Original Article
Self-monitoring of blood glucose and effectiveness analysis in subjects with diabetes related urinary tract infections (UTI) after subcutaneous insulin infusion

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Abstract: *Objective:* Urinary tract infections (UTI) is the most common complication among the patients with diabetes. It is a chronic complication with great complexity. The introduction of comprehensive management has salutary effect on reducing the incidence of diabetic microvascular complication and diabetic macrovascular complication. At present, Chinese patients are in a lack of self-management ability and therapy compliance. This research evaluated the effectiveness of supported self-management in subjects with diabetes related UTI. *Methods:* We chose 180 outpatients diagnosed with diabetes related UTI from 2014.11 to 2016.10, and then randomly divided them into treatment and control groups. For the treatment group, we provided instructions in their diabetes self-management. The control group received conventional comprehensive community intervention. After 2 years of treatment, we recorded the patients' BMI, FBG, 2hPG, HbA$_1$c, SBP/DBP, FC, TG, HDL-C, LDL-C as well as their level of diabetes mellitus-related knowledge and self-management ability as evaluated by DKT and Deborah's diabetes self-management scale, and then compared them to the data before treatment. *Results:* Compared to the control group, patients in the treatment group who received two years of comprehensive management showed a statistically significant improvement in their FBG, 2hPG, HbA$_1$c, SBP, TC, and LDL-C ($p<0.05$); the treatment group showed a statistically significant improvement in their level of diabetes mellitus-related knowledge and self-management skills including compliance of diet control, exercise, medication and monitoring ($p<0.05$). *Conclusion:* The introduction of supported self-management significantly improved the metabolic indices and blood pressure of patients with UTI. It also raised the patients' level of diabetes mellitus-related knowledge and self-management ability.

Keywords: Urinary tract infections (UTI), diabetes, supported self-management, HbA$_1$c, ROC analysis

Introduction

As one of the three major threats of human health according to WHO's report, diabetes mellitus, with its ever-growing incidence [1, 2], has become the most serious public health issue man faces in the 21st century [3]. It is a complex chronic disease with a variety of complications [4]. Diabetes related urinary tract infections (UTI) is the most common complication among patients with diabetes [1, 3]. Its morbidity among adolescent patients is about 20%, and ranges between 40% to 50% for adult patients [5, 6]. While chronic end-stage renal disease (CERD) shares some features with T1DM and T2DM, diabetes related urinary tract infections possesses totally different clinical nature from them [7, 8]. Deficiency of insulin is

the major cause of UTI [9-11]. The fluctuation of Insulin resistance (IR) caused by acute and chronic diseases can also influence its incidence [11]. UTI brings detrimental impacts on patients' urinary function and survival rates, especially for female patients [12-14]. Unlike other types of diabetes mellitus, UTI has not yet caused any direct case of atherosclerotic death, while some of the patients are already in their sixties or even seventies [15-17].

In most cases UTI has asymptomatic bacteriuria [17]. According to researchers like Shingler, diabetes might cause considerable influence in patient's nutrition and urinary function [18, 19]. What's more, since it's related to the loss of weight, the degradation of protein, the weakening of urinary function and the increase of death

rate, regular screening of this disease is highly necessary [20]. Although HbA$_1$c is possibly the standard screening indicator for T2DM, its low sensitivity in diagnosing UTI makes it unqualified as the screening test [12, 21]. With reference to Ramirez's research on clinical cases and other suggestions, we agreed that OGTT (oral glucose tolerance test) should be conducted as the screening test [22]. Its innate variability and the patients' individual variability makes OGTT imperfect as a screening test [22]. According to the longitudinal follow-up research, important clinical effects on patients with UTI or diabetes mellitus (diagnosed by OGTT) include remarkable improvement in urinary function after 4 years of treatment and a reduction in the incidence of microvascular complication and early death [12, 23, 24].

