Journal of Health and Nutrition Research
Vol. 5, No. 1, 2026, pg. 54-60, https://doi.org/10.56303/jhnresearch.v5i1.720
Journal homepage: https://journalmpci.com/index.php/jhnr/index

e-ISSN: **2829-9760**

Correlation Between Hydration Status and Renal Ultrasonographic Parameters: A Cross-Sectional Study

Wahyu Hidayat[1]*, Minda Fitrah Riwanda[1], Nurbaiti[1], Puspa Pamella Suci[2], Sriyatun[1], Puji Supriyono[1]

[1] Department of Radiodiagnosis and Radiotherapy, Poltekkes Jakarta II, Indonesia
[2] Cabangbungin Regional General Hospital, Bekasi Regency, Indonesia

Corresponding Author Email: wahyu.hidayat@poltekkesjkt2.ac.id

ORIGINAL ARTICLES

Submitted: 15 August 2025

Accepted: 7 November 2025

Keywords:
Renal Ultrasonography, Parenchymal Echogenicity, Hydration Status Assessment, Perceived Urine-Richness Index (PURI)

ABSTRACT

The kidneys play a critical role in maintaining fluid homeostasis, and suboptimal hydration may lead to morphological alterations detectable via imaging. This study aimed to analyze the correlation between hydration status and various renal ultrasonographic parameters. An observational, cross-sectional study was conducted with 30 healthy radiology students selected through purposive sampling. Hydration status was evaluated using the Perceived Urine-Richness Index (PURI) based on morning urine color. Renal ultrasound examinations were performed to assess kidney size, parenchymal echogenicity, corticomedullary differentiation, and resistive index. Data were statistically analyzed using the Chi-Square test with a significance threshold of $p<0.05$. The assessment revealed that 76.7% of participants had low to very low hydration levels . Statistical analysis demonstrated that parenchymal echogenicity was the only parameter significantly correlated with hydration status ($p=0.001$ for the right kidney; $p=0.004$ for the left kidney). Other ultrasonographic markers, including kidney length, cortical thickness, and resistive index (RI), showed no significant association with hydration levels. Hydration status is significantly associated with changes in renal parenchymal echogenicity, identifying it as a sensitive, non-invasive marker for early renal stress and subclinical morphological changes. These findings underscore the necessity of maintaining adequate fluid intake to preserve renal structural integrity as visualized through ultrasonography.

