Infection & Chemotherapy

Original Article

Check for updates

The Predictive Value of Glycated Hemoglobin and Albumin for the Clinical Course Following Hospitalization of Patients with Febrile Urinary Tract Infection

Minoru Kobayashi [1], **Toshitaka Uematsu**[2], **Gaku Nakamura**[2], **Hidetoshi Kokubun**[2], **Tomoya Mizuno**[3], **Hironori Betsunoh**[2], **and Takao Kamai**[2]

[1]Department of Urology, Utsunomiya Memorial Hospital, Tochigi, Japan
[2]Department of Urology, Dokkyo Medical University, Tochigi, Japan
[3]Department of Urology, Nasu Red Cross Hospital, Tochigi, Japan

OPEN ACCESS

Corresponding Author:
Minoru Kobayashi, MD, PhD
Department of Urology, Utsunomiya Memorial Hospital, 1-3-16 Ohdori, Utsunomiya-shi, Tochigi 320-0811, Japan.
Tel: +81-28-622-1991
Fax: +81-28-611-5603
E-mail: minorukoba@hotmail.com

ORCID iDs
Minoru Kobayashi
https://orcid.org/0000-0002-6859-7064

ABSTRACT

Background: Diabetes is considered a risk factor for acquisition of febrile urinary tract infection (f-UTI), but information on the association of diabetes with subsequent course of the disease is lacking. Thus, we investigated the clinical variables including diabetic status which determined the clinical course in patients with community-acquired f-UTI.

Materials and Methods: Patients hospitalized consecutively for f-UTI between February 2016 and January 2018 were used for this single center study. The routine laboratory tests including blood glucose and glycated hemoglobin (HbA1c) were done and empiric treatment with parenteral antibiotics was commenced on admission. The clinical course such as duration of fever (DOF) and length of hospital stay (LOS) were compared among groups classified by the clinical variables.

Results: Among the 101 patients admitted for f-UTI, 15 patients with diabetes (14.9%) experienced significantly longer febrile period and hospitalization compared to those with hyperglycemia (n = 18, 17.8%) or those without diabetes and hyperglycemia (n = 68, 67.3%). Of the laboratory parameters tested on admission and several clinical factors, the presence of diabetes and risk factors for severe complicated infection (hydronephrosis, urosepsis, and disseminated intravascular coagulopathy) as well as HbA1c and albumin were identified as predictors for LOS by univariate analysis, whereas none of the variables failed to predict DOF. In the subsequent multivariate analysis, HbA1c levels and albumin levels were isolated as independent predictors of LOS.

Conclusion: Patients with higher HbA1c and lower albumin levels required the longest period of hospitalization. Thus, an evaluation of diabetic and nutritional status on admission will be feasible to foretell the clinical course and better manage the subset of patients at risk of prolonged hospitalization.

Keywords: Albumin; Glycated hemoglobin; Febrile; Urinary tract infection

INTRODUCTION

Diabetic patients have a higher incidence of bacterial infections with increased morbidity and mortality [1-4]. Urinary tract infection (UTI) is one of the most frequent infections among hospitalized as well as community-based patients with diabetes mellitus (DM). UTI in diabetic patients might present with more severe clinical course [5-7], tend to recur [8], and stay longer in hospital [9]. Despite certain predisposition to bacterial infection in diabetic patients, there are conflicting reports regarding the risk of UTI associated with hemoglobin A1c (HbA1c), blood glucose, and diabetic conditions [10-18].

Till date, very little information exist regarding the impact of diabetes, glycemic control, and other clinical features on the clinical course of patients hospitalized for UTI. If there are some differences in this regard, identifying variables predictive of clinical outcomes will be feasible to better understand the clinical presentation and improve the current management of this patient population. Therefore, in the present study, we aimed to evaluate the clinical outcomes in association with clinical variables including the presence of DM, blood glucose, and HbA1c in hospitalized patients with febrile community-acquired UTI.