Self-management is the ability to manage the symptoms, therapy, one's physiological and psychological status, to adapt to social change and to revise one's lifestyle one develops while receiving treatment of chronic diseases [25-27]. With effective skills in self-management, the patient may enhance his living quality by self-monitoring over his health condition and making alterations in his cognition and emotional patterns [27]. By learning basic theories of diabetes prevention and treatment, diabetes specialty care skills and management of diabetes complications, the patients may acquire self-care techniques and hone their self-management ability [28]. By providing the patients with relative knowledge, we can remarkably strengthen the effectiveness of diabetes diet, which is the basis of treatment against diabetes mellitus [29]. Through scientific diet considering the balance of protein, fat and carbohydrate, we put the patients' weight and blood glucose under control and change their behavior and cognition, thus raises the compliance and operability of diet therapy [27]. Patients who require tong-term insulin injection should receive education of the right use of insulin and learn the preservation method of the medicine, the cycle of injection sites and injection practice that comforts the specifications [30]. We should instruct the patients to adjust the dosage of insulin to enhance its effectiveness. Comprehensive health education may resolve problems patients come across in their use of the insulin [28]. We should make exercise plan for a patient with consideration of his condition, and for patients with diabetes mellitus moder-

ate sports like walking, swimming and bicycling seem to be appropriate. The exercise should last for 20 minutes at least, and 30 to 40 minutes of aerobic exercise per day is highly recommended [2]. Adequate exercise (with the patients' safety assured) brings numerous benefits for the patients' recovery, including a better control over blood glucose, effective monitoring of the disease, reduced incidence of complications and an improved living quality [18].

Studies have showed that introduction of comprehensive management significantly reduces the morbidity of diabetic microvascular complication and diabetic macrovascular complication. At present, Chinese patients are in a lack of self-management ability and therapy compliance. In purpose of building an effective community management over UTI, we took patients of UTI as subjects of the research and collaborated with the society to carry out this comprehensive management engaging the hospital, the community along with the family.

Subjects and methods

Subjects

We chose outpatients with UTI from 2014.11 to 2016.10 as subjects of the observation. The inclusion criteria included the age, which should fall between 30 and 70, more than 5 years of dwelling in the district, certain communicating ability, symptoms corresponding to diagnosis and willingness in receiving the management. Patients with serious difficulty in moving, acute or chronic complications, organ dysfunctions, psychological diseases, history of alcoholism or drug abuse and patients in pregnancy or lactation period were excluded from the experiment. Basic information of patients included in the experiment is listed in **Table 1**.

Grouping and preparations

The 180 patients with diabetes related UTI were divided into treatment and control groups, each consisting of 90 patients. Both groups received intervention management in addition to conventional medication treatment. The treatment group received extra support from experts in tertiary hospitals. Each patient in the treatment group chose a relative to assist and monitor his self-management, building up a community-family supporting system.

Table 1. Basic information of patients with UTI (n = 180)

Item	Control group (n = 90)		Treatment group (n = 90)		X^2	P
	Number of cases	Constituent ratio (%)	Number of cases	Constituent ratio (%)		
Age						
<60	44	48.9	41	45.6	0.843	0.387
≥60	46	51.1	49	54.4		
Sex						
Male	24	26.7	27	30	0.782	0.834
Female	66	73.3	63	70		
Marital status						
Divorced/Widowed	13	14.4	16	17.8	0.917	0.958
Married	77	85.6	74	82.2		
Education background						
University or above	47	52.2	52	57.7	0.636	0.295
Primary school to high school	25	27.8	23	25.6		
Illiterate	18	20	15	16.7		
Average monthly income (￥)						
>5000	33	36.7	35	38.8	0.082	0.642
1500-5000	41	45.5	43	47.8		
<1500	26	28.8	22	24.4		

Intervention methods

Supported self-management method for patients with diabetes related UTI consisted of rational application of insulin under instruction of the medical team. Short-term intensive education, regular health promotions and follow-ups were applied to the treatment group. Instruction of the medical team consisted of time, dosage and route of medication. Patients received short-term intensive education through self-compiled teaching materials, seminars, group discussions and personal instructions. Patients received a total of 6 diabetes self-management lessons in 3 weeks, 2 hours per lesson. The lessons covered basic diabetes-related knowledge, blood glucose monitoring, foot care, diet and exercise methods, correction of unhealthy habits, psychological adjustment and treatment compliance. Health promotion included activities in the "Live High with Diabetes" club, prize-winning quizzes and patient forums, each was held once per month. In addition, we made follow-ups every two months, checking the patients' diabetes symptoms, lifestyles and physical signs (including blood pressure, heart rates and weight). For those who showed fluctuations in blood glucose, intensive measurements of their FBG and 2hPBG before and after adjustments of their therapy were carried out. The HbA₁c was moni-

tored every 3 months, and blood lipid, urinary and kidney function, microalbuminuria and evaluation of their diabetes-related knowledge and self-management ability were carried out every 6 months. The management lasted for two years.

