Does qSOFA score predict ICU admission and outcomes in patients with obstructed infected ureteral stones?

Phillip Stokes, MD, Mohamed Keheila, MD, Muhannad Alsyouf, MD, Zachary Gilbert, BS, Mohammad Hajiha, MD, Akin Amasyali, MD, Joshua Belle, MD, Jason Groegler, BS, D. Duane Baldwin, MD
Department of Urology, Loma Linda University Health System, Loma Linda, California, USA

STOKES P, KEHEILA M, ALSYOUF M, GILBERT Z, HAJIHA M, AMASYALI A, BELLE J, GROEGLER J, BALDWIN DD. Does qSOFA score predict ICU admission and outcomes in patients with obstructed infected ureteral stones? *Can J Urol* 2021;28(5): 10841-10847.

Introduction: *Obstructing stones with infection represent a true urologic emergency requiring prompt decompression. Historically the systemic inflammatory response syndrome (SIRS) criteria has been used to predict outcomes in patients with sepsis. The quick Sequential Organ Failure Assessment (qSOFA) score has been proposed as a prognostic factor in patients with acute pyelononephritis associated with nephrolithiasis. However there has been limited application of qSOFA to patients undergoing ureteral stenting with obstructive pyelonephritis. The purpose of this study was to evaluate the predictive value of the qSOFA score for postoperative outcomes following renal decompression in this patient population.*

Materials and methods: *A retrospective review was conducted at three medical centers within one academic institution to identify patients with obstructive pyelonephritis secondary to ureteral stones. All patients underwent emergent ureteral stent placement for decompression. The primary outcome was the predictive value of preoperative qSOFA score ≥ 2 for intensive care unit (ICU) admission postoperatively. Univariate analysis and multivariate regression analysis were performed to identify factors associated with postoperative outcomes, with $p < 0.05$ considered significant.*

Results: *Of the 289 patients who had ureteral stents placed, 147 patients met inclusion criteria. Twenty-four (16.3%) patients required ICU admission and there were 3 (2%) mortalities, all of these within the ICU admission group. The sensitivity and specificity of the qSOFA score ≥ 2 for ICU admission was 70.8% and 79.5% respectively which outperformed SIRS criteria, which had a sensitivity and specificity of 100% and 33.6% respectively.*

Conclusion: *A preoperative qSOFA score ≥ 2 was a significant predictor for postoperative ICU admission in patients undergoing ureteral stent placement for obstructive pyelonephritis. The qSOFA score can be used to determine which patients will require ICU admission.*

Key Words: qSOFA score, ICU admission

Introduction

Sepsis is a life-threatening condition that affects more than 1 million patients in the United States annually.[1] With increased attention directed toward early recognition and appropriate management, mortality has improved over time.[2] The definition of sepsis is also evolving and is defined as a life threatening organ dysfunction caused by a dysregulated host response to infection.[3] The urinary tract has been shown to be a source in up to 26% of cases in a large multicenter observational study.[4] Furthermore, approximately 10% of patients presenting with septic shock due to a urinary source will have concomitant mechanical urinary obstruction.[5] Renal decompression is of paramount importance in obstructive pyelonephritis and both the American Urological Association and the European Association of Urology recommend

Accepted for publication July 2021

Address correspondence to Dr. D. Duane Baldwin, Department of Urology, Loma Linda University Health System, 11234 Anderson Street, Room A560, Loma Linda, CA 92354 USA

prompt drainage in the setting of obstruction from ureteral stones with either percutaneous nephrostomy or ureteral stent decompression.[6,7]

As the understanding of sepsis has evolved, several scoring systems have been developed to aid in early identification of patients with sepsis and to predict outcomes. Finding the optimum predictive tool for ICU admission will help in preoperative counseling, setting patient expectation, predict hospital course and allows the managing team to be prepared to deliver the appropriate level of care. Originally the systemic inflammatory response syndrome (SIRS) criteria were proposed in 1991 with the addition of infection to define sepsis. SIRS criteria includes fever (< 36C or > 38C), heart rate (> 90/min), respiratory rate (> 20/min or PaCO2 < 32 mm Hg and leukocytosis (> 12K/mm^3), leukopenia (< 4K/mm^3) or bandemia (10% immature bands). With time this definition has fallen out of favor due to poor specificity.[3] The most recent published definitions utilize the Sequential Organ Failure Assessment (SOFA) which considers the worst values of various clinical and laboratory parameters over a 24-hour period to determine level of acuity and mortality risk. A score of 2 or more is associated with greater than 10% in-hospital mortality.[3,8] However, due to the fact it is focused on a 24-hour period it is not practical for initial evaluation of a patient presenting in sepsis requiring prompt intervention and determining the need for ICU admission.