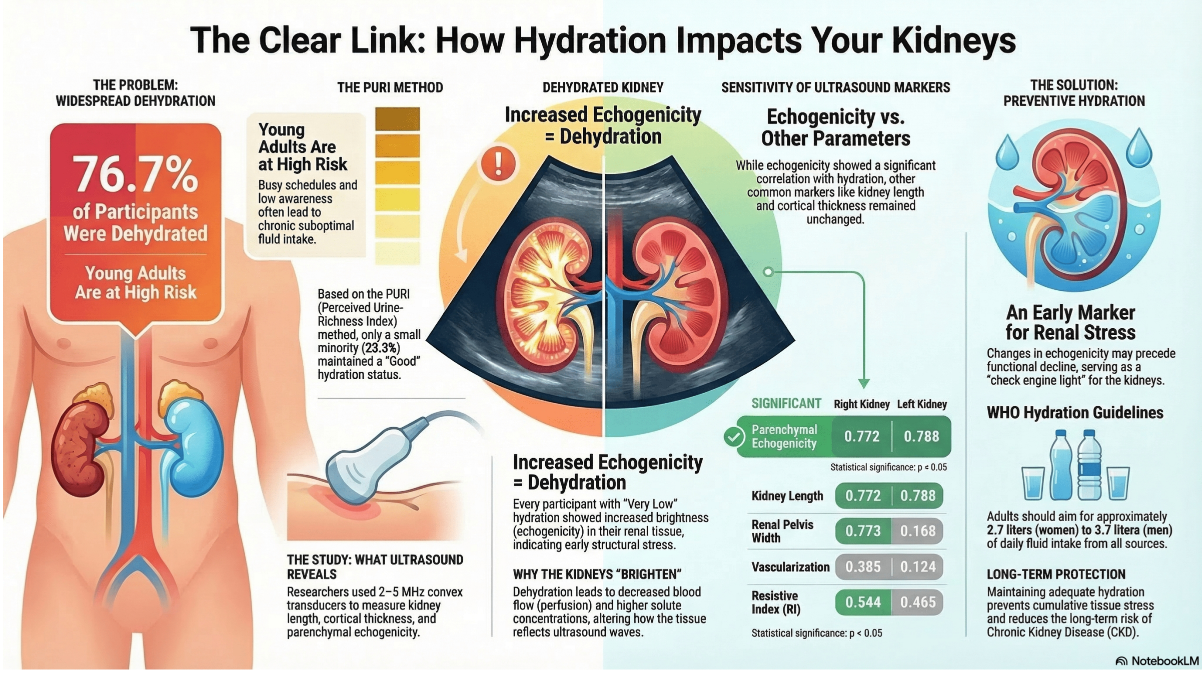
Access this article online

Quick Response Code

Key Messages:

- Hydration status demonstrates a significant statistical correlation with renal parenchymal echogenicity, where suboptimal hydration levels are associated with increased echogenic intensity, reflecting early morphological changes.
- Renal parenchymal echogenicity serves as a more sensitive and dynamic indicator of hydration-related renal stress compared to other ultrasonographic parameters such as kidney length, cortical thickness, or the resistive index.

GRAPHICAL ABSTRACT



INTRODUCTION

The kidneys are vital organs responsible for blood filtration, electrolyte regulation, and maintaining acid–base balance (1). The kidneys are vital organs responsible for blood filtration, electrolyte regulation, and maintaining acid–base balance(2)(3). Anatomically, they are bean-shaped structures measuring between 9 and 12 cm in length, located retroperitoneally on either side of the spine, with the right kidney positioned slightly lower than the left(4)(5). One of the key factors that influence kidney function is the body's hydration status and any imbalance in fluid either due to dehydration or overhydration may alter kidney morphology which can be evaluated through ultrasonographic examination (6)(7)(8).

According to the World Health Organization (WHO), the recommended daily fluid intake for adults is approximately 2.7 liters for women and 3.7 liters for men, including water from food and beverages(9). However, data from the THIRST (The Indonesian Regional Dehydration Study) indicate that 46.1% of Indonesians experience dehydration, particularly among young adults(10). Chronic dehydration can reduce plasma volume and impair renal function by disrupting the glomerular filtration process (11)(12)(13). Renal ultrasonography provides a non-invasive means to evaluate structural parameters, including kidney length, cortical thickness, and parenchymal echogenicity (14)(15)(16)(17). Hydration status can be assessed simply using the Perceived Urine-Richness Index (PURI), which evaluates morning urine color (18)(19).

The kidney ultrasound examination begins with proper patient and equipment preparation to ensure optimal imaging quality. The examination uses a 2–5 MHz convex transducer and ultrasound gel as a transmission medium. Participants were instructed not to alter their eating or drinking patterns before the scan, to wear loose clothing, and to follow breathing and positioning instructions, such as the supine position for the right kidney and the right lateral decubitus for the left kidney, to obtain accurate, artifact-free images (20)(21).

This study aims to analyze the correlation between hydration status, as measured by the PURI method, and renal ultrasound findings in radiology students, with emphasis on echogenicity as a potential early marker of renal stress.

https://doi.org/10.56303/jhnresearch.v5i1.720

METHODS

This study was designed as an observational, cross-sectional study. This approach was applied to examine the relationship between two variables, namely hydration status and kidney ultrasonography findings, both of which were measured simultaneously at a single point in time. Without any intervention applied to the subjects, this design allows researchers to objectively assess participants' actual condition.