The control group received conventional comprehensive community intervention, which consisted of regular lectures on diabetes mellitus and follow-ups. Contents of the lectures were identical to those delivered to the treatment group. Lectures were carried out every two months, totaling 6 times in one year, each lasted for 1-2 hours. The monthly education consisted oral education and delivering of reading materials. The follow-up schedule was identical to that of the treatment group.

Evaluation indices

For a quantitative research on the influence of the intervention on diabetes related UTI, patients' diabetes-related blood indicators, namely BMI, FBG, 2hPG, HbA₁c [12, 24], SBP, DBP, FC, TG, HDL-C and LDL-C, were analyzed and compared. Moreover, the patients' urinary tract infections-related urine status with indices including urine culture bacterial count (Clean Catch Midstream Urine), urinary pain onset per week, average hematuria times per week were

Table 2. Comparison of diabetes mellitus-related blood indices before and after the intervention

Indices	Treatment group		Control group	
	Before intervention	After intervention	Before intervention	After intervention
BMI (kg/m^2)	25.35±3.47	23.96±3.06	25.26±2.76	25.18±3.08
FPG (mmol/L)	7.93±1.36	6.35±1.03$^{#,*}$	8.05±1.61	6.92±1.24$^#$
2hPG (mmol/L)	12.31±2.06	7.93±2.46$^{#,*}$	12.07±2.58	9.17±1.89$^#$
HbA$_1$C (%)	8.13±1.37	6.85±1.63$^{#,*}$	8.21±1.56	7.74±1.43$^#$
SBP (mmHg)	147.31±17.25	136.15±13.45$^#$	149.24±18.11	133.85±14.27
DBP (mmHg)	74.29±9.85	72.38±9.04	73.72±8.38	72.69±8.89

Data are shown as mean ± SD. $^#P<0.05$, compared to those before intervention; $^*P<0.05$, compared to control group.

Table 3. Comparison of diabetes mellitus-related blood lipid status before and after the intervention

Group		TC (mmol/L)	TG (mmol/L)	HDL-C (mmol/L)	LDL-C (mmol/L)
Treatment group	Before intervention	5.84±1.41	2.39±1.08	1.67±0.37	3.49±0.26
	After intervention	3.62±1.28	1.97±1.01	1.71±0.41	2.37±0.33$^{#,*}$
Control group	Before intervention	5.93±1.52	2.45±1.26	1.73±0.42	3.55±0.31
	After intervention	4.64±0.93	2.13±1.13	1.77±0.48	2.79±0.36$^#$

Data are shown as mean ± SD. $^#P<0.05$, compared to those before intervention; $^*P<0.05$, compared to control group.

tested; and the patients' level of diabetes mellitus-related knowledge and self-management ability were then tested. the data before and after the experiment were compared and analyzed.

Data collection and statistic analysis

Scales were collected in the 6th month before and after the intervention. The patients filled and handed in the questionnaires on the spot. All the measurement data were processed by SPSS 16.0 and indicated as mean ± SD. T test was employed for statistic analysis of the data. The receiver operating characteristic (ROC) area was calculated to assess the discrimination of the model. Finally, the data were recombined to refit the final risk model. The regression coefficients from this model were scaled and rounded to provide a simplified risk formula.

Results

FBG, 2hPG and HbA$_1$c of patients with UTI showed significant reduction after the comprehensive management

In order to make a quantitative research on influence of the intervention method over patients with UTI, we carried out two years of comprehensive management, made statistical analysis over indices including FBG, 2hPG and HBA$_1$c before and after the intervention, then

compared the 2 sets of data. According to the results, FBG, 2hPG and HBA$_1$c of patients in the treatment group showed reduction of statistical significance (p<0.05); Further, 2hPG of patients in the control group showed reduction of statistical significance (p<0.05). Moreover, HBA$_1$c of patients in the treatment group showed reduction of statistical significance (p< 0.05) (**Table 2**). Overall, our intervention method improved the health condition of patients with UTI.