The quick Sequential Organ Failure Assessment (qSOFA) has been developed as a rapid bedside screening tool to identify patients who may have infection and are at risk for poor outcomes. The score consists of 3 parameters; altered mentation, systolic blood pressure < 100 mm Hg, and respiratory rate of 22/min or greater. A score of 2 or more should prompt further investigation or higher level of care.[3] The purpose of this study was to evaluate the predictive value of a preoperatively obtained qSOFA score for postoperative outcomes in a homogeneous population with obstructive pyelonephritis following renal decompression with a ureteral stent.

Materials and methods

After approval by the institutional review board, a retrospective review was conducted to identify patients who presented with obstructive pyelonephritis between July 2014 and August 2018. Patients were divided into two groups based on the need for postoperative ICU admissions. The first group included patient that required ICU admission and the second group included patients who did not need ICU admission postoperatively. The primary goal of this study was to determine the predictive value of qSOFA for ICU admission following ureteral stent placement for obstructive pyelonephritis. Secondary outcomes included predictive value for mortality, hospital length of stay and comparison of these variables to positive SIRS criteria.

Inclusion criteria included age greater than 18 years, ureteral stone with suspected infection and hydronephrosis, and subsequent urgent ureteral stent insertion. Suspected infection is defined as pyuria and/or bacteriuria and/or nitrite positive dipstick with other clinical signs of infection such as fever, abnormal white blood cell count. Obstructing stones with suspected infection are considered a life-threatening emergency requiring rapid decompression and are considered level A cases to proceed to OR without delay. In all patients suspected obstruction and infection were the documented indication for stent placement by the operative surgeon. Exclusion criteria were stent placement for pain only, stent placement for non-stone obstruction (i.e. stricture or ureteropelvic junction obstruction), decompression with nephrostomy tube placement, or elective stent placement for other reasons. Patient demographics were collected from the electronic medical record. The time from patient arrival in the emergency department (ED) to the urology consult request was obtained. Time from arrival to ureteral stent placement and time from consult to stent placement were also reviewed and compared between groups.

ICU admission criteria included hypotension requiring vasopressor support and/or respiratory failure requiring mechanical ventilation. Immunosuppression was defined as taking an immunosuppressive medication (i.e. steroid, immune modulator), prior solid organ transplant status, or HIV/AIDS. Univariate analysis and multivariate regression analysis were performed to identify factors associated with ICU admission, with $p \leq 0.05$ considered significant. To compare the predictive value of qSOFA and SIRS, receiver operator curve analysis was performed to determine the area under the curve as well as sensitivity and specificity. All statistical analyses were performed using SPSS (IBM, Armonk, NY, USA).

Results

Two hundred and eighty-nine consecutive patients were identified who underwent ureteral stent placement during the study period. After exclusion criteria were applied, 147 patients were identified who presented

