



# High bacterial titers in urine are predictive of abnormal postvoid residual urine in patients with urinary tract infection



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## ABSTRACT

Urine bacterial titers (BTs) are influenced by bacterial and host factors. The impact of an abnormal postvoid residual (PVR) on BT in urine was investigated. A total of 103 inpatients with a urine growing Enterobacteriaceae ( $\geq 10^2$  CFU/mL) and a PVR measure were analyzed, mostly female (62%), elderly (mean age: 72 years), with urinary tract infection (25% of asymptomatic bacteriuria) due to *Escherichia coli* (85%). Fifty-two subjects (56%) had BT  $\geq 10^6$  CFU/mL; 48 (53%) had a PVR  $\leq 100$  mL, while 26 (25%) had a PVR  $> 250$  mL. PVR increased with BT, and a significant ( $P < 0.0001$ ) threshold was reached for  $10^6$  CFU/mL: 100 mL mean PVR for patients with BT  $\leq 10^5$  CFU/mL versus 248 mL for patients with BT  $> 10^5$  CFU/mL. High PVR and BT were associated with complicated infections, concomitant bacteremia, and delayed apyrexia. Screening for patients with BT  $\geq 10^6$  CFU/mL is an easy way to identify patients at high risk for acute retention and voiding disorders.

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## 1. Introduction

Urine culture is by far the most common microbiological analysis performed in daily practice worldwide, due to both the high incidence of urinary tract infection (UTI) or asymptomatic bacteriuria (AB) that deserve detection and treatment (e.g., during pregnancy or before an urological surgery) and to the high feasibility and acceptability of the method (Foxman, 2002; Manickam et al., 2013). Because of a common contamination of the sample by periurethral bacteria (even for mid-stream urines), colony count thresholds have been established to help interpret positive culture (Hooton et al., 2013). For decades, numerous studies have investigated the influence of several bacterial or host factors on such thresholds. It is usually admitted that thresholds are lower for bacterial species such as *Escherichia coli*, *Proteus* spp., and *Staphylococcus saprophyticus* that produce virulence factors favoring invasion of the urothelium (i.e., the so-called uropathogens), as compared to organisms less frequently responsible for UTI such as enterococci or *Pseudomonas* spp. (Aspevall et al., 2001). It is also admitted that thresholds for UTI are lower than for AB (Nicolle et al., 2005).

Curiously, the influence of voiding dysfunction on bacterial titers (BTs) in urines of patients with UTI or AB has been theorized but has not been investigated in clinical studies (O'Grady and Cattell, 1966a,b). Conceptually, high postvoid residual (PVR) urine is at risk to

favor microbial proliferation, while complete voiding should clear most bacteria from bladder (Sobel, 1987). Thus, a positive correlation between BT and PVR values could be expected, but this remains to be demonstrated.

For this purpose, the primary aim of this study was to evaluate the correlation between BT and PVR among patients with positive urine culture. The secondary aim was to analyze the role of other factors that might interfere with both parameters (BT and PVR): gender, AB or UTI, risk factors for complication, and concomitant bacteremia.

## 2. Materials and methods

### 2.1. Patients

This study was conducted retrospectively at the Rouen University Hospital (Normandy, France) from January 2013 to May 2014. Patients with an urine sample growing Enterobacteriaceae (whatever the BT, and the presence or absence of leucocyturia) were first identified by the department of microbiology. Patients were then included if they had at least 1 PVR measure within 48 h after the urine sample was collected. The study was limited to the departments of infectious diseases, geriatrics, and urology where a PVR measure by portable ultrasound device is performed when urine retention is suspected. A diagnosis of UTI was retained for patients with clinical symptoms, BT  $\geq 10^2$  CFU/mL, and leukocyte count  $> 10^4$ /mL. Patients were considered at risk for complicated UTI in case of functional or anatomical abnormality of the urinary tract, male gender, diabetes mellitus, or if they had healthcare-related infections. For patients with febrile UTI ( $T \geq 38$  °C), the delay of apyrexia

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was noticed; it was defined as the interval between the initiation of an effective antibiotic regimen and 2 consecutive temperature measures  $\leq 37.3$  °C in the morning and 37.8 °C in the afternoon. A diagnosis of asymptomatic bacteriuria was retained in asymptomatic patients with bacteriuria, whatever the leukocyturia. Healthcare-related bacteriuria were defined as those occurring 48 h after admission or within 1 month after any invasive urological procedure (Hooton et al., 2010).

## 2.2. BT measure

The BT was determined using quantitative urinalysis, which consisted of inoculating 10- $\mu$ L urine onto a nonselective chromogenic agar plate (CPS3; bioMérieux, Marcy l'Etoile, France) using a calibrated loop. After 24 h of incubation at 37 °C in aerobic conditions, the number of colonies was counted and expressed as CFU/mL and quantified in a  $10^2$  to  $\geq 10^7$  range for AB and UTI, in order to investigate the correlation between BT and PVR. Patients with urine growing organisms other than Enterobacteriaceae were excluded because detection of bacteria such as enterococci or streptococci in midstream urines is not necessarily predictive of their presence in bladder, as recently established among premenopausal women with acute uncomplicated cystitis (Hooton et al., 2013).

