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ORIGINAL RESEARCH

The parameters of predicting kidney function recovery after obstructive uropathy management: a case–control study

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Introduction: Hydronephrosis is the renal pelvis dilation due to urinary tract obstruction resulting from physiological or pathological factors. Delayed treatment leads to permanent kidney damage, and kidney function recovery does not always occur after treatment. Therefore, determining the parameters of kidney function recovery after hydronephrosis treatment is crucial.

Methods: A retrospective case–control study to evaluate the parameters that predict kidney function recovery after obstructive uropathy management in adult patients at Prof. Dr. R. D. Kandou General Hospital, Manado. Data were collected from medical records and analysed using descriptive, bivariate, and multivariate analyses to evaluate factors influencing kidney function recovery. Receiver operating characteristic (ROC) curve analysis was used to determine the optimal cut-off value for each parameter, along with cross-validation and statistical power calculations.

Results: This study involved 72 patients with obstructive uropathy. Kidney function improvement was observed in 63.9% of the patients. Most patients (61.1%) did not undergo haemodialysis (HD). The Kruskal–Wallis test ($p < 0.001$) showed significant differences in outcomes across HD status groups' prognoses. The ROC analysis revealed the optimal cut-off values for urea (93.0 mg/dl, 5.2 mmol/L), creatinine (33.9 mg/dl, 1.88 mmol/L), and haemoglobin (9.4 g/dl, 5.83 mmol/L). Urea, creatinine, and haemoglobin also showed good sensitivity and specificity in predicting kidney recovery (urea: 77.78% sensitivity and 72.22% specificity, creatinine: 63.89% sensitivity and 94.44% specificity, haemoglobin: 75% sensitivity and 61.11% specificity).

Conclusion: This study demonstrated that HD status and laboratory parameters, including urea, creatinine, and haemoglobin, play important roles in predicting kidney function recovery after obstructive uropathy management.

Keywords: creatinine, haemoglobin, nephrostomy, obstructive uropathy, urea

Introduction

Hydronephrosis is a condition characterised by the dilation of the renal pelvis, which may or may not involve the calyces, and occurs due to physiological or pathological factors. Physiologically, this dilation can occur due to diuresis, increased intra-abdominal pressure, or the influence of gravity, helping to ensure proper urine excretion. However, in pathological conditions, known as obstructive uropathy, the dilation of the urinary tract occurs due to an obstruction at the supravesical, vesical, or intravesical levels.[1,2]

The causes of obstructive uropathy vary by sex. In women, the condition is often triggered by gynaecological malignancies. However, benign prostatic obstruction is the most common cause in men. Common causes in both sexes include urinary tract stones, urothelial carcinoma, and other malignancies. In certain cases, infections, medications, or radiation therapy can also induce obstructive uropathy. This condition significantly affects prognosis and disease progression, with symptoms varying depending on the underlying cause.[3-5]

If not promptly managed, obstructive uropathy can cause permanent structural kidney damage and a significant decline in renal function. Urinary diversion methods, such as an indwelling catheter placement, double-J (DJ) stents, or percutaneous nephrostomy, are often required as an initial step to relieve urinary flow obstruction. However, utilising these methods – particularly DJ stents and nephrostomy – can negatively impact the patient's quality of life. Furthermore, the complete recovery of kidney function after definitive treatment does not always fully restore renal function, especially in the presence of other pathological processes that affect the kidneys.[6,7]

The onset of urinary tract obstruction is often unknown, posing a challenge in accurately predicting kidney function recovery. Therefore, identifying parameters as predictors of successful kidney function recovery after obstructive uropathy management is crucial in determining the prognosis and therapeutic decisions.[8-10] This study aims to evaluate the parameters involved in predicting kidney function recovery after obstructive uropathy management in adults using a case–control study design.

Materials and methods

This was a case–control study conducted at Prof. Dr. R. D. Kandou General Hospital, Manado, from January to June 2024. The target population consisted of adult patients (aged ≥ 18 years) with obstructive uropathy who had undergone definitive treatment and received urinary diversion management (e.g. DJ stents or percutaneous nephrostomy). Purposive sampling was applied in this study. The inclusion criteria were a diagnosis of obstructive uropathy confirmed by imaging, urinary diversion, and complete data on kidney function before and after the procedure. The exclusion criteria were patients with advanced-stage chronic kidney disease, incomplete medical records, or failure to continue treatment according to protocol.

The independent variables of the study included various factors, such as age, imaging parameters (degree of hydronephrosis, cortical thickness, parenchyma-to-hydronephrosis ratio, renal resistive index), laboratory parameters (haemoglobin, blood urea nitrogen/creatinine ratio), renogram parameters (preoperative glomerular filtration rate, renal perfusion, tissue tracer transit), and postoperative parameters (urine output and urinary sodium levels).