The research was conducted at the Ultrasonography Laboratory of Poltekkes Kemenkes Jakarta II, which is equipped with complete diagnostic radiology facilities. The data collection period spanned three months, from March to May 2025. The location was selected based on the availability of appropriate equipment, skilled personnel, and eligible study participants.

The target population consisted of radiology students at Poltekkes Jakarta II. A total of 30 participants were selected using purposive sampling, based on the following inclusion criteria: aged between 18–26 years, in good health, with no history of kidney or urinary disorders, and willing to follow the research procedures. The exclusion criteria included female participants currently menstruating, individuals undergoing treatments that could affect urine color or kidney function, and those who failed to meet the inclusion criteria.

Data collection in this study was conducted through several complementary approaches. First, a literature review was conducted to develop the theoretical framework and identify relevant references, including scientific journals, books, and articles on hydration status and kidney ultrasonography (USG) techniques. This information served as the conceptual foundation for designing the research methods and instruments.

Subsequently, direct field observation and measurement were conducted to obtain empirical data. Monitoring was carried out on the process of assessing hydration status using the Perceived Urine-Richness Index (PURI), a method based on the visual evaluation of morning urine color against a standardized chart, as well as the implementation of kidney ultrasonography performed by a trained operator, namely the researcher. All observation results were systematically recorded on a pre-prepared observation sheet to ensure data accuracy and consistency. In addition, documentation was used to record and store all collected data, including hydration status assessments and visualizations of kidney ultrasound parameters. This documentation served as a primary source for further analysis and as supporting evidence for the validity of the research findings.

The data analysis began with the determination of the study location, population, and sample, followed by the development of research instruments and the execution of data collection, which included literature review, direct observation, and measurement of hydration status using the PURI method (Perceived Urine-Richness Index) and ultrasonographic parameters. All data were systematically recorded in dedicated worksheets and entered into statistical software to ensure accuracy and facilitate analysis.

The relationship between hydration status and kidney ultrasound findings was analyzed using the Chi-Square test, as all variables were categorical. This test was used to determine whether a statistically significant correlation existed between the variables. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful relationship. Conversely, a p-value of 0.05 or greater indicated no statistically significant association between the variables.

CODE OF HEALTH ETHICS

This study was conducted in strict adherence to established ethical research standards. Ethical clearance was obtained from the Health Research Ethics Committee of Poltekkes Jakarta II, with the approval number DP.04.03/I/KE/30/352/2025.

RESULTS

Table 1 presents a cross-tabulation analyzing the relationship between hydration status and renal parenchymal echogenicity in both the right kidney (RK) and left kidney (LK) across a total sample size of 30 subjects. The cohort is categorized into three hydration statuses: Good (n=7, 23.3%), Low (n=20, 66.7%), and Very Low (n=3, 10.0%). The majority of the study population exhibits a "Low" hydration status.

https://doi.org/10.56303/jhnresearch.v5i1.720

Table 1. Hydration Status and Renal Parenchymal Echogenicity

Hydration Status	Renal Parenchymal Echogenicity					
	Right Kidney (RK)			Left Kidney (LK)		
	Normal	Increased	Total	Normal	Increased	Total
Good	7 (23.3%)	0 (0.0%)	7 (23.3%)	6 (20.0%)	1 (3.3%)	7 (23.3%)
Low	18 (60.0%)	2 (6.7%)	20 (66.7%)	17 (56.7%)	3 (10.0%)	20 (66.7%)
Very Low	0 (0.0%)	3 (10.0%)	3 (10.0%)	0 (0.0%)	3 (10.0%)	3 (10.0%)
	Total		30 (100%)			30 (100%)

Table 2 presents the Chi-Square test results evaluating the association between hydration status and various renal ultrasonography parameters, revealing that a highly significant statistical relationship exists exclusively between hydration status and renal parenchymal echogenicity in both the right (\chi^2 = 17.040, p = 0.001) and left kidneys (chi^2 = 10.954, p = 0.004). In contrast, hydration status did not demonstrate any statistically significant effect on the remaining morphological or hemodynamic parameters assessed, including kidney length, renal pelvis width, vascularization, and resistive index (RI) across both kidneys (all $p > 0.05$), while cortical thickness was not statistically evaluated. These findings indicate that while hydration levels profoundly influence the sonographic echogenicity of the renal parenchyma, variations in hydration within this cohort do not significantly alter the macroscopic dimensions or vascular resistance of the kidneys detectable via routine ultrasound.