MATERIALS AND METHODS

1. Study setting

A single-center, prospective observational study was conducted at Utsunomiya Memorial Hospital. Patients consecutively hospitalized for f-UTI between February 2016 and January 2018 were used for this study. The following laboratory tests were obtained on admission: complete blood count, blood chemistry including blood glucose, HbA1c, albumin, creatinine, blood urea nitrogen (BUN), estimated glomerular filtration ratio (eGFR), aspartate aminotransferase, alanine aminotransferase, alkali phosphatase, lactate dehydrogenase, total bilirubin and C-reactive protein, urinalysis and urine culture. Urine samples were collected using the clean-catch midstream method or urethral catheterization. Urine samples were placed on the blood agar and the deoxycholate-hydrogen sulfide-lactose agar and incubated under aerobically at 37°C. Urine samples showing a colony count more than 10^4 colony forming unit (cfu)/ml were considered as positive for UTI and microorganisms were identified using automated system VITEC2 (bioMèrieux inc, Durham, NC, USA). All patients received empiric treatment using parenteral antibiotics following the discretion of the attending doctor until susceptibility testing was available. The clinical course such as duration of fever (DOF) and length of hospital stay (LOS) were compared among groups classified by the clinical variables to know the underlying differences among them and how diabetic status affects the clinical course of patients hospitalized for f-UTI.

This study was conducted in accordance with the Helsinki Declaration and was approved by the ethical review board of Ustunomiya Memorial Hospital. Each patient signed a consent form that was approved by our institutional review board.

2. Definitions

Febrile UTI was defined as body temperature ≥38°C with pyuria (≥10 leukocytes/ high power field) in the absence of other infectious focus. Acute pyelonephritis was defined as f-UTI with lumbar tenderness or dirty fat sign around the kidney on computed tomography. Acute prostatitis was defined as f-UTI with lower urinary tract symptoms and tenderness by the

digital rectal examination. Urine culture was considered positive for UTI when organisms were growing at a concentration of $\geq 10^5$ cfu/ml. Patients were considered afebrile when body temperature remained below 37°C for more than 24 hours. Admission blood glucose (ABG) level was defined as the blood glucose level closest to the arrival time within 24 hours of the admission date. Patients were dichotomized by the median value of each clinical variable except for the cut-off of 140 mg/dl for ABG and 6.5% for HbA1c. Patients were also divided into three groups by diabetic status: those with known DM before hospitalization (DM group), those without known DM but with ABG ≥ 140 mg/dl (H group), and those without DM and with ABG <140 mg/dl (nDM group). Concurrent hydronephrosis caused by urolithiasis, urosepsis, and disseminated intravascular coagulopathy (DIC) were considered as risk factors for severe complicated infection.

3. Statistics

As collected data were not normally distributed, continuous variables compared two groups using the Mann-Whitney U test or the Kruskal-Wallis test for three groups. Intergroup comparison among three groups was performed by bonferroni correction. The case distribution for categorical variables were analyzed by the chi-square test or Fisher's exact test. The Kaplan-Meier curves were generated to estimate the probability of febrile condition and hospitalization as well as differences between the curves were assessed by the log rank test. Patients were regarded as having events at afebrile condition or hospital discharge and censored at death for this analysis. The Cox proportional hazard analysis was used to evaluate the impact of multiple variables on DOF and LOS. Data were expressed as median [interquartile range (IQR)]. P-value <0.05 was considered to be significant.

RESULTS

1. Patients characteristics

A total of 101 patients (30 men and 71 women) with mean age of 77.7 ± 15.7 years were enrolled, of whom majority (69.3%) were not hyperglycemic on admission. Fifteen (14.9%) patients were presented with known diabetes (DM group), 18 (17.8%) with hyperglycemia (H group), and 68 (67.3%) without diabetes and hyperglycemia (nDM group). Thirty seven (36.6%) patients had any of the comorbidities of cardiovascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, chronic renal failure, malignancies, and so forth other than DM and urolithiasis. Febrile UTI mostly consisted of pyelonephritis (n = 94, 93.1%) with a few exception of prostatitis (n = 4, 3.9%), epididymitis (n = 1, 1%), renal abscess (n = 1), and emphysematous cystitis (n = 1). Fourteen (13.8%) patients had obstructive urolithiasis, 5 of whom needed ureteral stenting during hospitalization. Eight (7.9%) patients showed signs of sepsis, DIC, or both, and were treated with concomitant recombinant human soluble thrombomodulin, immunoglobulin, or both. Overall, 18 (17.8%) patients had either of the risk factors which led to severe complicated infection.

