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ARTICLE

Post-obstructive diuresis; underlying causes and hospitalization

Lisbeth Roesen Leinum[a], Connie Berthelsen[b] and Nessn Azawi[c]

[a]Department of Urology, Zealand University Hospital, Roskilde, Denmark; [b]Section of Nursing, Aarhus University, Emdrup, Denmark; [c]Department of Urology, Zealand University Hospital, Roskilde, Denmark and Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark

ABSTRACT

Objective: This paper aims to estimate the incidence of post-obstructive diuresis (POD) among patients with urinary retention, explore possible underlying causes and identify patients who need hospitalization.

Material and methods: This retrospective study includes patients admitted for urinary retention in Zealand University Hospital, Denmark. We collected demographic characteristics, health information and laboratory results from patients' charts and analyzed data statistically.

Results: We assessed 64 patients, and POD occurred in 29.7%. A significant correlation was observed between POD and residual urine, serum creatinine, serum urea and systolic and diastolic blood pressure. We identified increased residual urine volume as an independent predictor of POD by OR 1.21 (95% CI: 1.06–1.40), $p = 0.006$ per 100 mL and creatinine of >120 umol/L is an independent predictor of POD by OR 7.17 (95% CI; 1.63–31.37), $p = 0.009$. Patients with residual urine at the time of diagnosis of more than 1150 ml will suffer POD with a probability of area under curve (AUC) 0.874 ($p < 0.001$) with 84% sensitivity and 78% specificity. Patients with creatinine >120 umol/L will suffer POD with a probability of AUC 0.774 ($p < 0.001$) with 68% sensitivity and 82% specificity.

Conclusion: In this small retrospective study residual urine of more than 1150 mL and elevated creatinine are independent predictors of POD in patients with urinary retention. However, larger prospective studies are needed to confirm these findings.

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Introduction

Urinary retention is a common urological problem, especially among older men, and a significant burden on health systems [1,2].

This disorder can be classified as acute urinary retention (AUR) or chronic urinary retention (CUR). Some patients present acutely with large residual volumes; such cases are defined as acute-on-chronic retention (ACR) [3]. The management of AUR begins with immediate catheterization to decompress the bladder and relieve the patient's discomfort. This treatment can be associated with post-obstructive complications such as hematuria, low blood pressure and post-obstructive diuresis (POD), which is clinically defined as urine production exceeding 200 mL/h for two consecutive hours or urine output exceeding 3,000 mL/day [4,5].

Physiological POD is a normal response to fluid overload and is usually self-limiting when homeostasis is restored. Sometimes pathological POD occurs with the continued excretion of salt and water, causing a risk of severe dehydration and electrolyte disturbances that can be life threatening [4]. To prevent this life-threatening condition, many patients require hospital admission for observation; however, there is no consensus on the admission criteria [6].

The prevalence of POD following the removal of an obstruction is uncertain, with estimates ranging from 0.5% to 78%, depending on the diagnostic criteria and selection of study participants [5,7,8].

Hamdi et al. [9] identified three independent predictors of POD in intensive care unit (ICU) patients: high serum creatinine, high serum bicarbonate and urinary retention.

It is common knowledge in urology that low residual volume rarely precipitates POD; however, no studies have statistically investigated the association between residual volume and POD. Ahmed et al. [10] have reported that 18.2% of patients developed POD in a small prospective study with 22 patients suffering from chronic urinary retention. These patients exhibited residual urine above 2,000 mL and serum creatinine above 120 umol/L.

The aim of our study is to estimate the incidence of POD among patients with urinary retention, explore the possible underlying causes and identify patients who require hospitalization.

Materials and methods

We conducted this retrospective chart review with patients admitted to Zealand University Hospital, Denmark, for urinary retention between November 2017 and January 2019. Informed consent was obtained from the patients, and the

CONTACT Nessn Azawi nesa@regionsjaelland.dk Department of Urology, Zealand University Hospital, Sygehusvej 10, DK-4000, Roskilde, Denmark

study was approved by the Data Protection Agency of Region Zealand (19-000079/003).

To ensure rigor, the data collection was conducted in accordance with Sarkar and Seshadri's [11] six steps for conducting a chart review:

1. Identify an appropriate data source
2. Devise a data extraction instrument
3. Extract data
4. Re-evaluate a small dataset
5. Perform statistical analysis
6. Disseminate findings

In addition, we used the checklist REporting of studies Conducted using Observational Routinely collected Data (RECORD), which is an extension of the existing STROBE guideline [12].