TABLE 1. **Descriptive statistics**

	Patients	**(%)**	**Non-ICU admission**	**(%)**	**ICU admission**	**(%)**	**p value**
Patient number	147	100%	123	83.7%	24	16.33%	
Gender							0.38
Male	42	28.6%	34	27.64%	8	33.33%	
Female	105	71.4%	89	72.35%	16	66.67%	
Age (mean)	52.06		50.3		62.2		**0.00**
Length of stay (mean)	4.89		4.67		6		**0.02**
Mortality < 30 days	3		0	0.00%	3	12.50%	**0.00**
ASA score > 2	141	95.9%	67	57.3%	22	91.67%	**0.00**
BMI (mean)	31.18		31.19		31.07		0.99
Comorbidities							
DM (diabetes mellitus)	36	24.7%	29	23.6%	7	29.17%	0.37
Immunosuppression	41	29.08%	33	26.83%	8	33.33%	0.39
SIRS criteria							
WBC > 12K or < 4K	88	60.27%	70	56.91%	18	75.00%	0.08
Temp > 100.4 or < 96.8	55	37.67%	41	33.33%	14	58.33%	0.18
RR > 20	86	58.90%	63	51.22%	23	95.83%	**0.00**
HR > 90	110	75.34%	87	70.73%	23	95.83%	**0.01**
Clinical presentation							
Met SIRS criteria	105	71.43%	81	65.85%	24	100.00%	**0.00**
Preop hypotension	62	42.47%	46	37.40%	16	66.67%	**0.01**
Positive qSOFA score (≥ 2)	92	62.59%	70	56.91%	22	91.67%	**0.00**
Prior to arrival abx	35	23.81%	30	24.39%	5	20.83%	0.06
MDR (multi-drug resistance) current or past	27	18.37%	21	17.07%	6	25.00%	0.32
PCN (penicillin) allergy	18	12.24%	15	12.20%	3	12.50%	0.91
Time to Consult (hrs)	14.74		13.09		24.91		**0.03**
Time from arrival to OR (hrs)	30.88		28.16		42.68		**0.04**
Time from consult to OR (hrs)	6.81		5.85		7.62		0.42
Time from symptom onset to OR (hrs)	89.77		98		81.54		0.51
Stone characteristics							
Stone location							0.75
UPJ (uretero pelvic junction)	25	17.00%	19	15.45%	6	25%	
Proximal ureter	65	44,22%	55	44.72%	10	41.67%	
Mid	18	12.24%	15	12.19%	3	12.50%	
Distal	39	26.65%	34	27.64%	5	20.83%	
Degree of hydronephrosis							**0.67**
Mild	77	52.38%	63	55.30%	14	66.70%	
Moderate	45	30.61%	42	36.80%	3	14.30%	
Severe	13	8.84%	9	7.90%	4	19.00%	
Forniceal rupture	22	14.97%	16	13.01%	6	25.00%	0.21

*bold values indicate statistical significance; SIRS = systemic inflammatory response syndrome

with obstructive pyelonephritis requiring urgent ureteral stent placement. Twenty-four patients (16.33%) required admission to the ICU postoperatively, Table 1. Patients who required ICU admission were older (62.2 vs. 50.3 years, $p < 0.001$), had higher rates of positive preoperative qSOFA scores (92% vs. 57%, $p < 0.001$), longer hospital stays, (6.0 vs. 4.67 days, $p = 0.02$) and higher mortality (3 vs. 0, $p < 0.01$) than those admitted to the floor.

There were no significant differences between the two groups in terms of gender, BMI, diabetes, or immunosuppression, Table 1. There were no significant differences in urine culture results, presence of multidrug resistant bacteria or rates of antibiotics prior to arrival, Figure 1. There was also no difference in symptom duration prior to arrival. However, patients admitted to the ICU had a longer duration from arrival to urology consult request (24.91 hrs vs. 13.09 hrs, $p = 0.03$) and time from arrival to stent placement (42.68 hrs vs. 28.16 hrs, $p = 0.04$). There was no difference between the two groups in time from symptom onset (98 hrs vs. 81.54 hrs; $p = 0.51$) or consult request to stent placement (5.85 hrs vs. 7.62 hrs; $p = 0.42$).

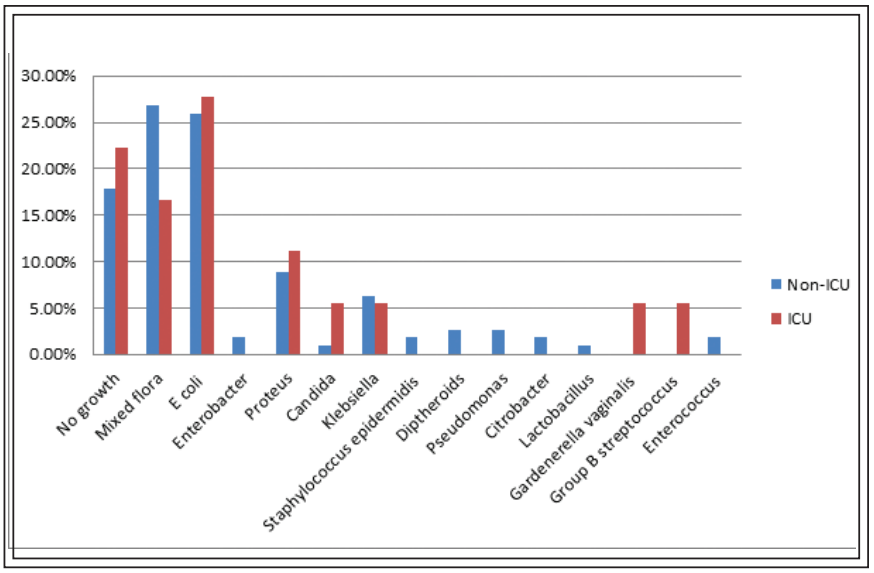

Figure 1. Results of urine cultures.