2. Comparison of the patients' characteristics, laboratory parameters, and clinical course among the groups according to the diabetic status

Patients profile represented by age and the presence of comorbidity and risk factors for severe complicated infection were not different among the three groups according to the diabetic status. Of the tested laboratory parameters, ABG, HbA1c, BUN, and eGFR levels were significantly different by the diabetic status. HbA1c levels in diabetic patients were significantly higher than those in H group and nDM group (P < 0.0001). Patients in

Table 1. Comparison of age, laboratory reults, duration of fever, and length of hospital stay according to the diabetic status

		Diabetics (n = 15)		Hyperglycemics (n = 18)		Non-diabetics (n = 68)		P-value[a]	P-value[b]
		Median	IQR	Median	IQR	Median	IQR		
Age		76	72–85	80	75–91	84	74–88	0.5380	
ABG (mg/dL)		198	156–290	159	147–185	113	98–122	<0.0001	
HbA1c (%)		8.05	7.63–8.7	5.6	5.38–6.5	5.4	5.1–5.6	<0.0001	
BUN (mg/dL)		29.3	21.8–34	14.6	10.9–23.8	16.9	11.2–26.5	0.0066	
eGFR (ml/min/1.73m²)		35.8	22.1–56.2	73.9	40.5–96.4	58.3	43.1–74.9	0.0441	
Creatinine (mg/dL)		1.59	0.74–1.92	0.64	0.49–1.22	0.8	0.66–1.07	0.0767	
Duration of fever (days)		6	2.5–8	2.5	2–3.75	4	3–6	0.0289	
Length of stay (days)		10	8–14	8	7–8.75	8	6–12	0.0330	
Number of patients									
Comorbidities	Yes	8		7		22			0.3045
	No	7		11		46			
Risk factors	Yes	4		1		13			0.2570
	No	11		17		55			

IQR, interquartile range; ABG, admission blood glucose; BUN, blood urea nitrogen; eGFR, estimated glomerular filtration rate.
Risk factors include hydronephrosis caused by urolithiasis, urosepsis, or disseminated intravascular coagulopathy.
[a]P-values were determined by the Kruskal-Wallis test.
[b]P-values were determined by the chi-square test or Fisher's exact test.

DM group showed significantly worse renal function indicated by BUN ($P = 0.0066$) and eGFR ($P = 0.0440$), but not by creatinine level ($P = 0.0767$) compared with the other two groups. Median DOF and LOS in all patients were 3.5 (IQR; 2-6) days and 8 (IQR: 7-12) days, respectively. Patients in DM group experienced significantly longer febrile periods ($P = 0.0289$) and hospitalization ($P = 0.0330$) compared with those in the other two groups (**Table 1**).

3. Comparison of the clinical course between the dichotomized groups according to the clinical variables

During the study period, two patients died of sepsis and one patient who had pneumonia subsequently were censored.

Of the laboratory parameters tested on admission and clinical factors including age, sex, presence of comorbidity or diabetes, and risk factors for severe complicated infection, the last two factors as well as HbA1c and albumin were identified as predictors for LOS by the univariate analysis, whereas none of the variables failed to predict DOF. In subsequent multivariate analysis, HbA1c and albumin were associated with LOS (**Table 2**). **Figure 1** depicts Kaplan-Meier survival curves comparing the two groups dichotomized by the defined cut-off values for HbA1c or albumin. Patients with lower HbA1c (≤6.5%) or higher albumin level (>3.2 g/dl) had a shorter hospitalization period than their counterparts ($P = 0.0185$ and 0.0008, respectively). Since HbA1c and albumin were isolated as independent predictors of LOS, patients were classified into three groups according to the combined status of HbA1c and albumin; lower HbA1c and higher albumin (group A, n = 42), higher HbA1c and lower albumin (group B, n = 9), and both higher or lower (group C, n = 50). These categorized groups were significantly associated with LOS ($P = 0.0002$). The intergroup comparison revealed that patients in group A had a significantly shorter period of hospitalization compared with those in group B or C [median LOS of A, B, and C were 7, 11.5, and 9 days, and the pair-wise P-values were 0.0015 (A *vs.* B) and 0.0090 (A *vs.* C), respectively] (**Fig 2**).