TC and LDL-C of patients with UTI showed significant reduction after the comprehensive management

In order to make a quantitative research on influence of the intervention method over patients with UTI, we carried out two years of comprehensive management, made statistical analysis over indices including TC, TG, HDL-C and LDL-C before and after the intervention, then compared the 2 sets of data. According to the results, TC of patients in the treatment group showed reduction of statistical significance (p<0.05); TG of patients in the control group showed reduction of statistical significance (p<0.05). Compared to control group, HDL-C and LDL-C of patients in the treatment group showed reduction of statistical significance (p<0.05) (**Table 3**). Overall, our intervention method improved the blood lipid condition of patients with UTI.

Table 4. Comparison of patients' urinary tract infections-related urine status before and after the intervention

Group		Urine culture bacterial count (CFU/mL)	Urinary pain onset per week (times)	Average hematuria per week (times)
Treatment group	Before intervention	$9.71\pm1.41*10^8$	12.33±1.08	10.37±0.37
	After intervention	$3.19\pm1.28*10^3$	4.33±1.01	3.33±0.41
Control group	Before intervention	$11.91\pm1.52*10^8$	11.33±1.26	9.73±0.42
	After intervention	$10.91\pm0.93*10^8$	12.33±1.13	9.53±0.48

Data are shown as mean ± SD. #P<0.05, compared to those before intervention; *P<0.05, compared to control group.

Table 5. Comparison of patients' diabetes mellitus-related knowledge and self-management

Group		Diabetes knowledge	Patient's self-evaluation				
			Total score	Diet control	Exercise compliance	Medication compliance	Monitoring compliance
Treatment group	Before intervention	12.84±3.12	18.31±4.83	4.59±1.13	5.06±2.16	4.78±2.24	1.99±2.14
	After intervention	20.37±3.86#,*	26.28±5.03#,*	5.79±1.07#,*	6.24±2.29#,*	6.73±2.07#,*	4.03±2.38#,*
Control group	Before intervention	13.09±2.98	18.46±4.67	4.79±1.36	4.97±1.95	4.68±2.19	2.03±2.45
	After intervention	16.74±3.47#	22.89±5.11#	5.03±1.31#	5.78±1.89#	4.96±2.31	2.54±2.51

Data are shown as mean ± SD. #P<0.05, compared to those before intervention; *P<0.05, compared to control group.

Urine culture bacterial count, pain onset and average hematuria of patients with UTI showed significant reduction after the comprehensive management

In order to make a quantitative research on influence of the intervention method over patients with UTI, we carried out two years of comprehensive management, made statistical analysis over indices including urine culture bacterial count, pain onset and average hematuria before and after the intervention, then compared the 2 sets of data. According to the results, urine culture bacterial count, pain onset and average hematuria of patients in the treatment group showed reduction of statistical significance (p<0.05); urine culture bacterial count, pain onset and average hematuria of patients in the control group showed reduction of statistical significance (p<0.05) (**Table 4**). Overall, our intervention method improved the urine condition of patients with UTI.

Level of diabetes mellitus-related knowledge, self-management ability, diet control and compliance of exercise, medication and monitoring of patients with UTI showed significant improvement after the comprehensive management

In order to make a quantitative research on influence of the intervention method over patients with UTI, we carried out two years of comprehensive management, made statistical analysis over indices including level of diabetes mellitus-related knowledge, self-management ability, diet control and compliance of exercise, medication and monitoring before and after the intervention, then compared the 2 sets of data. According to the results, level of diabetes mellitus-related knowledge, self-management ability, diet control and compliance of exercise, medication and monitoring of patients in the treatment group showed improvement of statistical significance (p<0.05) (**Table 5**).

ROC curve comparisons were illustrated for the mean ROC curves of the observers in patients with UTI

The best combination of sensitivity and specificity of ROC was for the combination of treatment group vs. control group, pregestational BMI (<25; ≥25 kg/m^{-2}) [13, 14], age (<35; ≥35 yr), obstetric history (none versus at least one), family history (no risk factors vs. at least one), and physical activity (sports >2 days a week vs. ≤ 2 day a week). The AUC the ROC of the complete model was 0.7192 (95% CI = 0.698-0.731; p < 0.001) with 60% sensitivity and 65% specificity for detection of patients with UTI (**Figure 1**).