Table 2. Chi-Square Analysis of the Association Between Hydration Status and Renal Ultrasonography Parameters

Renal Ultrasonography Parameter	Kidney Side	Chi-Square Value	Degrees of Freedom	p-value
Parenchymal Echogenicity	Right Kidney	17.040	2	0.001
	Left Kidney	10.954	2	0.004
Kidney Length	Right Kidney	0.517	2	0.772
	Left Kidney	0.476	2	0.788
Cortical Thickness	Right Kidney	-	-	-
	Left Kidney	-	-	-
Renal Pelvis Width	Right Kidney	0.515	2	0.773
	Left Kidney	3.571	2	0.168
Vascularization	Right Kidney	4.155	4	0.385
	Left Kidney	7.232	4	0.124
Resistive Index	Right Kidney	1.218	2	0.544
	Left Kidney	1.531	2	0.465

DISCUSSION

The findings of this study indicate a significant relationship between hydration status and renal echogenicity. The increase in renal echogenicity under dehydrated conditions can be explained by decreased renal perfusion and increased urine concentration, which impact the structural composition of renal tissue (22). More specifically, reduced renal perfusion may induce subtle parenchymal ischemia, while higher solute concentration in the tubular system may alter renal tissue's acoustic properties, thereby increasing echogenicity. This finding is consistent with previous literature stating that hydration status influences the ultrasonographic appearance of the kidneys(13).

Furthermore, this study highlights the importance of hydration for long-term kidney health. Chronic dehydration has been shown to be a significant risk factor in the development of chronic kidney disease (CKD) (23). Inadequate hydration not only impairs the kidney's filtration function but may also trigger progressive structural damage. Therefore, maintaining adequate hydration holds strategic value not only in preventing changes in renal echogenicity but also as a preventive effort against more serious kidney diseases (24).

The use of the Perceived Urine-Richness Index (PURI) method in this study enhances its practical value, as PURI is a non-invasive, simple, low-cost method that can be easily used by the general population.

https://doi.org/10.56303/jhnresearch.v5i1.720

This opens up opportunities for independent and widespread monitoring of hydration status, both at the individual level and within public health service settings. PURI hold great potential for integration into early screening systems, particularly in primary healthcare facilities(25).

The finding that renal echogenicity increases in individuals with very low hydration levels affirms that this parameter may be more sensitive than other ultrasonographic parameters such as kidney length or cortical thickness, which in this study did not show significant correlation with hydration status. The absence of a correlation with kidney length, cortical thickness, or resistive index may suggest that these parameters are less sensitive to acute or mild changes in hydration status and are more indicative of chronic or substantial renal pathology. Accordingly, echogenicity can be considered an early indicator of renal morphological changes caused by dehydration and a crucial signal for early intervention.

This study also pays particular attention to the young population, particularly university students, as a group vulnerable to mild to moderate dehydration. Habits such as insufficient water intake, a busy schedule, and a lack of awareness about the importance of hydration put this group at risk of developing long-term renal dysfunction. Previous studies have shown that dehydration in this population may increase the concentration of renal waste products in the urine and decrease the quality of renal excretory function(15). Therefore, interventions in the form of education and reinforcement of adequate hydration awareness are highly relevant.

Overall, this study provides a strong basis for recommending the use of PURI in clinical practice as an early screening tool for hydration status, particularly prior to more complex radiological or laboratory examinations. Healthcare practitioners can utilize this method to identify patients at risk of kidney impairment due to poor hydration and proactively recommend increased fluid intake as part of a preventive strategy.