We designed an instrument, including a coding manual, to extract data from the case charts. The following data were collected from the electronic patient charts:

- General demographic characteristics: age, housing and social status
- Health information: systolic and diastolic blood pressure, pulse, residual volume, hematuria, cause of obstruction, occurrence of POD and duration of POD (based on hourly diuresis)
- Laboratory results: urine protein, urine nitrite, serum creatinine, estimated glomerular filtration rate (eGFR), serum urea, serum sodium (Na), serum potassium (K) and serum albumin

The causes of obstruction were divided into the following categories: benign enlarged prostate, prostate cancer, bladder cancer, other cause of obstruction, infection, neurological cause, postoperative cause, alcohol intake and unknown. The category 'other cause of obstruction' was defined as an obstruction due to stricture or macroscopic hematuria.

Urine production exceeding 200 mL/h for at least two consecutive hours was defined as POD. The duration of POD was determined based on the number of hours exceeding 200 mL/h and divided into the following categories: $\leq$4 h, 5–8 h, 9–12 h, 13–24 h and $>$24 h.

We identified 155 patients with the diagnostic code of urinary retention (DR339) or POD (DR35); 73.5% (114 patients) of these patients responded to requests for patient consent. Six patients refused to participate, and thus 108 patients' charts were reviewed. Forty-four patients were excluded from the study due to either ineligibility or missing data. This exclusion resulted in a study population of 64 male patients. These patients were divided into two groups, patients with and without POD according to the definition, for comparison for clinical characteristics. Twenty-four patients admitted to the emergency unit with urinary retention and observed for POD were discharged without documentation for their urinary excretion data; thus, they were considered patients without POD.

The tables only display the results based on the group of 64 patients, as this group represents patients who had urinary retention. However, some additional analyses were performed on 40 of the 64 patients whose charts provided enough information on post-catheter diuresis to document whether the diagnostic criteria for POD were met. These analyses were performed to ascertain whether including 40 or 64 patients has a significant impact on the estimates and conclusion of the analyses.

We used the Stata version 15 software for the statistical analysis.

The descriptive statistics are displayed as number, percentage, mean (SD) and median (IQR). The inferential statistics analyzing the continuous data used the Student *t*-test or Mann-Whitney *U* test depending on the normal distribution. The categorical data were analyzed with Fisher's Exact.

The predictors of the occurrence of POD were identified with a simple logistic regression, followed by multiple logistic regression. A *p*-value above 0.05 was considered statistically significant [13].

The receiver operating characteristics (ROC) curve was derived from the data, and the area under the curve (AUC) was calculated to establish a cutoff point of residual urine to predict POD occurrence. A sensitivity of at least 80% was required for the result of the analysis to be considered usable as an admission criterion.

Results

Sixty-four patients were included in the analysis. The median age was 72.5 years old (IQR: 66–75), the median of the depleted residual urine was 1,000 mL (IQR: 600–1,500), and hematuria was noted in 31.6% of the patients.

The incidence of POD was 29.7% (95% CI; 18.9%–42.4%). The descriptive statistics of the demographic and clinical characteristics are presented in Table 1.

Prostate diseases were the main cause of urinary retention and were present in 55% of the patients. The causes of urinary retention are depicted in Figure 1.

More than half of the patients experienced POD for less than four hours; otherwise, only one patient developed pathological POD lasting for more than 24 h (Figure 2). Table 2 presents the distribution of the possible predictors in patients with different levels of POD. The patient who developed pathological POD was characterized by high systolic blood pressure ($>$180 mmHg) and had severe elevated creatinine (1,500 umol/L).

The univariate analysis indicated that a larger volume of residual urine, increased serum creatinine, low eGFR, increased serum urea, high systolic and diastolic blood pressure were all significant poor predictors for the development of POD (Table 3).

These results were replicated in the analyses performed on the groups of 64 and 40 patients. The results were clearer in the cohort of 64, which indicates that we correctly placed these patients in the group without POD.

The multivariate analysis demonstrated that serum creatinine over 105 umol/L increased the risk of POD by OR

Table 1. Demographic and clinical characteristics of the study population (n=64).

