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Original Article

Developing a model to estimate the probability of bacteremia in women with community-onset febrile urinary tract infection

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Abstract

Introduction: Among patients with urinary tract infection (UTI), bacteremic cases show higher mortality rates than do nonbacteremic cases. Early identification of bacteremic cases is crucial for severity assessment of patients with febrile UTI. This study aimed to identify predictors associated with bacteremia in women with community-onset febrile UTI and to develop a prediction model to estimate the probability of bacteremic cases.

Methodology: This cross-sectional study included women consecutively hospitalized with community-onset febrile UTI at 10 hospitals in Korea. Multiple logistic regression identified predictors associated with bacteremia among candidate variables chosen from univariate analysis. A prediction model was developed using all predictors weighted by their regression coefficients.

Results: From July to September 2014, 383 women with febrile UTI were included: 115 (30.0%) bacteremic and 268 (70.0%) nonbacteremic cases. A prediction model consisted of diabetes mellitus (1 point), urinary tract obstruction by stone (2), costovertebral angle tenderness (2), a fraction of segmented neutrophils of > 90% (2), thrombocytopenia (2), azotemia (2), and the fulfillment of all criteria for systemic inflammatory response syndrome (2). The *c* statistic for the model was 0.807 (95% confidence interval [CI], 0.757–0.856). At a cutoff value of ≥ 3, the model had a sensitivity of 86.1% (95% CI, 78.1–91.6%) and a specificity of 54.9% (95% CI, 48.7–91.6%).

Conclusions: Our model showed a good discriminatory power for early identification of bacteremic cases in women with community-onset febrile UTI. In addition, our model can be used to identify patients at low risk for bacteremia because of its relatively high sensitivity.

Key words: urinary tract infection; pyelonephritis; bacteremia; decision support technique; sensitivity; specificity.

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Introduction

Urinary tract infection (UTI) is the most common extraintestinal infectious disease in women [1]. The incidence of bacteremia in patients with febrile UTI has been reported to be approximately 20%–30% [2−4]. Although the overall mortality rate of febrile UTI is low (~0.3%), that of bacteremic cases increases up to 7.5%–30% [5,6]. In addition, the development of septic shock and admission to the intensive care unit are more frequently observed in patients with bacteremic UTI than in nonbacteremic UTI [2,7]. Furthermore, bacteremic cases have longer time to defervescence and hospital stay than nonbacteremic cases [8].

In acute healthcare settings, including the emergency department, it is important to identify bacteremic cases in patients with febrile UTI for the

assessment of disease severity. Blood cultures, a standard reference test for the detection of bacteremia, are not useful for early identification of bacteremic cases because of the delay in reporting their results [9−11]. We hypothesized that a mathematical tool could be used to identify bacteremic cases in patients with febrile UTI and to assess their severity at the time of initial presentation in acute healthcare settings.

The aim of the study was to investigate predictors associated with bacteremia in women hospitalized with febrile UTI via the emergency department and to develop a prediction model incorporating these predictors for early identification of bacteremic cases.

Methodology

Design

For the model development, a cross-sectional study was conducted at 10 university hospitals in Korea. The study protocol was approved by the Institutional Review Board (IRB) of Inje University Sanggye-Paik Hospital (SGPAIK 2014-06-019) as the central IRB for the multicenter study, which waived the need for informed consent from the participants.

Subjects

From July to September 2014, consecutive female patients over 18 years of age who had a positive urine culture (> 10^5 colony-forming units/mL) performed in the emergency department were prospectively collected using microbiological databases at each hospital. Through a review of medical records, patients who were hospitalized with febrile UTI via the emergency department were included in the study. Febrile UTI was defined by the following criteria: fever (temperature ≥ 38°C) and/or a history of fever and chills within 24 hours before initial presentation, at least one symptom of UTI (dysuria, frequency, urgency, perineal pain, flank pain, or tenderness on costovertebral angle), and a positive urine nitrite dipstick test or pyuria as defined by a positive leukocyte esterase dipstick test or the presence of more than five leukocytes per high-power field (HPF) in a centrifuged sediment [12]. Cases with polymicrobial UTI were excluded. Only the first episode of febrile UTI in each patient during the study period was considered.