CONCLUSION

This study demonstrates a high prevalence of suboptimal hydration among the study population, with 76.7% of participants classified as having low to very low hydration levels according to the Perceived Urine-Richness Index (PURI). Statistical analysis confirms a significant correlation between hydration status and renal parenchymal echogenicity ($p<0.05$ for both kidneys), whereas other parameters—including kidney length, cortical thickness, and the resistive index (RI)—showed no significant association.

These findings suggest that renal parenchymal echogenicity serves as a sensitive, dynamic, and non-invasive marker for early renal stress and subclinical morphological changes resulting from fluid deficit. Furthermore, the study underscores the practical utility of the PURI method as a cost-effective screening tool for hydration monitoring in clinical and daily settings.

To preserve renal structural integrity and prevent long-term functional decline, adequate daily fluid intake is essential. Future research should aim to validate these results through longitudinal designs, incorporate more objective biomarkers such as urine osmolality, and involve larger, more diverse populations to enhance the generalizability of these findings.

FUNDING

This study did not receive any external funding and was conducted entirely using the authors' own resources.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the lecturers, management and academic staff of the Department of Radiodiagnostic and Radiotherapy, Poltekkes Kemenkes Jakarta II, for their technical support and provision of laboratory facilities essential for the completion of this research.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest in relation to the publication of this research.

https://doi.org/10.56303/jhnresearch.v5i1.720

REFERENCES

1. Dalal R, Bruss ZS, Sehdev JS. Physiology, Renal Blood Flow and Filtration. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2026 Mar 16]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK482248/ PubMed PMID: 29489242.
2. Seal AD, Suh HG, Jansen LT, Summers LDG, Kavouras SA. Hydration and Health. Analysis in Nutrition Research: Principles of Statistical Methodology and Interpretation of the Results. Elsevier Inc.; 2019. 299–319 p. doi:10.1016/B978-0-12-814556-2.00011-7
3. Imenez Silva PH, Mohebbi N. Kidney metabolism and acid–base control: back to the basics. Pflugers Archiv European Journal of Physiology. 2022;474(8):919–34. doi:10.1007/s00424-022-02696-6 PubMed PMID: 35513635.
4. Mrs. Shrutika D. Adkine ST, AP. Kidney And Dialysis With Its Complications And Management. Journal of Pharmaceutical Negative Results. 2022;13(8):178–84. doi:10.47750/pnr.2022.13.S08.27
5. Myram S. Development of a biomimetic multitube system for the study of ADPKD To cite this version : HAL Id : tel-04643279 Sorbonne Université pour l ' étude de l ' ADPKD. 2024.
6. Ummah MS. Anatomi, Fisiologi dan Histologi Ginjal. Sustainability (Switzerland). 2019;11(1):1–14. PubMed PMID: 25246403.
7. Rahmayati E, Sari G, Heru Apriantoro N, Dimas Prayogi U, Irwan D, Restiyanti Y, et al. Gambaran Morfologi Usg Ginjal Dengan Kreatinin Tinggi Pada Kasus Gagal Ginjal Kronik. Kocenin Serial Konferensi. 2021;1(1):1–7.
8. Gao J., Thai, A., Lee, J., & Fowlkes JB. Ultrasound Shear Wave Elastograhy and Doppler Sonography to Assess the Effect of Hydration on Human Kidnes: a Preliminary Observation. 2020.
9. Bartram J, William. Domestic Water Quantity , Service Level and Health, second edition. World Health Organization. 2020. 76 p.
10. Alam S, Majid NI. Nutritional Status, Physical Activity, and Fluid Intake with Dehydration Status of Farmers in Jeneponto Regency. Al GIZZAI: Public Health Nutrition Journal. 2023;III(1):43–51. doi:10.24252/algizzai.v3i1.35768
11. Garrett DC, Rae N, Fletcher JR, Zarnke S, Thorson S, Hogan DB, et al. Engineering Approaches to Assessing Hydration Status. IEEE Reviews in Biomedical Engineering. 2018;11(c):233–48. doi:10.1109/RBME.2017.2776041 PubMed PMID: 29990109.
12. Reber E, Gomes F, Dähn IA, Vasiloglou MF, Stanga Z. Management of dehydration in patients suffering swallowing difficulties. Journal of Clinical Medicine. 2019;8(11). doi:10.3390/jcm8111923
13. Karakosta P. Comparative analysis between rapid evaluation algorithm and finite differences approximations solution for the Pennes Bioheat Equation Supervised by Professor Theodoros Samaras. 2020.
14. Roumelioti ME, Glew RH, Khitan ZJ, Rondon-Berrios H, Argyropoulos CP, Malhotra D, et al. Fluid balance concepts in medicine: Principles and practice. World Journal of Nephrology. 2018;7(1):1–28. doi:10.5527/wjn.v7.i1.1
15. Yang X, Wu H, Li H. Dehydration-associated chronic kidney disease: A novel case of kidney failure in China. BMC Nephrology. 2020;21(1):1–5. doi:10.1186/s12882-020-01804-x PubMed PMID: 32366263.
16. Nurmurzaev Z.N., Suvonov Z.K. KIKh. Ultrasound of the Abdominal Cavity. 2023;6.
17. Miesner M. Abdominal Ultrasound. Veterinary Techniques in Llamas and Alpacas, Second Edition. 2023. 152–156 p. doi:10.1002/9781119860792.ch37
18. Herawati E, Wijayanti ET. Uji PURI Sebagai Gambaran Status Hidrasi Jangka Pendek Selama Jam Kuliah Pada Mahasiswa. Biofaal Journal. 2023;4(2):090–9. doi:10.30598/biofaal.v4i2pp090-099
19. Dewi Aryanti, Triguna Y. Status Hidrasi pada Mahasiswa dan Pekerja: Studi Komparasi. Media Informasi. 2024;20(1):9–15. doi:10.37160/mijournal.v20i1.442
20. O'Boyle MK. Color Atlas of Ultrasound Anatomy. American Journal of Roentgenology. 2005. 1371–1371 p. doi:10.2214/ajr.184.4.01841371