4. Difference in isolated microorganisms according to the glycemic status

We thereafter investigated how glycemic conditions affected the etiology of isolated microorganisms. Detailed case distribution of isolated microorganisms according to the diabetic status was displayed in **Table 3** (upper). To characterize the etiology of isolates by the glycemic status, patients were dichotomized into hyperglycemic group (DM and H groups)

Table 2. Significat variables predictive of length of hospital stay by univariate and multivariate analyses

	Univariate				Multivariate		
	No. patients	HR	95% CI	P-value	HR	95% CI	P-value
HbA1c (low *vs.* high)	90/11	2.115	1.04–4.29	0.0185	2.063	1.01–4.23	0.0477
Albumin (low *vs.* high)	56/45	0.585	0.37–0.92	0.0097	0.541	0.36–0.82	0.0036
Diabetes (Yes *vs.* No)	15/86	0.566	0.32–0.94	0.0302			
Risk factors (Yes *vs.* No)	18/83	0.531	0.31–0.91	0.0101			

HR, hazard ratio; CI, confidential interval.
Risk factors include hydronephrosis caused by urolithiasis, urosepsis, or disseminated intravascular coagulopathy.
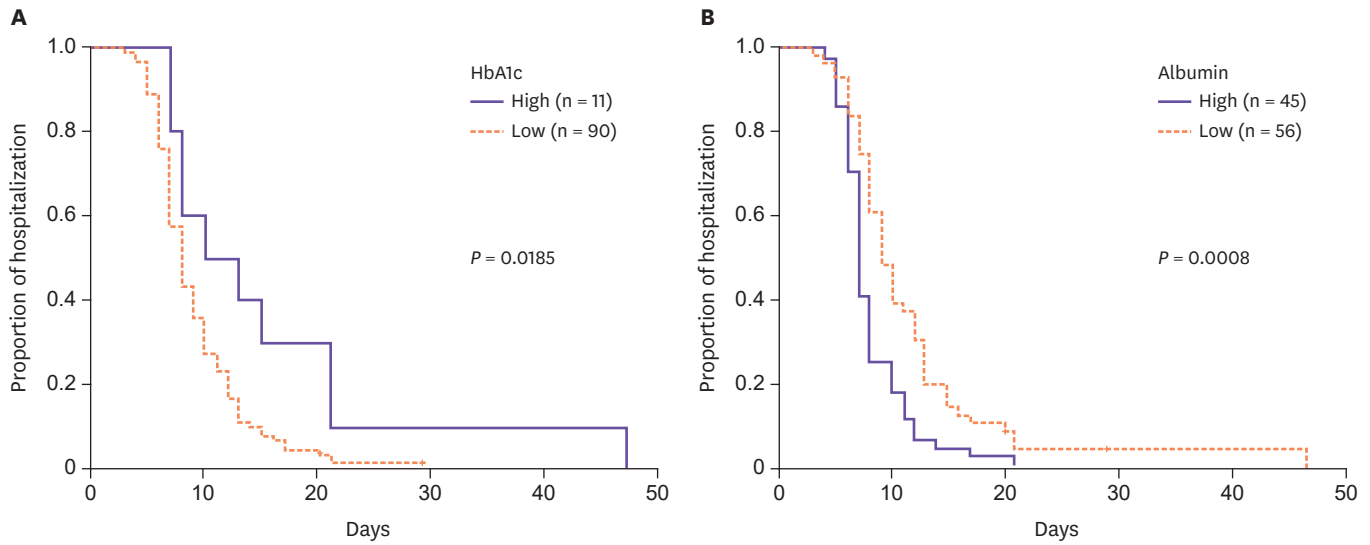
Figure 1. Probability of hospital stay indicated by Kaplan-Meier curves according to HbA1c (A) or albumin (B) levels. Patients with higher HbA1c or lower albumin required longer hospitalization. Note that the lower curves represent better outcomes of shorter hospital stay as discharge from the hospital is counted as an event.
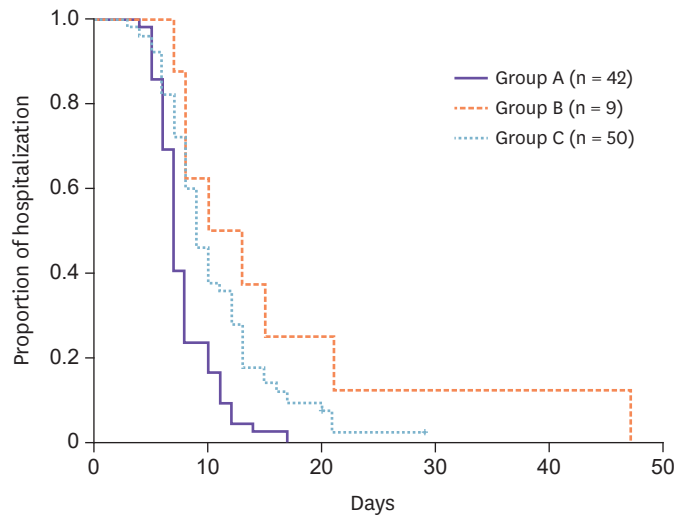
Figure 2. Probability of hospital stay indicated by Kaplan-Meier curves according to the combination of HbA1c and albumin levels.
group A: patients with lower HbA1c and higher albumin, group B: patients with higher HbA1c and lower albumin, group C: patients with both higher or lower albumin.
Patients in group A experienced the shortest hospital stay.

