CASE REPORT

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Impact of radiocontrast media on microscopic urine morphology and output in children following cardiac catheterization

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ABSTRACT

Background: The incidence of contrast-induced acute kidney injury (CI-AKI) was relatively high, especially in lower-income countries following cardiac catheterization. Urine morphology outperforms serum creatinine as an early, more specific, and cost-effective marker for detecting and differentiating CI-AKI. Urine output (UO) is also a cost-effective marker capable of detecting early CI-AKI. This study aims to determine differences in urine morphology and UO in pediatric patients pre- and post-cardiac catheterization, including subgroup analysis based on contrast type.

Methods: A one-group pre-post experimental study from pediatric congenital heart disease (CHD) diagnosed by echocardiography patients aged 0-18 years, who underwent cardiac catheterization at a tertiary referral hospital in Bali (June-December 2025). Urine samples for urinalysis were obtained 2-12 hours before and 12-48 hours after the intervention. Fluid balance and urine output were collected using a urine bag or pediatric urine collector and totaled over 24 hours, 2-12 hours before and 24 hours after contrast administration. Urinalysis was analyzed using standard urine microscopy for morphology at a standardized private clinical laboratory. Data were analyzed using SPSS version 29.0.

Results: A total of 43 pediatric patients who underwent cardiac catheterization; 3 declined participation; 40 eligible subjects. Urine morphology findings were not significantly different pre- and post-catheterization (McNemar exact test, $p = 0.25$, CI 95%). Urine output (mL/kg/hour) was significantly different and higher post-catheterization (Wilcoxon signed-ranks test, $Z = -3.105$, $p = 0.002$). There were significant differences in urine output between pre-and-post catheterization in Iohexol (p=0.004) but slightly not significant in Iopromide group (p=0.051). The increase in UO levels in the Iohexol group is significantly (p=0.042) higher than in the Iopromide group.

Conclusion: No significant changes in urine morphology were observed pre-and-post catheterization. There is a significant change in urine output, which increased significantly after cardiac catheterization.

Keywords: *CHD, Catheterization, Urine Morphology, Urine Output, CI-AKI*.
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INTRODUCTION

The use of contrast agents in cardiac catheterization procedures is often associated with an increased risk of contrast-induced acute kidney injury (CI-AKI), which is an important consideration in patients undergoing cardiac catheterization.[1] Acute kidney injury (AKI) is a key determinant of long-term prognosis after cardiac catheterization, associated morbidity, chronic kidney disease, and mortality.[2]

Studies on the incidence of CI-AKI following cardiac catheterization in the pediatric population remain varied between 0-18.75%.[3-5] Data on the prevalence of CI-AKI in pediatric patients in Indonesia remain limited. Most available studies in Indonesia focus on adult populations undergoing cardiovascular procedures. Therefore, epidemiological estimates in pediatric research often rely on international studies. Serum creatinine often rises slowly, so alternative markers that are faster, less expensive, and show high specificity, such as urine morphology, are needed.[6-10]

Urine morphology has been said to be diagnostically useful to differentiate AKI that is due to prerenal azotermia caused by renal hypoperfusion characterized by bland urine sediment with little cellular activity and primarily hyaline or few finely granular casts; from true renal parenchymal injury characterized by urine sediment containing renal tubular epithelial cells (RTEC), RTEC casts, and coarse granular/muddy brown casts caused by structural injury from acute tubular injury (ATI).[11-13] A study by Perazella in 2020, conclude that urine morphology was highly specific in pedicting AKI.[11] Contrast-induced AKI began with tubular injury leads to shedding of renal tubular epithelial cells and formation of granular casts, which appear in urine sediment as markers of acute tubular damage.[14,15]

The outcome of a procedure should not rely only on the technical success of the intervention, as other factors influence

patient prognosis. One of these is the risk of CI-AKI, which may worsen the condition after cardiac catheterization. By identifying urine morphology and urine output as cost-effective examinations capable of detecting early CI-AKI, clinical outcomes may improve, and procedural failure may be prevented. Based on those mentioned above, this study aims to evaluate the impact of radiocontrast media on microscopic urine morphology and output in children following cardiac catheterization.