The majority of stones were located in the proximal ureter (44%), followed by the distal ureter (27%), ureteropelvic junction (17%), and mid ureter (12%). There were no significant differences between the two groups in terms of stone location. There were no significant differences in laterality, stone size (average 7.84 mm), or proportion of forniceal rupture.

When examined for predictive value on multivariate logistic regression, only qSOFA score ≥ 2 and ASA score were predictive of ICU admission (OR 4.45, $p = 0.0107$ and OR 3.179, $p = 0.026$ respectively) when included in a model containing time to consult, time from arrival in hospital to OR, age, and presence of diabetes, Table 2. Positive qSOFA scores in the preoperative setting had a sensitivity of 71% and specificity of 80% for ICU admission with an area under the curve (AUC) of 0.752. qSOFA score ≥ 2 was associated with hospital stay greater than 4 days (OR 2.743, 95% CI 1.236-6.089). With respect to in-hospital mortality the sensitivity and specificity of a positive qSOFA score was 67% and 72% respectively with AUC of 0.69. In comparison, the sensitivity and specificity of meeting SIRS criteria for ICU admission were 100% and 34% respectively with AUC 0.67. The sensitivity and specificity for in hospital mortality was 100% and 29% respectively with an AUC of 0.64. Meeting SIRS criteria was also associated with the likelihood of a hospital stay greater than 4 days (OR 2.443, 95% CI 1.114-5.357).

TABLE 2. **Multivariate regression model for risk factors for ICU admissions**

Variable	OR	95% CI	p value
Age	1.006	(0.97-1.05)	0.7519
Diabetes	0.721	(0.18-2.51)	0.6215
Time to consult (hrs)	1.019	(0.98-1.07)	0.3833
Time from arrival to OR (hrs)	0.987	(0.94-1.02)	0.4428
Qsofa (>= 2 vs. < 2)	4.448	(1.43-14.59)	**0.0107**
ASA score	3.179	(1.19-9.36)	**0.0262**

Discussion

Life threatening sepsis from a urinary source is a common pathology encountered by urologists. Sepsis scoring systems provide objective data that aid in clinical assessment and prognosis. Although all patients should be taken to the OR urgently in this situation, a higher qSOFA could indicate more extreme consequences with delay and could be used as an objective data point to justify more rapid surgical intervention. In addition, it can mitigate costs by admitting to ICU only the patients who require ICU stay. The data in this cohort showed that 20% of patients will require admission to the intensive care unit following renal decompression of an obstructing ureteral stone using a double pigtail stent. Patients who present with infection secondary to obstructive pyelonephritis represent a urologic emergency and warrant prompt intervention in the form of renal decompression to prevent associated morbidity and lower the potential for mortality. However, beyond expeditious intervention, anticipation of subsequent management of the septic patient is critical as many will require aggressive resuscitation and a higher level of care following decompression.[9]

In the population of patients with sepsis, early aggressive treatment is of the utmost importance. The qSOFA score allows for rapid bedside assessment of the potential for decompensation based on examination and vital signs.[3] Our data show that in a homogenous population of patients with obstructive pyelonephritis, a preoperatively obtained positive qSOFA score is significantly associated with postoperative ICU admission following ureteral stent placement. In our study, the qSOFA had much higher specificity at 80% while, in contrast, the SIRS specificity of 33% makes it unreliable as a predictor of sepsis and ICU stay.

Although recommended for use in rapid evaluation of patients presenting with suspected sepsis, some have criticized the qSOFA scoring system. Multiple studies with heterogeneous populations have shown varied predictive values. Askim et al published data from a prospectively enrolled observational study of 1535 patients presenting with signs of infection of multiple etiologies, of which 7% met criteria for severe sepsis. In their series, the qSOFA score had a sensitivity and specificity of 32% and 98% for sepsis and 16% and 96% for 7-day mortality respectively.[10] However, Finkelsztein et al performed a prospective study including 152 patients presenting to ED with suspicion of infection secondary to different etiologies such as pneumonia, malignancy, and bacteremia. This study showed improved performance of qSOFA for prediction of ICU length of stay when compared to SIRS (AUC 0.65 vs. 0.54) as well as significant higher prediction for in-hospital mortality using qSOFA vs. SIRS (AUC, 0.74 vs. 0.59).[11] Similarly, qSOFA was evaluated for predictive value for ICU admission and mortality by Wang et al who found an AUC of 0.636 and 0.666 for ICU admission and mortality respectively in patients admitted to the emergency department and diagnosed with infection.[12] In our series the AUC for qSOFA was 0.752 for ICU admission and 0.694 for mortality which shows improved sensitivity and specificity in the more specific population of patients who underwent ureteral stent placement for obstructive pyelonephritis.