https://doi.org/10.56303/jhnresearch.v5i1.720

21. Diwakar RK. Basics of Abdominal, Gynaecological, Obstetrics and Small Parts Ultrasound. Basics of Abdominal, Gynaecological, Obstetrics and Small Parts Ultrasound. 2018. doi:10.1007/978-981-10-4873-9
22. Chapman, C.L., Holt, S.M., & O'Connell CT. Acute kidney injury biomarkers and hydration assessments following prolonged mild hypohydration in healthy young adults. American Journal of Physiology-Renal Physiology. 2023.
23. Radic, J., Kolak, E, Vuckovic, M, Gelemanovic, A., & Dogas H. Assessment of hydration, nutritional status and arterial stiffness in hyertensive chronic kidney disease patients. Nutrients, 15(9), 2045. 2023.
24. Qian G, Liu C, Guo J, Dong W, Wang J, Chen Y. Prevention of contrast-induced nephropathy by adequate hydration combined with isosorbide dinitrate for patients with renal insufficiency and congestive heart failure. Clin Cardiol. 2019 Jan 7;42(1):21–5. doi:10.1002/clc.23023 PubMed PMID: 30054906; PubMed Central PMCID: PMC6436482.
25. Dakio F, Idris N, Muis M, Alfian A, Kasim H, Murtala B. the Correlation Between the Size of Cortex Thickness and the Resistive Index of Kidney Based on Ultrasonography Examination in Hydronephrosis Patients. A Scientific Journal. 2019;12(2):183–93. doi:10.20884/1.mandala.

https://doi.org/10.56303/jhnresearch.v5i1.720