METHODS

This one-group pre-posttest experimental study aimed to evaluate the differences and correlation of urine morphology and urine output in pediatric (aged <18 years old) patients who underwent cardiac catheterization at a tertiary referral hospital in Bali, Indonesia, between June and December 2025. All pediatric patients diagnosed with congenital heart disease (CHD) who underwent cardiac catheterization procedures involving the use of contrast media during the study period and had complete medical records, including urinalysis and urine production data on preoperative, intraoperative, and postoperative periods. Exclusion criteria were incomplete medical records, patients with pre-existing kidney disease (pre-existing AKI), patients taking other nephrotoxic medications during the study period, or patients undergoing a repeat contrast procedure in the near future.

The data were collected from the electronic and paper-based medical records. Variables obtained were age, sex, body weight, length/height, type of CHD, contrast dose, procedural type, procedural time, and contrast type. Variables such as urinalysis (urine pH, leucocyte, nitrite, protein, glucose, ketone, blood, urobilinogen, bilirubin, color, leucocyte, erythrocyte, epithelial cell sediment, and bacteria) and urine production were collected before, during, and after contrast injection.

Urine samples (30 mL) were collected using a urine specimen container or pediatric collector. Samples for urinalysis and were obtained 2–12 hours before and 12–48 hours after the intervention and analyzed in a standardized laboratory. For sediment analysis, fresh urine from spontaneous voiding or catheter tubing was examined within 1–2 hours or refrigerated if delayed. Approximately 10 mL was centrifuged (≥1500 rpm, 5 minutes) and examined on a glass slide. Microscopy (100× and 400×) evaluated ≥10–20 fields to identify formed elements. Dipstick parameters (pH, osmolality) were considered during interpretation.[12]

Fluid balance and urine output were collected using a urine bag or pediatric urine collector and totaled for 24 hours, on 2-12 hours before and 24 hours after contrast administration. Urine output (UO) was calculated by dividing total urine volume (mL) in 24 hours by body weight (kg) to assess renal excretory function/oliguria every kilogram per hour in 24 hours, then dividing by 24 to express in mL/kg/hour.

Contrast volume was defined as the total amount of contrast (Iohexol and Iopromide) used (in milliliters) per body weight (kg). Urine sediment abnormalities was defined as there was an abnormal findings in red blood cells (RBCs) sediments (>2/ low power field (LPF)), renal tubular epithelial cells (RTECs) (>1/ LPF), transitional (urothelial) cell (>1/ LPF), squamous cell (>1/LPF), acellular casts (hyaline, granular, waxy or fatty casts positive) and cellular casts (RBC or RTEC casts positive), and others (pigmented, bacterial and crystal casts positive).[15]

Congenital heart disease (CHD) was diagnosed by echocardiography and classified as acyanotic and cyanotic types. Age was defined as months at the time the intervention occurred. Nutritional status were classifed by well-nourished, mild protein-energy malnutrition (PEM), moderate PEM, severe PEM, overweight, and obesity based on World Health Organization (WHO) classification of nutritional status that are adjusted based on age and length/ height or BMI.[16,17] Procedural types were categorized as diagnostic (hearth catheterization and ventrical septal defect (VSD) angiography) and therapy (VSD closure, atrial septal defect (ASD) closure, patent ductus arteriosus (PDA) closure, coarctation of the aorta (CoA) stenting, interatrial septum (IAS) stenting and urgent percutaneous transvenous balloon valvotomy (PTBV)). Procedural times were defined as the duration from needle puncture until the end of intervention in minutes. Contrast volume was defined as the total amount of contrast in milliliters (mL) administered divided by body weight (in kilograms). Fluoroscopy time refers to the cumulative duration (minutes) of fluoroscopic imaging used during the cardiac catheterization procedure.