Discussion

Diabetes related UTI (urinary tract infection) is a life-long disease [17, 20]. It is incurable but
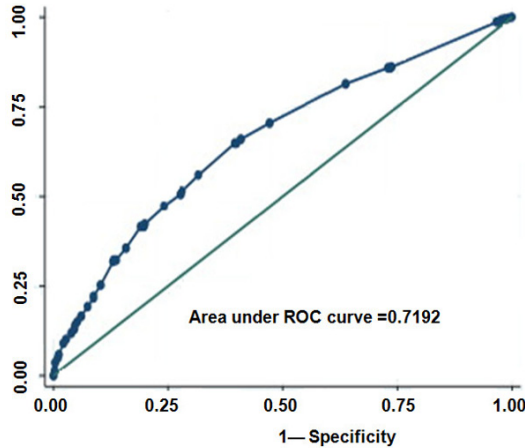
Sensitivity	Specificity	Area under the ROC (95% IC)	P value
0.701	0.746	0.7192 (0.698-0.731)	0.0001

Figure 1. Receiver operating curves for identifying patients with UTI considering modifiable risk factors (categorical nutrition pattern and physical activity level) and non-modifiable risk factors (Pregestational BMI, age and obstetric and family history).

preventable and controllable [17]. In order to get an effective control over the patient's blood glucose, we must help the patient evolve a good self-management, which is the foundation and key element in the treatment, before medications are applied [7, 28]. What's more, since UTI is a somatopsychic disease that interacts with the patient's physiological, psychological and social status, we should introduce support from varied sources and of varied degree so as to meet different needs in different periods of treatment [18]. This feature of the disease decides that that its management takes place mostly in community and family and appoints the patient and his family members to bear the major responsibility [30].

This research combines features of UTI and management advantage of community sanitary service. We processed this disease with applied psychology, introduced "motivational interviewing" developed by Australian researchers, and established the "Live High with Diabetes" club and referred to successful cases of diabetes self-management in foreign countries. On one hand, experts from tertiary hospitals provided full-period support over diabetes self-management; on the other hand, we mobilized patients to collaborate with each other (or their relatives and people in their social network) to provide self-management support of social sort while enhanced their knowledge, skills and confi-

dence of self-management. Compared to the control group, we found that patients in the treatment group showed remarkable improvement in indices of FBG, 2hPG, HbA$_1$c, SBP, TC and LDL-C. after two years of intervention. Moreover, the urine status was also improved after two years self-management. What's more, their cognition of diabetes mellitus and relevant self-managing ability have raised notably in accordance with the report of literature. This comprehensive intervention method might have benefited from its innate advantage in finding contradictions, making schedule, awakening independence and confidence, and changing lifestyles relating to chronic diseases.

When evaluated from perspective of resource optimizing, the application of hospital-community-family intervention method has not only integrated the resources of hospital and community, but also made full use of the collaboration from family members of patients, thus developed a personal and all-round management over patients performed by hospital, community and family acting as a whole. Result-wise the intervention method is equally laudable for its enhancement to the control over blood glucose, blood lipid and blood pressure in patients with UTI along with the positive effect on patients' self-management ability.

Patients with UTI should always receive treatments including oral medication, insulin injection along with scheduled diet and appropriate exercise [18, 19]. All these methods require the patient's self-management ability for better effectiveness, making it a determining factor for the patient's living quality [31, 32]. Through self-management education, patients with UTI acquire knowledge of self-management, learn how to control acute and chronic complications and change lifestyle for a better control over diabetes mellitus [18, 19]. These finally lead to a better collaboration between the doctor and the patient while the patient's living quality gets improved.

Diabetes self-management education offers diabetes mellitus-related knowledge to the patient, improves his self-management ability,

enhances his control over blood glucose, defers development of chronic complications, and consequently improves the quality of his life. In practice, we should evaluate each patient's basic status and customize contents of the lessens for him. Follow-ups should be continually conducted to update the course content for reach self-management.

Disclosure of conflict of interest

None.

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