Measurements

The primary outcome was bacteremia in women with community-onset febrile UTI. Data were collected using standardized case report forms as soon as patients were enrolled in the study. Collected data included age, comorbidity, underlying conditions, presence of complicated, recurrent, or healthcare-associated UTI, clinical features, and microbiology data.

Comorbidity included cardiovascular, pulmonary, hepatobiliary, neurologic, or connective tissue diseases, diabetes mellitus, malignancy, transplantation, or HIV infection. Comorbidity was also assessed by the Charlson comorbidity index [13].

Underlying conditions at the time of initial presentation included hospitalization for ≥ 48 hours within the preceding 90 days; intravenous therapy at home or intravenous medication therapy; wound care by healthcare workers; hemodialysis clinic attendance or intravenous chemotherapy on an outpatient basis within the preceding 30 days; nursing home residence; bed-ridden state; antibiotic use within the preceding seven days; immunosuppressive, radiation, or renal replacement therapy; chemotherapy; neutropenia; surgery; or invasive procedure within the preceding 30 days.

Complicated UTI was defined as having indwelling urethral catheterization, chronic intermittent catheterization, cystostomy, double-J stent insertion or percutaneous nephrostomy within the preceding seven days, a postvoid residual urine of > 100 mL, urinary tract obstruction by stone or other causes, chronic renal failure (glomerular filtration rate of < 60 mL/minute) or end-stage renal failure, or renal transplantation [14]. Patients who had either three or more episodes of febrile UTI within the preceding 12 months or two or more episodes within the preceding six months were defined as having recurrent UTI [15]. Community-onset UTI was classified to community-acquired or healthcare-associated infections. Healthcare-associated UTI was defined as one of the following at the time of initial presentation or within 48 hours of admission: hospitalization for ≥ 48 hours within the preceding 90 days, intravenous therapy at home or intravenous medication therapy, wound care by healthcare workers, hemodialysis clinic attendance or intravenous chemotherapy on an outpatient basis within the preceding 30 days, or nursing home residence [14]. Otherwise, the remaining cases were defined as having community-acquired UTI.

Collected data on clinical features at the time of presentation included duration of fever (temperature ≥ 38°C), chills, dysuria, frequency, urgency, perineal pain, flank pain, anorexia, nausea, vomiting, tenderness on costovertebral angle, altered mental status, hypotension (systolic blood pressure < 90 mmHg), tachycardia (heart rate > 90 beats/minute), tachypnea

(respiratory rate > 20 breaths/minute), hypothermia (temperature < 36°C), leukocytosis (white blood cell [WBC] > 12,000 cells/μL) or leukopenia (WBC < 4,000 cells/μL), anemia (hemoglobin < 10 g/dL), thrombocytopenia (platelet < 150,000 cells/μL), prolongation of prothrombin time (international normalized ratio > 1.3), hypoalbuminemia (serum albumin < 3.5 g/dL), hyperbilirubinemia (total bilirubin > 1.5 mg/dL), azotemia (blood urea nitrogen > 20 mg/dL or serum creatinine > 1.5 mg/dL), or a positive nitrite dipstick test or pyuria (positive leukocyte esterase test or > 5 leukocytes/HPF) in a centrifuged sediment. Serum procalcitonin level was measured according to the judgement of doctors in the emergency department. Finally, the criteria for systemic inflammatory response syndrome (SIRS) that were observed in each case were assessed.

