella pneumoniae	0 (0.00)	3 (13.64)	3.887[a]	.869[a]
Pseudomonas aeruginosa	0 (0.00)	3 (13.64)		
Acinetobacter baumannii	0 (0.00)	1 (4.55)		
Enterococcus faecalis	0 (0.00)	1 (4.55)		
Total UTIs	8 (17.78)	22 (46.81)		

[a]$\chi^2 = 7.431$, $P = .000$

Table 6. The Sensitivity Rate of 12 strains of Escherichia Coli and 7 strains of Enterococcus to Antibiotics

Antibiotics	Escherichia Coli n = 12 n (%)	Enterococcus n = 7 n (%)
Amikacin	10 (83.33)	6 (85.71)
Gentamicin	5 (41.67)	2 (28.57)
Imipenem	11 (91.67)	6 (85.71)
Aztreonam	10 (83.33)	6 (85.71)
Cefatriaxone	9 (75.00)	5 (71.43)
Ceftazidime	10 (83.33)	5 (71.43)
Ciprofloxacin	2 (16.67)	2 (28.57)
Levofloxacin	3 (25.00)	2 (28.57)
Piperacillin	4 (33.33)	1 (14.29)

antibiotics. The sensitivity of Escherichia coli to gentamicin, levofloxacin and piperacillin was higher than that of ciprofloxacin, while the sensitivity of Enterococcus to gentamicin, ciprofloxacin and levofloxacin was higher than that of piperacillin. not in conformity with the table, should be hanged in parentheses

DISCUSSION

The current study's follow-up management of urinary catheters in the intervention group, found that the total effective rate for the intervention group was 91.11%, which was significantly higher than that of the control group. The study also found that the incidence of UTIs in the intervention group was significantly lower than that of the control group.

In addition, the current study found that the intervention group's QoL was significantly higher than that of the control group postintervention, which suggests that catheter follow-up management can reduce patients' physical and mental burdens.

In the current study, no significant difference existed in the distribution of bacterial species in UTIs between the intervention group and the control group, and Escherichia coli and Enterococcus were the main pathogenic bacteria. Compared with findings of previous studies,[18,19] the detection rate of Enterococcus increased.,

Study Limitations

However, this study also has limitations. Due to the lack of rehabilitation concepts and limited medical conditions in some primary hospitals, the management of urinary control cannot be accurately implemented, and the complications of bladder function and urinary tract infection in spinal cord injury have not been fully evaluated. The requirements for the recovery of limb and organ function of patients and their families are strong, which makes the management of urinary control not detailed enough and requires a large amount of clinical data support.

CONCLUSIONS

For patients with SCIs, catheter follow-up management can be helpful in restoring the function of the bladder and urinary tract, improve patients' quality of life, and reduce their rate of UTIs. Clinically, medical practitioners should select antibiotics reasonably according to a bacterial culture and drug sensitivity test.

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