and normoglycemic group (nDM group), and microorganisms were dichotomized into *Escherichia coli* and non-*E. coli*. Patients with DM or hyperglycemia were more likely to have non-*E. coli* uropathogens compared with those without both. (*P* = 0.0328) (**Table 3**, lower).

**Table 3.** Distribution of isolarted microorganisms according to the diabetic status

Microorganisms	DM group	H group	DM or H group	nDM group
Escherichia Coli (ESBL −)	8	6		36
Escherichia Coli (ESBL +)	1	2		8
Enterococcus species	3	7		17
Staphylococcus species	3	2		5
Proteus species	1	1		3
Klebsiella pneumoniae	3	2		2
Others	1	2		1
Escherichia Coli			17 (40.5%)	44 (61.1%)
non-*Escherichia Coli*			25 (59.5%)	28 (38.9%)
Total			42	72

DM, diabetes mellitus; ESBL, extended spectrum β-lactamase.

DISCUSSION

In the present study, we explored the impact of diabetes, glycemic control, and other clinical features on the clinical course of patients with community-acquired f-UTI. It was found that HbA1c and albumin levels at admission were identified as independent predictors for length of hospitalization. When patients were classified by their diabetic status based on known history of diabetes and admission blood glucose level, diabetic patients experienced significantly longer febrile period and hospitalization than those with hyperglycemia but without DM or those without both. The latter had less incidence of non-*E. coli* uropathogens compared with diabetic or hyperglycemic patients.

Previous studies indicated mixed results regarding the risk of symptomatic UTI associated with HbA1c, blood glucose, and diabetic conditions including its presence, duration, and complications. Some studies demonstrated significant associations between predisposition to UTI and HbA1c level or duration of diabetes [10-14], while the others did not find meaningful associations between the incidence of UTI and HbA1c, blood glucose, or diabetic conditions [15-17]. Collectively, the evidence for a causal relationship between UTI and glycemic status seems to be lacking. On the other hand, although it is widely held that diabetic patients are more likely to have a complicated course of infections, the information on how diabetic status affects the clinical course of patients hospitalized for established UTI is quite scarce. Horcajada et al. demonstrated that the duration of hospitalization was significantly longer in diabetics than in non-diabetic patients, although the duration of fever after therapy was similar in both groups [9]. Kim *et. al* also showed a longer period of hospitalization in diabetic than in non-diabetic women with acute pyelonephritis [19]. In contrast, van der Starre *et. al* reported that diabetes was not associated with a longer duration of fever or prolonged hospitalization [20]. In the present study, diabetic status was further classified into 3 groups according to known history of diabetes and ABG level, and their clinical course was compared. Diabetic patients experienced significantly longer febrile period and hospitalization compared with non-diabetics with or without hyperglycemia, suggesting that diabetic patients may need a longer time to recover from acute infection and regain the strength needed to leave the hospital. Inconsistent results regarding the relationship between diabetic status and clinical course may partly come from the difference in uropathogens between diabetics and non-diabetics. That is, previous studies including ours, in which a longer hospitalization in diabetics was indicated, demonstrated that non- *E. coli* and extended spectrum β-lactamase (ESBL) positive or fluoroquinolone resistant *E. coli* were more frequently isolated than in non-diabetics [9, 19]. However, the only report by van der Starre, in which duration of fever and hospitalization were similar, did not
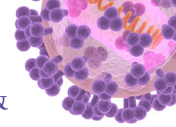
mention the difference in uropathogens but showed that *E. coli* was the most common in both diabetics and non-diabetics [20]. Taken together, diabetics are more susceptible to complicated uropathogens and thus need a longer time for cure compared with non-diabetics. This is biologically plausible, given that diabetics have immunologic deficits such as impaired leukocyte function [21] and a lower pro-inflammatory cytokine production [22], and neuropathic complications that lead to incomplete emptying of the bladder [23].