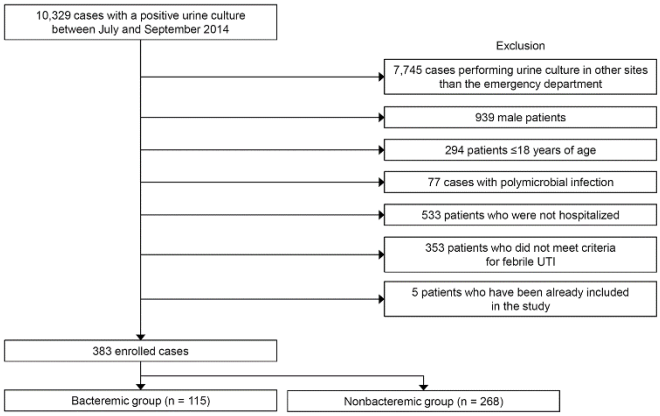
Microbiology data included microorganisms isolated from urine or blood cultures.

Statistical analyses

In univariate analysis, baseline characteristics of bacteremia group were compared with those of nonbacteremia group. Pearson's χ^2 test was used for categorical variables and the results were represented as frequencies or proportions. Student's *t*-test was used for continuous variables, and the results were shown as either mean and standard deviation or median and range. All candidate variables with $p < 0.20$ in the univariate analysis were included in a multiple logistic regression analysis using forward stepwise selection. A level of significance of $p < 0.10$ was used for inclusion, and $p > 0.05$ for exclusion. The goodness-of-fit of the model was assessed using the Hosmer-Lemeshow test. A prediction model was developed by assigning the nearest whole number points to all chosen predictors derived from a multiple logistic regression model in proportion to their regression coefficients. The score of the model was represented as the sum of the assigned points to all predictors presenting in each case. The discriminatory power of the model was assessed by drawing a receiver operating characteristic (ROC) curve. For the model calibration, the risk for bacteremia in all enrolled cases was stratified to low (the predicted probability < 10%), intermediate (10%–30%), or high (> 30%), in accordance with the model score. As internal validation while adjusting the model parameters for potential over-fitting or optimism, area under a ROC curve (*c* statistic) and its 95% confidence interval (CI) were calculated by bootstrapping with 1,000 replications. Missing data was assumed to have occurred at random, depending on the observed variables. Missing values were imputed by a use of multiple imputation techniques. To ensure reliability of data, any variable recorded for < 50% of all enrolled cases was not included in the regression analysis, resulting in the exclusion of serum procalcitonin level from the model development. Instead, the *c* statistic of the model was compared with that of serum procalcitonin level in the subgroup in which its results were available.

SPSS version 20 (IBM, Armonk, USA) was used for the statistical analyses. A two-tailed p value of < 0.05 was considered to be statistically significant.

Figure 1. Flow diagram for eligibility of cases with community-onset febrile urinary tract infection.



Results

From July to September 2014, a total of 10,329 cases with a positive urine culture were screened at 10 hospitals. Of these, 9,946 cases were excluded due to the following reasons: the urine culture was performed at sites other than the emergency department (7,745 cases), male gender (939 cases), age ≤ 18 years (294 cases), polymicrobial infection (77 cases), discharge from the emergency department (533 cases), criteria for febrile UTI were not fulfilled (353 cases), or previous enrollment in the study (5 cases). Finally, 383 women who were hospitalized with febrile UTI were included in the study: 115 (30.0%) bacteremic and 268 (70.0%) nonbacteremic cases (Figure 1).

Among 383 urinary isolates, *Escherichia coli* (86.9%) was the most common pathogen, followed by *Klebsiella* spp. (6.3%), *Proteus mirabilis* (2.1%), enterococci (1.8%), or streptococci (0.8%). Of 115 bacteremic cases, *E. coli* (89.6%) was the most common pathogen isolated from the urine, followed by *Klebsiella* spp. (6.1%), and *P. mirabilis* (2.6%). In each bacteremic case, an isolate from the urine was phenotypically identical to that from the blood. Of 268

nonbacteremic cases, *E. coli* (85.8%) was also the most common uropathogen, followed by *Klebsiella* spp. (6.3%), enterococci (2.2%), *P. mirabilis* (1.9%), and streptococci (1.1%).