Acute kidney injury (AKI) was categorized as AKI and no AKI based on the Acute Kidney Injury Network (AKIN) definition of AKI by serum creatinine, which is (a) an absolute increase in serum creatinine levels by ≥0.3 mg/dL from baseline, or (b) a relative increase in serum creatinine by ≥50% from baseline. The patient characteristics are described as frequencies and percentages. This study used the Shapiro-Wilk test to assess the normality of the data (which less than 50 samples).

Associations between two categorical compared groups, which were pre- and post-catheterization urine morphologies, were analyzed using the McNemar test. For the numerical data in two compared groups, we used the Wilcoxon test with a p-value ≤0.05, and a 95% CI was considered a significant result. This study was analyzed with SPSS version 24; SPSS, Inc., Chicago, IL, USA.

RESULTS

A total of 43 pediatric patients underwent cardiac catheterization during the study period; 3 of them declined participation. Forty pediatric patients met the inclusion and exclusion criteria and were aged <18 years old, underwent cardiac catheterization, and received contrast media. Table 1 shows the patients' characteristics.

According to the Shapiro-Wilk normality test, data were not normally distributed except for the procedure time and urine output pre- and post-catheterization. Bivariate analyses were conducted using Chi Square Mc Nemar test to find the significantly differences between pre-and post-catheterization urine sediment abnormalities. Urine sediment abnormalities were identified in 8 of 40 (20%) patients before catheterization and in 11 of 40 (27.5%)

Table 1. Study characteristics.

Patient Characteristics	Iohexol (n=20)	Iopromide (n=20)
Gender, n (%)		
Male	10 (50)	12 (60)
Female	10 (50)	8 (40)
Age at intervention of CHD (months), median (min-max)	73 (5-218)	33.5 (6-218)
Nutritional Status, n (%)		
Well-nourished	7 (35)	9 (45)
Mild PEM	6 (30)	7 (35)
Moderate PEM	5 (25)	2 (10)
Severe PEM	1 (5)	2 (10)
Overweight	1 (5)	0 (0)
Obesity	0 (0)	0 (0)
Congenital Heart Disease, n (%)		
Cyanotic	2 (10)	5 (25)
Acyanotic	18 (90)	15 (75)
Acute kidney injury (based on serum creatinine using AKIN criteria), n (%)		
AKI	0 (0)	0 (0)
No AKI	20 (100)	20 (100)
Urine morphology pre-catheterization, n (%)		
RBCs sediments (>2/LPF)	1 (5)	1 (5)
WBCs sediments (>2/LPF)	0 (0)	1 (5)
RTECs (>1/LPF)	1 (5)	1 (5)
Transitional (urothelial) cell (>1/LPF)	0 (0)	0 (0)
Squamous cell (>1/LPF)	0 (0)	0 (0)
Acellular casts and cellular casts	0 (0)	1 (5)
Others	2 (10)	0 (0)
Urine morphology post-catheterization, n (%)		
RBCs sediments (>2/LPF)	1 (5)	1 (5)
WBCs sediments (>2/LPF)	1 (5)	1 (5)
RTECs (>1/LPF)	0 (0)	0 (0)
Transitional (urothelial) cell (>1/LPF)	0 (0)	0 (0)
Squamous cell (>1/LPF)	0 (0)	0 (0)
Acellular casts and cellular casts	0 (0)	0 (0)
Others	2 (10)	2 (10)
Procedural type, n (%)		
Diagnostic	3 (15)	9 (45)
Therapy	17 (85)	11 (55)
Procedure time (minutes) (mean±SD)	41.15 ± 19.82	45.9 ± 25.68
Fluoroscopy time (minutes), median (min-max)	5.32 (2.42-23.16)	5.14(2.10-33.60)
Contrast volume (ml/kgBW), median (min-max)	1.25 (0.07-9.57)	2.08(0.08-7.54)
Urine output (mL) (mean±SD)		
Pre-catheterization	1.35 ± 0.59	1.78 ± 0.84
Post-catheterization	2.35 ± 0.59	2.21 ± 0.98
Urine sediment abnormalities, n (%)		
Pre-catheterization	4 (20)	4 (20)
Post-catheterization	4 (20)	4 (20)