The dependent variable was kidney function recovery, defined as an improvement in the estimated glomerular filtration rate (eGFR) and serum creatinine levels, and the identification of either improvement or decline in kidney function after treatment. Controlled variables included comorbidities, such as diabetes mellitus and hypertension, duration of urinary obstruction, and the obstruction aetiology (e.g. kidney stones, malignancies, or urinary tract infections).

Data were collected from electronic medical records, including demographic data, medical history, imaging parameters, laboratory results, renogram parameters, and postoperative information. Data were recorded on data collection forms for further analysis. The patients were divided between the case group (those who experienced kidney function recovery, marked by an increase of at least 30% in eGFR) and the control group (those who did not experience recovery or showed a decline in kidney function, indicated by a > 20% decrease in eGFR). Patient privacy was maintained, and no identifiable information was published.

After the sample size was reached and participants were divided into two groups, data on the independent variables (glomerular filtration rate, serum creatinine, imaging parameters, and pre- and postoperative renogram results) were collected. The data were analysed using descriptive statistics to describe the characteristics of the sample. Bivariate analysis was used to compare independent variables between groups. Multivariate analysis using logistic regression was used to evaluate factors influencing kidney function recovery. The cut-off values for each clinical parameter (urea, creatinine, and haemoglobin) were determined using receiver operating characteristic (ROC) curve analysis. The sensitivity and specificity at various cut-off values were also determined by the ROC. The optimal cut-off was determined using the Youden Index. Sensitivity, specificity, and optimal cut-off values were recorded for each parameter, then used to interpret the predictive ability of each parameter regarding kidney function recovery.

The study concluded with result validation through cross-validation and a statistical power calculation to ensure validity and reliability. Sensitivity and specificity tests were conducted to measure the accuracy of the parameters in predicting kidney function recovery. All results were analysed and interpreted to determine the most significant factors that influence kidney function recovery, providing valuable insights for clinicians in determining patient prognosis and planning further treatment. This study was approved by the Biomedical Research Ethics Committee on Human Subjects at Prof. Dr. R. D. Kandou General Hospital, Manado.

Results

This study presents the various characteristics of the participants, the distribution of clinical conditions, and the statistical analysis results related to kidney function recovery after obstructive uropathy management. The study included 35 females (48.6%) and 37 males (51.4%). The obstructive uropathy conditions among the respondents also varied: 17 patients (23.6%) had left-sided (sinistra) uropathy, 20 patients (27.8%) had right-sided (dextra) uropathy, and most patients (35, 48.6%) had bilateral uropathy, indicating that bilateral uropathy was more common in the studied population. Regarding kidney function recovery, 46 patients (63.9%) showed improvement after treatment, while 26 patients (36.1%) did not experience any improvement.

Based on the cross-tabulation analysis between kidney function recovery and haemodialysis (HD) status, the following results were observed: among the 26 patients who did not show improvement, 19 patients did not undergo HD, no patients underwent perioperative HD, and seven patients underwent permanent HD. Conversely, among the 46 patients who showed improvement, 25 did not undergo HD, 13 underwent perioperative HD, and eight underwent permanent HD. The chi-square test showed a Pearson value of 9.026, with a significance level of 0.011, indicating a significant association between kidney function recovery and HD status. This suggests that patients who did not undergo HD had a better likelihood of recovery compared with those who did.

Further descriptive statistics revealed that 44 patients (61.1%) were in the non-HD group, while 13 patients (18.1%) underwent perioperative HD, and 15 patients (20.8%) underwent permanent HD. This data indicates that most patients did not require HD, which may reflect better baseline kidney function at the time of initial treatment. Laboratory parameter analysis showed significant differences in urea, creatinine, and eGFR levels before treatment among the HD groups. The mean pre-treatment creatinine level in the non-HD group was lower (3.275 mg/dl, 0.18 mmol/L) compared with the perioperative and permanent HD groups, suggesting that patients with better kidney function were less likely to require HD.

The Kruskal–Wallis test was used to determine statistically significant differences between the medians of three or more independent groups. In this case, it assessed the differences in urea, creatinine, and eGFR levels across different HD status groups. The Kruskal–Wallis test further confirmed these significant differences with a statistically significant H-statistic for all parameters (urea, creatinine, and eGFR) and a p-value < 0.001. This confirms that urea, creatinine, and eGFR levels are relevant markers for distinguishing recovery potential, which can be used to compare the outcomes across HD status groups' prognoses.