Comparison of baseline characteristics

Baseline characteristics for both bacteremia and nonbacteremia groups are summarized in Table 1. The median age of bacteremia group (68 years) was higher than that of nonbacteremia group (61 years) ($p < 0.001$). Diabetes mellitus was more common in the bacteremic group than in the nonbacteremic group ($p < 0.001$). However, there was no significant difference in the Charlson comorbidity index between the two groups ($p = 0.121$). Urinary tract obstruction by stone was more frequent in the bacteremic group than in the

Table 1. Comparison of clinical characteristics between bacteremia and nonbacteremia groups.

Variable	No. (%) of cases (n = 383)		p value
	Bacteremia (n = 115)	Nonbacteremia (n = 268)	
Median age (range, years)	68 (18–102)	61 (19–97)	< 0.001
Comorbidity			
Diabetes mellitus	49 (42.6)	62 (23.1)	< 0.001
Malignancy	9 (7.8)	15 (5.6)	0.490
Neurologic diseases	24 (20.9)	38 (14.2)	0.129
Median Charlson comorbidity index (range)	1 (0–3)	1 (0–4)	0.121
Complicated urinary tract infection			
Urinary catheterization within the preceding 7 days	3 (2.6)	17 (6.3)	0.208
Postvoid residual urine > 100 mL	7 (6.1)	15 (5.6)	0.815
Urinary tract obstruction by stone	16 (13.9)	11 (4.1)	0.002
Urinary tract obstruction due to other causes	2 (1.7)	7 (2.6)	0.730
Vesicoureteral reflux	0	1 (0.4)	1.000
Chronic renal failure or end-stage renal disease	8 (7.0)	15 (5.6)	0.641
Renal transplantation	0	6 (2.2)	0.185
Healthcare-associated urinary tract infection	31 (27.0)	61 (22.8)	0.703
Recurrent urinary tract infection	13 (11.3)	28 (10.4)	0.857
Symptoms or signs at the time of initial presentation			
Median duration of fever (range, days)	2 (0−14)	2 (0−14)	0.411
Chills	82 (71.3)	179 (66.8)	0.405
Dysuria	34 (29.6)	93 (34.7)	0.346
Frequency	40 (34.8)	94 (35.1)	1.000
Urgency	9 (7.8)	33 (12.3)	0.217
Perineal pain	13 (11.3)	46 (17.2)	0.166
Flank pain	50 (43.5)	101 (37.7)	0.306
Tenderness on costovertebral angle	87 (75.7)	171 (63.8)	0.024
Altered mental status	29 (25.2)	44 (16.4)	0.048
Systolic blood pressure < 90 mmHg	26 (22.6)	26 (9.7)	0.002
Heart rate > 90 beats/min	69 (60.0)	150 (56.0)	0.500
Respiratory rate > 20 breaths/min	42 (36.5)	56 (20.9)	0.002
Temperature > 38°C or < 36°C	94 (81.7)	202 (75.4)	0.186
Laboratory findings at the time of initial presentation			
WBC > 12,000/μL or < 4,000/μL or band form > 10%	78 (67.8)	163 (60.8)	0.206
Fraction of segmented neutrophils > 90%	45 (39.1)	32 (11.9)	< 0.001
Platelet < 150,000/μL	45 (39.1)	40 (14.9)	< 0.001
Prothrombin time (INR) > 1.3	15 (13.0)	35 (13.1)	1.000
Albumin < 3.5 g/dL	51 (44.3)	70 (26.1)	0.001
BUN > 20 mg/dL or creatinine > 1.5 mg/dL	70 (60.9)	78 (29.1)	< 0.001
Positive urine nitrite dipstick test	64 (55.7)	144 (53.7)	0.739
Positive urine leukocyte esterase test	93 (80.9)	188 (70.1)	0.032
Urine sediment leukocyte > 5/HPF	112 (97.4)	247 (92.2)	0.065
Fulfillment of all SIRS criteria [a]	24 (20.9)	12 (4.5)	< 0.001