SD: Standard Deviation; RBCs: Red Blood Cells; WBCs: White Blood Cells; LPF: Low Per Field; AKI: Acute Kidney Injury; PEM: Protein Energy Malnourished.

patients after catheterization. Among 40 subjects, all (8 of 40, 20%) individuals with pre-catheterization urine sediment abnormalities remained abnormal post-catheterization. Of the 32 subjects without abnormalities, 3 (9.4%) developed abnormalities after catheterization, while 29 (90.6%) remained normal. Overall, urine sediment abnormalities increased from 8 to 11 cases; however, this difference was not statistically significant based on the McNemar exact test ($p = 0.25$).

Bivariate analysis using the Wilcoxon Signed Ranks test was done to determine the differences in urine output (UO; in ml/kg/hour) between pre- and post-catheterization. Among 40 patients, 26 patients showed an increase in UO after catheterization, while 14 patients showed a decrease. The analysis demonstrated a statistically significant difference in urine output between pre-and post-catheterization measurements, with higher UO observed post-catheterization ($Z = -3.105$, $p = 0.002$). Shapiro-Wilk normality test for both group (Iohexol and Iopromide) on the urine output (UO) variables pre-and-postcatheterization were normally distributed ($p>0.05$). Bivariate analysis using paired T Test were done to determine the differences of UO (in ml/kgBW/hour) between pre-and-post catheterization Iohexol and Iopromide group.

Table 2 showed that the mean UO pre-catheterization in the Iohexol group was 1.35 ± 0.59 ml/kgBW/hour, and the mean UO post-catheterization was 2.35 ± 0.59. In the Iopromide group, it was shown that the mean UO pre-catheterization was 1.78 ± 0.85 and post-catheterization was 2.21 ± 0.98. There were significant differences between pre-and-post catheterization in Iohexol ($p=0.004$) but not significant in Iopromide group (0.051) (Table 2).

Table 3 shows the results of the independent t-test that showed there is a significant difference ($p=0.042$) between changes in UO pre-and-post catheterization in the Iohexol and Iopromide group. The mean increase in the Iohexol group was 1.00 ± 1.36, and in the Iopromide group was 0.43 ± 0.92. This shows that the increase in UO levels in the Iohexol group is significantly ($p=0.042$) higher than in the Iopromide group (Table 3).

Table 2. Difference in urine output between pre-catheterization and post-catheterization based on the Iohexol and Iopromide groups.

Group	Variable	Mean ± SD	p
Iohexol (n=40)	Pre	1.35 ± 0.59	0.004*
	Post	2.35 ± 0.59	
Iopromide (n=40)	Pre	1.78 ± 0.85	0.051
	Post	2.21 ± 0.98	

SD: Standard Deviations; *Statistically significant if p-value less than 0.05; Pre: urine output pre-catheterization; Post: urine output post-catheterization

Table 3. Mean increase in urine output between pre-and-postcatheterization in the Iohexol and Iopromide group.

Variable	Group	Mean ± SD	p
Urine output	Iohexol	1.00 ± 1.36	0.042*
	Iopromide	0.43 ± 0.92	

SD: Standard Deviations; *Statistically significant if p-value less than 0.05;

DISCUSSION

This study examined the differences in urine morphology and urine output (UO) pre-catheterization and post-catheterization in pediatric patients with congenital heart disease (CHD) and based on contrast type (Iohexol and Iopromide). The findings of this study highlights the importance of recognizing early signs of contrast-induced acute kidney injury (CI-AKI) that may resulting in increasing risk of mortality and decrease in prognosis following cardiac catheterization in pediatric patient with CHD.