Variable	Number (*n*)	Mean (SD) /median (range) or number (%)
Age (years), median (IQR)	64	72.5 years (66–75)
Systolic bloodpressure (mmHg), mean (SD)	54	145.5 mmHg (24.4)
Diastolic bloodpressure (mmHg), mean (SD)	54	81.8 mmHg (13.7)
Residual urine (mL), median (IQR)	64	1000 ml (600–1500)
Hematuria (yes), number (%)	57	18 (31.6 %)
eGFR (mL/min/1,73 m^2), median (IQR)	57	68 mL/min/1,73 m^2 (39–87)
Creatinine (umol/L), median (IQR)	57	95 umol/L (75–150)
Urea (mmol/L) median (IQR)	44	7.75 mmol/L (5.8–13.5)
Post obstructive diuresis (yes) number (%)	64	19 (29.7 %)

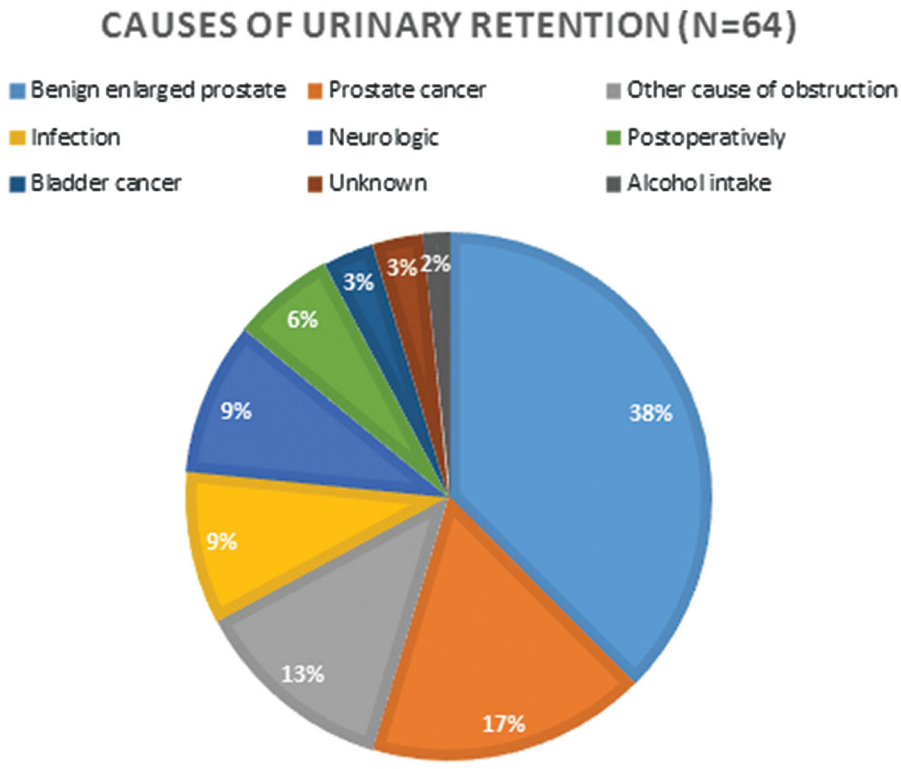

Figure 1. The underlying possible causes of urinary retention in 64 patients.

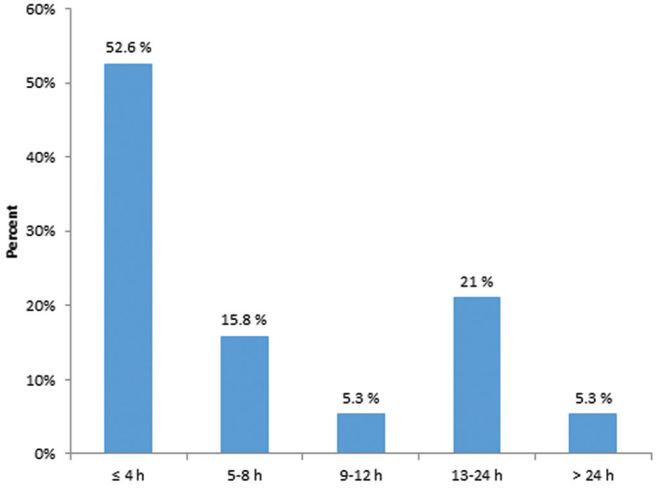

Figure 2. Duration of post obstructive diuresis.