Furthermore, it has been reported that elevated ABG level is associated with poor outcomes in patients with various acute conditions including stroke, myocardial infarction, heart failure, surgery, trauma, pneumonia, and pulmonary embolism [24-30]. Likewise, the recent study demonstrated that there was a significant association between ABG and short and long-term mortality in patients without DM, but not in patients with DM, hospitalized for UTI [18]. Elevated blood glucose in non-diabetics may be induced by acute infection in which several cytokines stimulate gluconeogenesis and increase insulin resistance as well as cortisol release [31]. Thus, it is assumed that ABG may have predictive value to short-term clinical course in patients hospitalized for UTI. However, ABG was not associated with DOF or LOS in patients without DM (data not shown) as well as in the whole patients.

The present study identified not only HbA1c, but also albumin as independent predictors for the clinical course of patients hospitalized for f-UTI. Combined use of these two predictors discriminate patients' clinical course more precisely. That is, patients with lower HbA1c and higher albumin experienced significantly shorter hospital stay than the others. In contrast, those with higher HbA1c and lower albumin needed the longest period of hospitalization. Low albumin level reflects not only malnutrition, but also underlying conditions such as nephrotic syndrome, enteropathies, and hepatic insufficiency, and also may occur in the setting of acute injury and illness [32]. Systemic inflammation decreases albumin synthesis but increases its degradation. Despite such various factors that affect albumin levels, some studies found that hypoalbuminemia was a risk factor related to the onset, complications, length of hospitalization and mortality caused by various infections [33, 34], as hypoalbuminemia causes deficient immunity in elderly patients, making them prone to infectious diseases [35].

The present study is limited by the relatively small number of patients from a single institution. Given the small subsets of patients for the proposed stratification on which the results are based, the statistical power may be insufficient to draw firm conclusion, and further confirmatory studies will be necessary to confirm the findings.

In conclusion, the present study suggests that poor nutrition and poor glycemic control may contribute to the vulnerability of patients to UTI and expose them to prolonged hospitalization. Thus, evaluation of HbA1c and albumin on first contact may provide accurate guidance to the physicians on which patients may run a complicated course and who may be safely treated. If attention is paid to the nutritional care of patients during hospital stay, hypo-nutrition on admission can be ameliorated, which may facilitate recovery from infections. Also, patients with diabetes or hyperglycemia were liable to have non-*E. coli* uropathogens, suggesting that they may develop more complicated infections and need early intensive treatments. Such approach will contribute to our understanding of the clinical and laboratory characteristics of infections and help to better treat patients suffering from f-UTI.

REFERENCES

1. Shah BR, Hux JE. Quantifying the risk of infectious diseases for people with diabetes. Diabetes Care 2003;26:510-3.
   PUBMED | **CROSSREF**

2. Peleg AY, Weerarathna T, McCarthy JS, Davis TM. Common infections in diabetes: pathogenesis, management and relationship to glycaemic control. Diabetes Metab Res Rev 2007;23:3-13.
   PUBMED | **CROSSREF**

3. Muller LM, Gorter KJ, Hak E, Goudzwaard WL, Schellevis FG, Hoepelman AI, Rutten GE. Increased risk of common infections in patients with type 1 and type 2 diabetes mellitus. Clin Infect Dis 2005;41:281-8.
   PUBMED | **CROSSREF**

4. Davis TM, Weerarathne T, Foong Y, Mason C, Davis WA. Community-acquired infections in type 2 diabetic patients and their nondiabetic partners. The Fremantle Diabetes Study. J Diabetes Complications 2005;19:259-63.
   PUBMED | **CROSSREF**