BUN: blood urea nitrogen; HPF: high-power field; INR: international normalized ratio; SIRS: systemic inflammatory response syndrome; WBC: white blood cell; [a] Including (1) heart rate > 90 beats/min, (2) respiratory rate > 20 breaths/min, (3) temperature > 38°C or < 36°C, or (4) white blood cell > 12,000/μL, < 4,000/μL, or band form > 10%.

nonbacteremic group (p = 0.002). At the time of initial presentation, tenderness on costovertebral angle, altered mental status, hypotension, and tachypnea were more common in the bacteremic group (p < 0.05). In initial laboratory findings, a fraction of segmented neutrophils of > 90%, thrombocytopenia, hypoalbuminemia, azotemia, and positive urine leukocyte esterase test were more frequent in the bacteremic group (p < 0.05). In addition, the fulfillment of all criteria for SIRS was more common in the bacteremic group than in the nonbacteremic group (p < 0.001).

Predictors associated with bacteremia

A multiple logistic regression model revealed that diabetes mellitus (odds ratio [OR], 1.959; 95% CI, 1.092–3.514; p = 0.024), urinary tract obstruction by stone (OR, 2.888; 95% CI, 1.154–7.228; p = 0.023), tenderness on costovertebral angle (OR, 3.216; 95% CI, 1.687–6.130; p < 0.001), a fraction of segmented neutrophils of > 90% (OR, 3.691; 95% CI, 2.010–6.777; p < 0.001), thrombocytopenia (OR, 3.333; 95% CI, 1.831–6.068; p < 0.001), azotemia (OR, 3.052; 95% CI, 1.708–5.455; p < 0.001), and the fulfillment of all SIRS criteria (OR, 3.336; 95% CI, 1.440–7.729; p = 0.005) were predictors associated with bacteremia (Table 2). The Hosmer-Lemeshow test revealed that the goodness-of-fit of this regression model was appropriate (p = 0.720).

Derivation, internal validation, and calibration of a prediction model

The score of a prediction model was represented as the sum of the assigned points to the following seven predictors (total score ranging from 0 to 13): diabetes mellitus (1 point), urinary tract obstruction by stone (2 points), tenderness on costovertebral angle (2 points), a fraction of segmented neutrophils of > 90% (2 points), thrombocytopenia (2 points), azotemia (2 points), and the fulfillment of all SIRS criteria (2 points).

On the ROC curve, the *c* statistic of the model was 0.807 (95% CI, 0.757–0.856). The corrected *c* statistic derived from bootstrapping for 1,000 repetitions was 0.807 (95% CI, 0.758–0.856). The risk stratification for bacteremia according to the model score is shown in Table 3. More than 90% of patients whose model score was ≤ 2 had a nonbacteremic UTI, whereas more than 70% of patients whose model score was ≥ 6 had a bacteremic UTI. When a cutoff value of the model score was set at ≥ 3, the model showed a sensitivity of 86.1% (95% CI, 78.1–91.6%), a specificity of 54.9% (95% CI, 48.7–91.6%), a positive predictive value of 45.0% (95% CI, 38.3–51.8%), and a negative predictive value of 90.2% (95% CI, 84.3–94.1%).

Of 383 enrolled cases, the results of serum procalcitonin were available in 156 (40.7%): 54 (34.6%) in bacteremia group and 102 (65.4%) in nonbacteremia group. Of 156 cases, the median level of serum procalcitonin of bacteremia group was significantly higher than that of of nonbacteremia group (5.64 versus 0.59 μg/L; p = 0.001). To compare

Table 2. Predictors associated with bacteremia in women with community-onset febrile urinary tract infection.