When the qSOFA scoring system is applied to more homogenous populations, specificity improves. Several authors have examined qSOFA score in populations of patients undergoing elective non-emergent instrumentation of the upper urinary tract. Yaghoubian et al examined qSOFA in a population of patients following percutaneous nephrolithotomy (PCNL), however in their series of 320 patients only 3 patients required ICU admission, all of which met qSOFA criteria.[13] The predictive value of qSOFA has also been examined in the acute pyelonephritis population. Fukushima et al examined the performance of qSOFA in a heterogenous population of patients with acute pyelonephritis and upper urinary tract calculi, however a substantial proportion (22%) had no decompression, and some patients had no obstruction. Of those patients that were decompressed, the majority (60%) had a nephrostomy placed.[14] A similar heterogenous population was examined by Pandey et al with 162 patients with pyelonephritis and upper urinary tract calculi. Similarly, their series included a majority of patients 46% decompressed with nephrostomy and 14% who did not have any type of decompression.[15]

As previously noted, sepsis causes a significant burden on the US healthcare system with over 1 million annual hospital visits[1] at a total cost of US $38.1 billion in 2014.[16] Worldwide, there are 35 million cases of sepsis annually.[17] Costs associated with sepsis are also a significant driver of health care expenditures, especially in patients requiring critical care. In a systematic review of studies done in multiple countries across Europe, Asia, and North America, Arefian et al evaluated the cost impact of sepsis and found a mean cost of $32,421 US dollars per patient and a mean ICU cost of sepsis per patient of $27,461.[18] As noted previously, up to 26% of cases of sepsis may be attributed to a urinary source.[4] In addition to the clinical importance of early recognition of patients who may require a higher level of care,

identification of those who may not require costly resuscitation and intervention would be beneficial in mitigating health care expenditure. In our cohort, the majority of patients did not require ICU admission postoperatively, however, the qSOFA score was useful in predicting those who would benefit from more costly ICU care.

In our data, patients admitted to the ICU had increased time interval from arrival to consult request and subsequently a longer interval from arrival to ureteral stent placement. This is likely in part due to patient complexity and co-ordination of care required for patients who are admitted to the ICU, but does suggest an area where an initial qSOFA score predicting ICU stay can be used to more rapidly contact consulting teams within the multidisciplinary model. No difference in time from consult request to operative intervention was seen in our data. In our series there was no statistical difference in duration of symptoms prior to arrival or time from symptom onset to operative intervention between groups. Other authors have examined symptom duration in similar populations and found conflicting results. Yamamoto et al examined risk factors for septic shock in a population of patients receiving emergent drainage and found those with septic shock had a median of 2 days from symptom presentation to intervention which was shorter than the median of 3 days for those without septic shock.[19] However Kamei et al, in a similar series showed that patients with septic shock had a median range of 3.5 days from symptom onset which was significantly longer than the 1 day median of those without shock.[20] Our data clarifies the importance of prompt recognition of obstructive pyelonephritis and early renal decompression.

Our study is not without limitations. Although our facilities cover a large catchment area, our data represents the experience of a single academic center and may not be generalizable to all patient populations. Our study is retrospective in nature and consequently carries the inherent associated limitations of a retrospective review. Although encouragingly low, the mortality rate in our cohort limits the analysis of qSOFA as a predictor of in-hospital mortality. Another potential limitation of this study is that it examined a homogenous population, all of whom underwent ureteral stent placement, which limits generalizability. We do feel that having a homogenous population of patients allows us to truly compare qSOFA to SIRS and understand the difference between these two predictive models. We do understand that there could potentially be different findings in patients managed with nephrostomy tubes or those undergoing no decompression. However, this fact may also be a strength as this is a population often encountered by the urologist and prompt recognition of patients requiring a higher level of care is important to appropriately manage these patients.