## 2.3. PVR measure

For patients with natural micturition, PVR was assessed by ultrasound portable device (BladderScann®, BVI 9400; Verathon, USA)

within 10 minutes of voiding. The PVR value retained for the study was the mean of 3 consecutive measures during a single evaluation. When patients had several PVR measures by ultrasound device spanning several days, the PVR value considered for the study was the one performed at the time of urine sampling, or the closest one. Patients with PVR measured performed more than 48 h apart from urine sampling were excluded from the study. For patients who required bladder catheterization (either for an acute retention or for a chronic voiding dysfunction), the PVR was measured by catheterization. PVR values up to 100 mL were considered as normal for that population of adult inpatients with a majority of subjects older than 60 years (see below) (Gehrich et al., 2007; Grabe et al., 2014). Patients with internal or external urinary bypass, indwelling Foley catheter, ascitis, and pregnant women were excluded because PVR cannot reliably be measured by ultrasound portable devices in such situations.

## 2.4. Ethical issues

In accordance with French regulations, no written informed consent was required because the data were obtained anonymously from medical files, with no participation of patients.

## 2.5. Statistics

Data were expressed as mean and SD. Continuous values were compared using Mann–Whitney test. To assess the accuracy of BT at log<sub>10</sub>

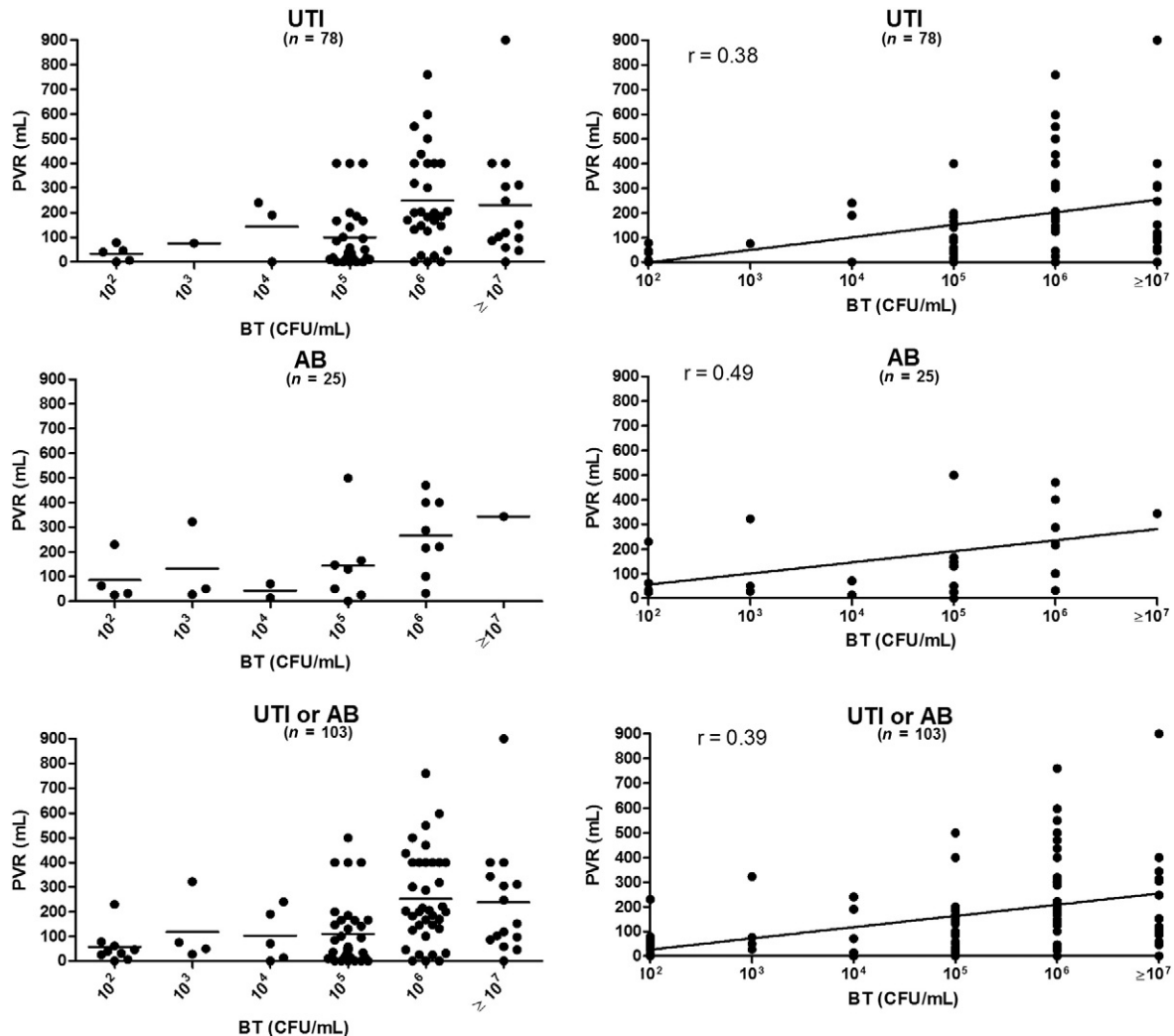


Fig. 1. Post-void residual urine (PVR) according to the bacterial titer (BT) in the urine sample of patients with urinary tract infection (UTI), asymptomatic bacteriuria (AB) or for the total series.

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