Predictors	β coefficients	OR (95% CI)	p value	Points
Diabetes mellitus	0.682	1.959 (1.092–3.514)	0.024	1
Urinary tract obstruction by stone	1.061	2.888 (1.154–7.228)	0.023	2
Tenderness on costovertebral angle	1.168	3.216 (1.687–6.130)	< 0.001	2
Fraction of segmented neutrophils > 90%	1.306	3.691 (2.010–6.777)	< 0.001	2
Platelet < 150,000/μL	1.204	3.333 (1.831–6.068)	< 0.001	2
BUN > 20 mg/dL or creatinine > 1.5 mg/dL	1.116	3.052 (1.708–5.455)	< 0.001	2
Fulfillment of all SIRS criteria [a]	1.205	3.336 (1.440–7.729)	0.005	2

BUN: blood urea nitrogen; CI: confidence interval; OR: odds ratio; SIRS: systemic inflammatory response syndrome; [a] Including (1) heart rate > 90 beats/min, (2) respiratory rate > 20 breaths/min, (3) temperature > 38°C or < 36°C, or (4) white blood cell > 12,000/μL, < 4,000/μL, or band form > 10%.

Table 3. Risk stratification for bacteremia according to the model score.

Risk stratification for bacteremia (predicted probability)	Model score	No. of bacteremia /total
Low (< 10%)	0–2	16/163 (9.8%)
Intermediate (10–30%)	3–5	41/140 (29.3%)
High (> 30%)	≥ 6	58/80 (72.5%)
Total		**115/383 (30.0%)**

the discriminatory power of the prediction model with that of serum procalcitonin level in 156 cases, *c* statistics were calculated by drawing ROC curves. The *c* statistic (0.771; 95% CI, 0.691–0.851) of the model was greater than that (0.726; 95% CI, 0.643–0.809) of the serum procalcitonin level.

Discussion

Our data showed that frequently isolated organisms from the urine in decreasing order were *E. coli*, *Klebsiella* spp., and *P. mirabilis* and there were no differences in the proportion of these uropathogens between bacteremia and nonbacteremia groups. In addition, diabetes mellitus, urinary tract obstruction by stone, tenderness on costovertebral angle, a fraction of segmented neutrophils of > 90%, thrombocytopenia, azotemia, and the fulfillment of all SIRS criteria were associated with bacteremia in women hospitalized with febrile UTI. In addition, a prediction model incorporating these predictors had a good discriminatory power for early identification of bacteremic cases.

In acute healthcare settings, including the emergency department or outpatient clinics, it is important to predict the occurrence of bacteremia in patients with febrile UTI. Prediction of bacteremia can assist physicians to assess the severity of febrile UTI. For this reason, several studies have been conducted to identify predictors associated with bacteremia in adult patients with febrile UTI [3,4,8,15-17]. In these studies, old age, home residence, diabetes mellitus, indwelling urinary catheter, chills, vomiting, altered mental status, hypotension, tachycardia, high temperature, leukocytosis, increased fraction of segmented neutrophils, presence of band forms, hypoalbuminemia, increased level of serum creatinine or procalcitonin, or high level of pyuria were associated with bacteremia. However, most of these studies had limitations in that they focused only on a few of the physiologic abnormalities that could be observed in patients with UTI, so that they had variable success for prediction of bacteremia.

The predisposition, infection, response, and organ dysfunction (PIRO) concept was proposed to develop prediction models for severity assessment in patients with sepsis [18]. The elements of PIRO include predisposition (demographics, comorbidities, or genetics), insult/infection (site, type, or extent of infections), response (systemic inflammatory responses), and organ dysfunction (failing organs or composite scores). On the basis of the PIRO concept, we intended to develop a prediction model for bacteremia in women with febrile UTI. As a result, our prediction model became a more comprehensive and discriminative tool to identify bacteremia: diabetes mellitus for predisposition; urinary tract obstruction by stone for insult/infection; tenderness on costovertebral angle or a fraction of segmented neutrophils of > 90% for response; and thrombocytopenia, azotemia, and the fulfillment of all SIRS criteria for organ dysfunction. To our knowledge, this is the first study to predict bacteremia in women with febrile UTI on the basis of the PIRO concept. In addition, all of these predictors derived from the present study were easily available at the time of initial presentation in the emergency department, not requiring additional laboratory testing.