No significant difference in urine morphology was found between pre- and post-catheterization samples (McNemar exact test, p=0.25). Although no previous studies have evaluated this comparison, 20% (8/40) of subjects showed urine sediment abnormalities after catheterization. No AKI was detected in either assessment, suggesting these abnormalities may reflect early or subclinical tubular injury not captured by serum creatinine. The lack of significant difference may be due to the small sample size, limited sensitivity of urine morphology for early CI-AKI detection, and possibly insufficient tubular injury induced by contrast exposure.

This study aligns with a study published in 2022 study involving 661 surgical patients, which showed that urine morphology abnormalities were detectable immediately and at 6 and 12 hours after surgical intensive care unit admission, with the higher urine morphology score at 6 hours independently associated with severe AKI.[7] Whereas an increase in serum creatinine reflects renal injury that had already occurred 24–48 hours earlier.[18]

Urine morphology was said to provide diagnostically useful information that can differentiate AKI that is due to prerenal azotemia (a bland urine sediment with little cellular activity and primarily hyaline or few finely granular casts due to renal hypoperfusion) from true renal parenchymal injury (urine sediment containing RTECs, RTEC casts, muddy brown casts due to acute tubular injury (ATI).[11] Most AKI cases were likely due to prerenal azotemia.[6,11] Consistent with this study, prerenal azotemia was found in 1 patient (5%) in each group, while WBC sediment was present in 1 patient (5%) post-catheterization.

The other study also concluded that the presence of even one RTEC or GC per high-power field has more than 90% specificity for AKI diagnosis, but it is not sensitive.[19] In this study, no RTECs or GC were identified in post-catheterization urine samples, which is consistent with the absence of AKI cases observed in this study.

This study found no patient diagnosed with AKI (AKIN criteria by serum creatinine). This aligns with a large prospective study involving 2,321 procedures in children <18 years of age who underwent cardiac catheterization using low-osmolar non-ionic contrast media, which demonstrated that contrast-related adverse events were very rare (0.09%), with only one case of transient nephropathy potentially attributable to contrast exposure. Even among the 50 cases with the highest contrast exposure, no CI-AKI was identified.[20]

We found no previous studies have specifically evaluated UO before and after cardiac catheterization in the pediatric population, and so does the differences between Iohexol and Iopromide. However, contrast exposure after catheterization is known to be associated with CI-AKI. The recent AKI standardized criteria by Acute Kidney Injury Network (AKIN) use serum creatinine or decreased UO for at least 6 hours within 48 hours after the administration of iodinated CM, as recommended by the American College of Radiology.[21-24] Contradictingly, previous studies found a significant increase in urine output after catheterization, which was previously reported by Liu et al. and could contribute to a lower risk of CI-AKI.[25,26]

An observational study by Stevens et al. also reported that strategies increasing urine output after contrast exposure (e.g., intravenous hydration and/or diuretics) were associated with a lower incidence of CI-AKI.[27] The more urine that was produced over the 24 hours following contrast exposure, the lower the incidence of CA-AKI.[26,27] Increase urine output related to adequate hydration can dilute intratubular contrast and accelerate its elimination, reducing nephrotoxic exposure.[25] However, the hydration and/or diuretics factor was not assessed in the present study

A limitation of this study is the timing of urine sample collection, which was performed 12–48 hours after the procedure. Previous studies have shown that prerenal azotemia may resolve within 24 hours; therefore, urine abnormalities could have already resolved at the time of sampling. This may have led to an underestimation of urine sediment abnormalities and reduced the ability to detect early renal changes post-catheterization.[6,11]

CONCLUSION

There were no statistically significant differences in urine morphology before and after cardiac catheterization. Urine output increased significantly in pediatric patients following the procedure, with a greater increase observed in the Iohexol group. Future research should focus on the pathophysiological mechanism behind the increased urine output observed with Iohexol.

ETHICS CONSIDERATION

This study was approved by released of ethical exemption from Research Ethics Committee of the Faculty of Medicine, Universitas Udayana/Ngoerah Hospital with ethical number of 0574/UN14.2.2.VII.14/LT/2026.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

All authors prepared the manuscript and agree for this final version of the manuscript to be submitted to this journal.

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