4.83 (95% CI; 1.14–20.44, $p = 0.032$), while serum creatinine over 120 umol/L increased the risk of POD by OR 7.17 (95% CI; 1.63–31.37, $p = 0.009$). Increased residual urine volume per 100 mL was associated with an increased risk of POD by OR 1.21 (95% CI; 1.06–1.40, $p = 0.006$). Overall, there is strong agreement between analyses for the groups of 64 and 40 patients.

Patients with residual urine of more than 1,150 ml at the time of diagnosis have a probability of AUC 0.874 (95% CI: 60.4–96.6, $p < 0.001$), with 84% sensitivity and 78% specificity (Figure 3), of suffering from POD.

Twenty-two of 64 patients had a creatinine level of more than 120 umol/L; of these twenty-two patients, two had chronic kidney disease. Patients with serum creatinine of more than 120 umol/L at the time of diagnosis have a probability of AUC 0.774 (95% CI: 43.4–87.4, $p < 0.001$), with 68% sensitivity and 82% specificity, of suffering from POD.

Discussion

We report an incidence of POD in 29.7% of participating patients with urinary retention. This incidence may be comparable to data reported by Ahmed et al. [10]; however, we observed a large variation in the reported incidences of POD between studies, ranging from 0.5% to 78%. Nyman et al. [7] have explained that this variation in incidence may be due

Table 2. Distribution of possible predictors in patients with different levels of post-obstructive diuresis (POD).

POD duration (hours)	Number (*n*)	Residual urine > 1150 ml (*n*)	Creatinine > 120 umol/L (*n*)	Systolic blood pressure > 140 mmHg (*n*)	Diastolic blood pressure > 90 mmHg (*n*)
≤4	10	8	6	6	3
5–8	3	3	2	3	3
9–12	1	1	1	1	0
13–24	4	4	3	4	2
>24	1	0	1	1	1

Table 3. Comparison of patients with and without post-obstructive diuresis (POD),

Variable	Number ($N = 19$)	Developed POD	Number ($N = 45$)	No-POD	*p* Value
Age, median, (IQR)	19	73 years (65–75)	45	70 years (67–74)	0.601
Systolic blood pressure, mean	19	159.2 mmHg (CI: 146.5; 171.8)	35	138.1 mmHg (CI: 131.2; 145.0)	0.002*
Diastolic blood pressure, mean	19	89.1 mmHg (CI: 83.3; 94.8)	35	77.9 mmHg (CI: 73.3; 82.4)	0.003*
Residual urine, median (IQR)	19	1600 mL (1250–2300)	45	750 mL (500–1100)	<0.001*
Hematuria	18	42.1 %	39	26.3 %	0.244
Creatinine, median (IQR)	19	156 umol/L (104–364.5)	38	88 umol/L (72–113.5)	0.001*
eGFR, median (IQR)	19	38 mL/min/1.73 m^2 (14–66)	38	76 mL/min/1.73 m^2 (55–89.5)	0.002*
Urea, median (IQR)	15	14 mmol/L (11–21.5)	29	6.7 mmol/L (5.75–8.25)	0.004*
Benign enlarged prostate	19	52.6 %	45	31.9 %	0.157

statistical significance at $p < 0.05$. If the data was normally distributed, we used mean and (95% CI), if not, we used median and IQR.

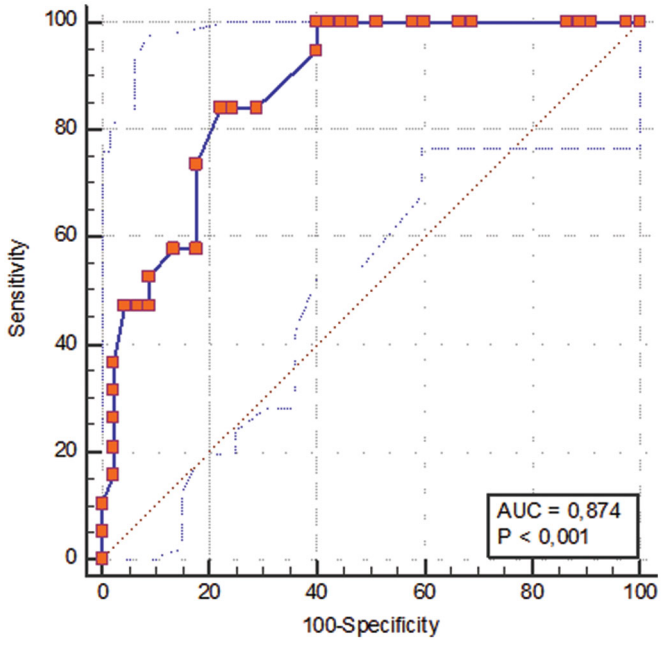

Figure 3. The volume of residual urine at the time of diagnosis with probability of post-obstructive diuresis using the area under curve.