Two previous studies derived and validated prediction models for identifying bacteremia in patients with UTI [4,16]. Leibovici *et al*. reported that diabetes mellitus, high temperature, leukocytosis, increased serum creatinine level, or hypoalbuminemia were associated with bacteremia, and a logistic model incorporating these predictors was used to divide the patients into three groups with increasing prevalence of bacteremia (6%, 39%, and 69%) [16]. In Kim *et al*.'s study [4], a prediction model consisting of five predictors (age of ≥ 65 years, vomiting, heart rate of > 110 beats/minute, a fraction of segmented neutrophils of > 90%, and urine sediment leukocyte of ≥ 50/HPF) was developed in the derivation cohort, and the *c* statistics of the model in the derivation and external validation cohorts were 0.792 (95% CI, 0.746–0.839) and 0.792 (95% CI, 0.720–0.865), respectively. However, when two these models were applied to our study population, their *c* statistics were decreased to 0.670 (95% CI, 0.612–0.728) and 0.690 (95% CI, 0.636–0.749), respectively (data not shown). Such decreases in the discriminatory power of two previous models come from the fact that the performance of a prediction model may change when it is applied to different study populations or under a phase of model development (derivation or validation) [19]. The study population and eligibility for enrollment in two previous studies were somewhat different from those in the present study. However, the case definition of febrile UTI used in the present study, which originated from van der Starre *et al*.'s study [12], is better described and more practical in the acute healthcare setting than those used in two previous studies.

Serum procalcitonin has been used as a biomarker for systemic inflammation in patients suspected of severe sepsis or septic shock. In van Nieuwkoop *et al*.'s study [17], serum procalcitonin appeared to be the strongest predictor for bacteremia in patients with

febrile UTI, and the *c* statistic of serum procalcitonin was 0.81 (95% CI, 0.77–0.85). In this study with serum procalcitonin values available only in 40.7% of the study patients, however, the *c* statistic of serum procalcitonin (0.726; 95% CI, 0.643–0.809) was lower than that of our prediction model (0.771; 95% CI, 0.691–0.851). Because only hospitalized women were included and applying serum procalcitonin as a prediction model to our study population corresponds to the validation phase of model development, the discriminatory power of our prediction model cannot be directly compared with that of serum procalcitonin level. Therefore, serum procalcitonin as a prediction model for bacteremia needs to be externally validated in other study populations that are similar to those of the previous study.

Our model showed not only a good discriminatory power (*c* statistic, 0.807) but also a relatively high sensitivity (86.1%) at a cutoff value of ≥ 3. These findings indicate that our model is useful for identifying patients at low risk for bacteremia (model score, 0–2) in women with febrile UTI [20]. Moreover, our model is expected to contribute to reducing unnecessary hospitalization, consequently leading to decreasing medical costs without a significant increase in morbidity or mortality.

The present study has several limitations. First, because only women who were hospitalized with febrile UTI via the emergency department were included in the present study, our prediction model should be used with caution in outpatient clinic or for male patients. Second, serum procalcitonin level, which is known to be a powerful predictor of bacteremia in patients with UTI in the previous studies, was measured in less than 50% of the study patients and, therefore, was not included in the regression analysis. Exclusion of serum procalcitonin from the model development could have a negative effect on the composition and discriminatory power of our model. Finally, this study aimed to develop a prediction model for bacteremia in women with febrile UTI, so further studies on external validation and impact analysis are needed.

Conclusions

Our prediction model, which comprised seven predictors associated with bacteremia on the basis of the PIRO concept, had good discriminatory power and a relatively high sensitivity at a cutoff value of ≥ 3 for identifying bacteremic cases in women with febrile UTI. Therefore, our model can help clinicians identify patients at low risk of bacteremia for the assessment of disease severity in the acute healthcare setting.

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Authors' contributions

WSO and BNK participated in study design, collected data, performed statistical analyses, and drafted manuscript. YSK, JSY, HKC, YGK, JBJ, SYP, JWC, and JYR collected data and edited manuscript. All authors read and approved this manuscript.

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