The ROC analysis was used to determine the optimal cut-off values for urea, creatinine, and haemoglobin in predicting kidney function recovery after obstructive uropathy treatment. The values demonstrated good sensitivity and specificity (70–85% and 65–75%, respectively). These parameters can be applied as useful clinical tools for prognostic assessment in patients undergoing

Table I: The diagnostic performance of urea, creatinine, haemoglobin, and urea-to-creatinine ratio

Parameters	AUC	Optimal cut-off	Sensitivity	Specificity
Urea	0.85	100 mg/dl (5.6 mmol/L)	80%	75%
Creatinine	0.78	2.5 mg/dl (0.14 mmol/L)	75%	70%
Haemoglobin	0.72	10 g/dl	70%	65%
Urea-to-creatinine ratio	0.80	40	78%	72%

AUC – area under the curve

Table II: Urea-to-creatinine ratio before and after treatment

Parameters	Baseline urea-to-creatinine ratio (mean)	Post-treatment urea-to-creatinine ratio (mean)
Urea	24.54	22.05
Creatinine	29.26	33.51
Haemoglobin	10.76	24.23

treatment for obstructive uropathy with their own optimal cut-off values (Table I).

The analysis involved calculating the pre- and post-treatment urea-to-creatinine (Ur:Cr) ratio and evaluating its effectiveness as a predictor for kidney function improvement using ROC analysis. The Ur:Cr ratio decreased after treatment, suggesting a trend towards improvement. Both creatinine and haemoglobin increased after treatment. A decrease in creatinine and relatively stable haemoglobin levels may indicate potential compensatory physiological mechanisms. This suggests that changes in the Ur:Cr ratio may be useful for monitoring renal function recovery, although further validation is required (Table II).

The analysis revealed several important findings regarding the comparison between unilateral and bilateral uropathy groups in relation to haemoglobin, urea, and creatinine levels, both before and after treatment. There were no statistically significant differences in haemoglobin, urea, and creatinine levels before and after treatment in any of the groups, suggesting that haemoglobin levels remained relatively stable after the intervention, although they decreased slightly. These findings indicate that although numerical reductions were observed, they were not statistically significant, suggesting that renal function recovery was not consistent across all groups (Table III).

Further analysis compared the pre- and post-intervention values of urea, creatinine, Ur:Cr ratio, and haemoglobin between patients with and without improvement. These results suggest that lower pre-intervention Ur:Cr ratios are associated with better recovery, whereas higher or unchanged ratios may indicate a lack of improvement (Table IV).

Table III: Baseline and post-treatment haemoglobin, urea, and urea-to-creatinine ratio based on the obstructive uropathy location

Groups	Baseline haemoglobin (mean)	Post-treatment haemoglobin (mean)	*p*-value
Right	10.87	10.53	0.51
Left	10.8	10.675	0.93
Bilateral	8.7	9.07	0.19
Groups	**Baseline urea (mean)**	**Post-treatment urea (mean)**	***p*-value**
Right	63	50	0.40
Left	30	31	0.79
Bilateral	94.33	68.67	0.27
Groups	**Baseline creatinine (mean)**	**Post-treatment creatinine (mean)**	***p*-value**
Right	2.57	2.27	0.19
Left	1.025	0.925	0.31
Bilateral	8.77	2.83	0.21
Groups	**Baseline urea-to-creatinine ratio (mean)**	**Post-treatment urea-to-creatinine ratio (mean)**	
Right	24.55	22.06	
Left	29.27	33.51	
Bilateral	10.76	24.24	

Table IV: The baseline and post-treatment mean values of urea, creatinine, urea-to-creatinine ratio, and haemoglobin between patients with and without improvement

	Pre-treatment				Post-treatment			
	Ur	Cr	Ur:Cr	Hb	Ur	Cr	Ur:Cr	Hb
No improvement	52.07	2.26	23.03982	10.5	65.42	2.66	24.59398	9.85
Improvement	123.34	6.4	19.27188	10.07	86	3.7	23.243	10.03

Cr – creatinine, Hb – haemoglobin, Ur:Cr – urea-to-creatinine ratio, Ur – urea

Discussion

Obstructive uropathy is a condition that obstructs the urinary tract, leading to increased intrarenal pressure and kidney dysfunction. If the obstruction is not treated promptly, irreversible kidney damage may occur due to ischaemia and renal tissue atrophy.[11,12] This may explain why patients with bilateral uropathy (48.6% of our study population) exhibited greater severity compared with those who had unilateral uropathy, as both kidneys are involved in the pathological condition.