5. Ubee SS, McGlynn L, Fordham M. Emphysematous pyelonephritis. BJU Int 2011;107:1474-8.
   PUBMED | **CROSSREF**

6. Ko MC, Liu CC, Liu CK, Woung LC, Chen HF, Su HF, Li CY. Incidence of renal and perinephric abscess in diabetic patients: a population-based national study. Epidemiol Infect 2011;139:229-35.
   PUBMED | **CROSSREF**

7. Nicolle LE, Friesen D, Harding GK, Roos LL. Hospitalization for acute pyelonephritis in Manitoba, Canada, during the period from 1989 to 1992; impact of diabetes, pregnancy, and aboriginal origin. Clin Infect Dis 1996;22:1051-6.
   PUBMED | **CROSSREF**

8. Gorter KJ, Hak E, Zuithoff NP, Hoepelman AI, Rutten GE. Risk of recurrent acute lower urinary tract infections and prescription pattern of antibiotics in women with and without diabetes in primary care. Fam Pract 2010;27:379-85.
   PUBMED | **CROSSREF**

9. Horcajada JP, Moreno I, Velasco M, Martínez JA, Moreno-Martínez A, Barranco M, Vila J, Mensa J. Community-acquired febrile urinary tract infection in diabetics could deserve a different management: a case-control study. J Intern Med 2003;254:280-6.
   PUBMED | **CROSSREF**

10. Wang MC, Tseng CC, Wu AB, Lin WH, Teng CH, Yan JJ, Wu JJ. Bacterial characteristics and glycemic control in diabetic patients with *Escherichia coli* urinary tract infection. J Microbiol Immunol Infect 2013;46:24-9.
    PUBMED | **CROSSREF**

11. Lenherr SM, Clemens JQ, Braffett BH, Cleary PA, Dunn RL, Hotaling JM, Jacobson AM, Kim C, Herman W, Brown JS, Wessells H, Sarma AV; DCCT/EDIC Research Group. Glycemic control and urinary tract infections in women with type 1 diabetes: results from the DCCT/EDIC. J Urol 2016;196:1129-35.
    PUBMED | **CROSSREF**

12. Burekovic A, Dizdarevic-Bostandzic A, Godinjak A. Poorly regulated blood glucose in diabetic patients-predictor of acute infections. Med Arch 2014;68:163-6.
    PUBMED | **CROSSREF**

13. Aswani SM, Chandrashekar U, Shivashankara K, Pruthvi B. Clinical profile of urinary tract infections in diabetics and non-diabetics. Australas Med J 2014;7:29-34.
    PUBMED | **CROSSREF**

14. Boyko EJ, Fihn SD, Scholes D, Abraham L, Monsey B. Risk of urinary tract infection and asymptomatic bacteriuria among diabetic and nondiabetic postmenopausal women. Am J Epidemiol 2005;161:557-64.
    PUBMED | **CROSSREF**

15. Czaja CA, Rutledge BN, Cleary PA, Chan K, Stapleton AE, Stamm WE; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Urinary tract infections in women with type 1 diabetes mellitus: survey of female participants in the epidemiology of diabetes interventions and complications study cohort. J Urol 2009;181:1129-34.
    PUBMED | **CROSSREF**

16. Hamilton EJ, Martin N, Makepeace A, Sillars BA, Davis WA, Davis TM. Incidence and predictors of hospitalization for bacterial infection in community-based patients with type 2 diabetes: the fremantle diabetes study. PLoS One 2013;8:e60502.
    PUBMED | **CROSSREF**

17. Jeon CY, Furuya EY, Smaldone A, Larson EL. Post-admission glucose levels are associated with healthcare-associated bloodstream infections and pneumonia in hospitalized patients with diabetes. J Diabetes Complications 2012;26:517-21.
    PUBMED | CROSSREF

18. Akirov A, Elis A. The prognostic significance of admission blood glucose levels in patients with urinary tract infection. Diabetes Res Clin Pract 2016;115:99-105.
    PUBMED | CROSSREF

19. Kim Y, Wie SH, Chang UI, Kim J, Ki M, Cho YK, Lim SK, Lee JS, Kwon KT, Lee H, Cheong HJ, Park DW, Ryu SY, Chung MH, Pai H. Comparison of the clinical characteristics of diabetic and non-diabetic women with community-acquired acute pyelonephritis: a multicenter study. J Infect 2014;69:244-51.
    PUBMED | CROSSREF