to the use of different criteria to diagnose POD, and the differing characteristics of the study populations can also be a contributing cause. Thus, knowledge of the prevalence of POD in patients with urinary retention remains uncertain and should be tested in larger, prospective studies.

To the best of our knowledge, the only existing study that describes the association between the volume of depleted residual urine and POD was done by Ahmed et al. [10] with 22 patients. Hamdi et al. [9] have identified urinary retention as a predictor of POD without describing the volume of residual urine. We report a statistically significant association between POD and residual urine, creatinine, eGFR and urea, as well as systolic and diastolic blood pressure, and the adjusted analyses support these findings. Thus, we have identified residual urine and creatinine as significant predictors for the development of POD.

The literature has described the volume of depleted residual urine as an important parameter for whether a patient should be admitted for observation [2,14]. Most sources have recommended admission at 750–1,000 mL of residual urine [2,5]; others have argued that POD is unlikely to occur unless the residual urine is 1,500 mL or less [15,16]. However, none of these recommendations are substantiated by clinical studies or clear evidence. Thus, this study contributes new knowledge to understanding the relationship between residual urine and POD. We report that a depleted residual urine volume greater than 1,150 mL is predictive of POD (AUC 0.87) in patients with urinary retention. Considering the retrospectivity and limited sample size of the study, depleted residual urine volume above 1,150 mL may be used as an admission criterion.

We also demonstrate that serum creatinine over 120 umol/L is associated with an increased risk of POD by OR 7, and this finding is supported by other recent studies. Hamdi et al. [9] have identified serum creatinine as an independent predictor of POD in ICU patients. Limjunyawong et al. [17] have found higher serum creatinine in patients with POD and have identified low eGFR as an independent predictor of POD in patients with renal failure due to an obstructed upper urinary tract. Ahmed et al. [10] have supported this finding in their study of 22 patients with chronic urinary retention, which found all patients with POD to have creatinine exceeding 120 umol/L. In contrast, Bishop [18] has reported that 57% of patients with chronic retention and onset or current renal failure developed POD and has concluded that the extent and duration of POD are not related to elevated creatinine. It is possible that the correlation may

become clearer if we can stratify whether the creatinine increase has occurred during retention. In our study, 22 patients had creatinine of over 120 umol/L, and two of these patients had chronic kidney disease. In the remaining patients, the only underlying cause of creatinine elevation was urinary retention. Thus, the increase in creatinine due to urinary retention, rather than just the current serum creatinine, could be a more relevant predictor of POD.

In our study, we observed that patients who developed POD had significantly elevated blood pressure, which has also been reported in previous studies and is common in acute urinary retention due to fluid retention and pain [7,19,20]. High blood pressure is often associated with other symptoms of overhydration, such as edema and hydronephrosis, and patients with these symptoms are at risk of developing pathological POD [4,21].

The limits of the study should be highlighted. First, due to the retrospective design, some data were missing, indicating the incomplete nursing observations with this standard manual registration procedure. For this reason, prospective studies should be conducted to improve data quality and ensure the accurate and timely documentation of urinary excretion. Registration of urinary excretion is an essential nursing observation both in predicting the occurrence of POD and in ensuring the best possible care and treatment. The digitalization of the fluid balance observation may be the solution for the missing data. Second, the sample size was small, implying wide confidence intervals and thus uncertainty associated with the estimates. Third, there was a risk of bias due to non-participation.

In conclusion, this small retrospective study contributes new evidence that depleted residual urine of more than 1,150 mL and creatinine of more than 120 umol/L are useful predictors of POD in patients with urinary retention. These results can be used to identify patients with urinary retention who require hospitalization; however, larger prospective studies with sufficient data collection should be conducted to validate the results and contribute more solid evidence.

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Disclosure statement

The authors declare no potential conflicts of interest in relation to this work.

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