Conclusion

To our knowledge this is the first study examining the use of the qSOFA score as a predictor of ICU admission in a homogeneous population of patients with obstructive pyelonephritis undergoing ureteral stent placement. When used in the preoperative setting, qSOFA score is a better predictor of ICU admission than SIRS. Urologists and other clinicians may utilize qSOFA as an adjunct when evaluating which patients undergoing renal decompression with ureteral stents would potentially benefit from higher level of care and more aggressive ICU resuscitation in the perioperative setting. □

References

1. Backer DD, Dorman T. Surviving sepsis guidelines a continuous move toward better care of patients with sepsis. *JAMA* 2017;317(8):807-808.
2. Kaukonen K-M, Bailey M, Suzuki S, Pilcher D, Bellomo R. Mortality related to severe sepsis and septic shock among critically Ill patients in Australia and New Zealand, 2000-2012. *JAMA* 2014;311(13):1308-1316.
3. Singer M, Deutschman CS, Seymour CW et al. The third International consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA* 2016;315(9):801-810.
4. Park DW, Chun BC, Kim JM et al. Epidemiological and clinical characteristics of community-acquired severe sepsis and septic shock: a prospective observational study in 12 university hospitals in Korea. *J Korean Med Sci* 2012;27(11):1308-1314.
5. Reyner K, Heffner AC, Karvetski CH. Urinary obstruction is an important complicating factor in patients with septic shock due to urinary infection. *Am J Emerg Med* 2016;34(4):694-696.
6. Assimos D, Krambeck A, Miller NL et al. Surgical management of stones: AUA/Endourology Society Guideline. 2016.
7. Türk C, Skolarikos A, Neisius A et al. Urolithiasis 2019. cited 2019.
8. Vincent J-L, de Mendonca A, Cantraine F et al. Use of the SOFA score to assess the incidence of organ dysfunction/failure in intensive care units: results of a multicenter, prospective study. *Crit Care Med* 1998;26(11):1793-1800.
9. Haas CR, Li G, Hyams ES, O. Shah O. Delayed decompression of obstructing stones with urinary tract infection is associated with increased odds of death. *J Urol* 2020;204(6):1256-1262.

10. Askim Å, Moser F, Gustad LT et al. Poor performance of quick-SOFA (qSOFA) score in predicting severe sepsis and mortality – a prospective study of patients admitted with infection to the emergency department. *Scand J Trauma Resusc Emerg Med* 2017;25(1):56.
11. Finkelsztein EJ, Jones DS, Ma KC et al., Comparison of qSOFA and SIRS for predicting adverse outcomes of patients with suspicion of sepsis outside the intensive care unit. *Crit Care* 2017;21(1):73
12. Wang JY, Chen Y-X, Guo S-B, Mei X, Yang P. Predictive performance of quick sepsis-related organ failure Assessment for mortality and ICU admission in patients with infection at the ED. *Am J Emerg Med* 2016;34(9):1788-1793.
13. Yaghoubian A, Batter T, Mozafarpour S et al. Use of the qsofa score for prediction of ICU admission due to septic shock after percutaneous nephrolithotomy: a multi-center study from The Edge Research Consortium. *J Urol* 2019;202(2):314-318.
14. Fukushima H, Kobayashi M, Kawano K, Morimoto S. Performance of quick sequential (sepsis related) and sequential (sepsis related) organ failure assessment to predict mortality in patients with acute pyelonephritis associated with upper urinary tract calculi. *J Urol* 2018;199(6):1526-1533.
15. Pandey S, Sankhwar SN, Goel A et al. Quick sequential (sepsis related) organ failure assessment: a high performance rapid prognostication tool in patients having acute pyelonephritis with upper urinary tract calculi. *Investig Clin Urol* 2019;60(2): 120-126.
16. Rubens M, Saxena A, Ramamoorthy V et al. Increasing sepsis rates in the United States: results from national inpatient sample, 2005 to 2014. *J Intensive Care Med* 2020;35(9):858-868.
17. Fleischmann C., Scherag A, Adhikari NKJ et al. Assessment of global incidence and mortality of hospital-treated sepsis. Current estimates and limitations. *Am J Respir Crit Care Med* 2016;193(3):259-272.
18. Arefian H, Heublein S, Scherag A et al. Hospital-related cost of sepsis: a systematic review. *J Infect* 2017;74(2):107-117.
19. Yamamoto Y, Fujita K, Nakazawa S et al. Clinical characteristics and risk factors for septic shock in patients receiving emergency drainage for acute pyelonephritis with upper urinary tract calculi. *BMC Urol* 2012;12(4):1471-2490.
20. Kamei J, Nishimatsu H, Nakagawa T et al. Risk factors for septic shock in acute obstructive pyelonephritis requiring emergency drainage of the upper urinary tract. *Int Urol Nephrol* 2014;46(3):493–497.