20. van der Starre WE, Borgdorff H, Vollaard AM, Delfos NM, van 't Wout JW, Spelt IC, Blom JW, Leyten EM, Koster T, Ablij HC, van Dissel JT, van Nieuwkoop C. Diabetes and the course of febrile urinary tract infection. Diabetes Care 2013;36:e193-4.
    PUBMED | CROSSREF

21. Delamaire M, Maugendre D, Moreno M, Le Goff MC, Allannic H, Genetet B. Impaired leucocyte functions in diabetic patients. Diabet Med 1997;14:29-34.
    PUBMED | CROSSREF

22. Geerlings SE, Brouwer EC, Van Kessel KC, Gaastra W, Stolk RP, Hoepelman AI. Cytokine secretion is impaired in women with diabetes mellitus. Eur J Clin Invest 2000;30:995-1001.
    PUBMED | CROSSREF

23. Daneshgari F, Liu G, Birder L, Hanna-Mitchell AT, Chacko S. Diabetic bladder dysfunction: current translational knowledge. J Urol 2009;182 6 Suppl:S18-26.
    PUBMED | CROSSREF

24. Capes SE, Hunt D, Malmberg K, Pathak P, Gerstein HC. Stress hyperglycemia and prognosis of stroke in nondiabetic and diabetic patients: a systematic overview. Stroke 2001;32:2426-32.
    PUBMED | CROSSREF

25. Yang JH, Song PS, Song YB, Hahn JY, Choi SH, Choi JH, Lee SH, Jeong MH, Kim YJ, Gwon HC. Prognostic value of admission blood glucose level in patients with and without diabetes mellitus who sustain ST segment elevation myocardial infarction complicated by cardiogenic shock. Crit Care 2013;17:R218.
    PUBMED | CROSSREF

26. Barsheshet A, Garty M, Grossman E, Sandach A, Lewis BS, Gottlieb S, Shotan A, Behar S, Caspi A, Schwartz R, Tenenbaum A, Leor J. Admission blood glucose level and mortality among hospitalized nondiabetic patients with heart failure. Arch Intern Med 2007;166:1613-9.
    PUBMED | CROSSREF

27. Yendamuri S, Fulda GJ, Tinkoff GH. Admission hyperglycemia as a prognostic indicator in trauma. J Trauma 2003;55:33-8.
    PUBMED | CROSSREF

28. Golden SH, Peart-Vigilance C, Kao WH, Brancati FL. Perioperative glycemic control and the risk of infectious complications in a cohort of adults with diabetes. Diabetes Care 1999;22:1408-14.
    PUBMED | CROSSREF

29. Foltran F, Gregori D, Caropreso A, Pagano E, Bruno A. Is blood glucose on admission a predictor of mortality in adult acute pneumonia? Clin Respir J 2013;7:276-80.
    PUBMED | CROSSREF

30. Scherz N, Labarère J, Aujesky D, Méan M. Elevated admission glucose and mortality in patients with acute pulmonary embolism. Diabetes Care 2012;35:25-31.
    PUBMED | CROSSREF

31. Marik PE, Raghavan M. Stress-hyperglycemia, insulin and immunomodulation in sepsis. Intensive Care Med 2004;30:748-56.
    PUBMED | CROSSREF

32. Hoffer LJ. Clinical nutrition: 1. Protein-energy malnutrition in the inpatient. CMAJ 2001;165:1345-9.
    PUBMED

33. Delgado-Rodríguez M, Medina-Cuadros M, Gómez-Ortega A, Martínez-Gallego G, Mariscal-Ortiz M, Martinez-Gonzalez MA, Sillero-Arenas M. Cholesterol and serum albumin levels as predictors of cross infection, death, and length of hospital stay. Arch Surg 2002;137:805-12.
    PUBMED | CROSSREF

34. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. Clin Nutr 2008;27:5-15.
    PUBMED | CROSSREF

Infection &
Chemotherapy

35. Takeuchi Y, Tashiro T, Yamamura T, Takahashi S, Katayose K, Kohga S, Takase M, Imawari M. Relationship of aging and nutritional status to innate immunity in tube-fed bedridden patients. Asia Pac J Clin Nutr 2017;26:36-41.
   PUBMED