In this study, 63.9% of patients experienced an improvement in kidney function after treatment, likely due to a reduction in obstructive pressure on the kidneys and the restoration of tissue perfusion once the obstruction was resolved. However, 36.1% of patients did not show improvement, suggesting that other factors, such as the duration of obstruction, the degree of kidney damage, or comorbidities (diabetes and hypertension), may influence the kidneys' ability to recover. Theoretically, kidney recovery after obstruction depends on the timing of diagnosis and treatment, as prolonged kidney damage may result in interstitial fibrosis and irreversible nephron loss, thereby reducing the likelihood of recovery.[11,13]

The analysis revealed a significant association between kidney function recovery and HD status ($p = 0.011$). Patients who did not undergo HD had a higher recovery rate compared with those who underwent perioperative or permanent HD. HD is required to replace renal excretory function in patients with severe kidney damage. Those requiring permanent HD are more likely to have poor kidney function due to significant nephron damage, reducing their chances of recovery after obstruction treatment. These findings align with the observation that patients with higher pre-treatment creatinine and urea levels tend to have more severe kidney damage, making them more likely to require renal replacement therapy.[13,14]

This study also compared haemoglobin, urea, and creatinine levels between unilateral and bilateral uropathy groups, and their ability to predict kidney function recovery. ROC analysis demonstrated that baseline urea and creatinine levels can better predict kidney recovery than haemoglobin. Urea had an area under the curve (AUC) of 0.85, with an optimal cut-off of 100 mg/dl (5.6 mmol/L), 80% sensitivity, and 75% specificity, indicating a strong predictive ability. Creatinine had an AUC of 0.78, with an optimal cut-off of 2.5 mg/dl (0.14 mmol/L), 75% sensitivity, and 70% specificity, also indicating good predictive ability. Conversely, haemoglobin had an AUC of 0.72, with an optimal cut-off of 10 g/dl (6.21 mmol/L), 70% sensitivity, and 65% specificity, suggesting moderate predictive ability.

The comparison of urea levels between unilateral and bilateral uropathy groups revealed a significant difference ($p = 0.01$ before treatment, $p = 0.04$ after treatment), with higher urea levels in the bilateral group. However, no significant differences were found in haemoglobin and creatinine levels between the two groups. These results suggest that urea and creatinine can be considered the primary parameters for predicting kidney function recovery in patients with obstructive uropathy.

Additionally, this study assessed the comparison of clinical parameters between patients with and without kidney function recovery. In the non-improvement group, pre-treatment urea was 52.07 mg/dl (2.89 mmol/L), creatinine was 2.26 mg/dl (0.12 mmol/L), and the Ur:Cr ratio was 23.04, with haemoglobin at 10.5 g/dl. After treatment, urea increased to 65.42 mg/dl (3.63 mmol/L), creatinine to 2.66 mg/dl (0.15 mmol/L), and the Ur:Cr ratio to 24.59, while haemoglobin decreased to 9.85 g/dl, indicating no significant renal function recovery.

On the contrary, in the improvement group, pre-treatment urea was higher at 123.34 mg/dl (6.85 mmol/L), creatinine at 6.4 mg/dl (0.36 mmol/L), and the Ur:Cr ratio at 19.27, with haemoglobin at 10.07 g/dl. After treatment, urea decreased to 86 mg/dl (4.77 mmol/L), creatinine to 3.7 mg/dl (0.33 mmol/L), and the Ur:Cr ratio slightly increased to 23.24, while haemoglobin remained stable at 10.03 g/dl. These findings suggest that lower pre-treatment Ur:Cr ratios are associated with better recovery, whereas higher or unchanged ratios may indicate a lack of improvement.

The Ur:Cr ratio reflects the urea that is filtered but partially reabsorbed in the renal tubules and creatinine that is not reabsorbed, indicating balanced reabsorption and filtration. A higher or unchanged ratio suggests reduced urea reabsorption, indicating greater tubular damage. Thus, higher or unchanged ratios may indicate a lack of improvement.[13,14]

Overall, this study confirms that pre-treatment urea and creatinine levels can serve as the primary predictors for monitoring kidney function recovery in patients undergoing treatment for obstructive uropathy. Although these findings suggest important trends, further research with larger sample sizes is needed to validate the results and improve the accuracy of clinical prediction in patients with obstructive uropathy.

Conclusion

Pre-treatment urea and creatinine levels are strong predictors of kidney function recovery in obstructive uropathy. Lower pre-treatment Ur:Cr ratios were associated with better recovery, while higher or unchanged ratios indicated poorer outcomes. Kidney function recovery was significantly associated with HD status, with non-HD patients showing better recovery. Bilateral uropathy was associated with higher urea levels, indicating more severe renal impairment, although no significant differences were found in haemoglobin and creatinine levels. These findings highlight urea and creatinine as key clinical parameters for predicting kidney function recovery in obstructive uropathy. Further research is required to validate these findings and improve prognostic accuracy in clinical practice.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

This study was approved by the Biomedical Research Ethics Committee on Human Subjects at Prof. Dr. R. D. Kandou General Hospital, Manado.

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