

ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

Potentiometric method vs reagent strip: A comparison of pH in urine samples Método potenciométrico vs tira reactiva: Una comparación del pH en muestras de orina

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Article history:

Received April 16, 2024

Received in revised from April

28, 2024

Accepted April 29, 2024

Available online

May 14, 2024

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ABSTRACT

Introduction: Urine has multiple chemical compounds and salts that are often related to the patient's symptoms. These compounds have various functional groups that determine the urinary pH accompanied by the electrolyte balance. Objective: The present study aimed to compare the pH parameter obtained by two brands of test strips with the potentiometric method, also associating it with urinary osmolarity. Materials and methods: 80 urine samples from apparently healthy patients were studied, in which no exclusion criteria were considered. To measure pH, two commercial brands coded as TR1 and TR2 and a Thermo Scientific Orion Lab Star PH111 peachimeter were used. Results: neither of the two brands coincided with the pH value obtained by the peachimeter, and there was also variability between both for the same sample. No correlation was observed between the pH measured by the test strips and urinary osmolarity. The TR2 brand showed pH values in 16 of the 80 samples, obtaining pH values between 7.7 and 8.1 in these same samples with the peachimeter. In 9 of these 16 samples mentioned the pH values were below 6.5 with the TR1 brand. Conclusions: It is evident that there is a lot of discrepancy when establishing the urinary pH by reagent strips when it is close to 7, for this reason it is advisable to establish a criterion to report only this parameter as layered or alkaline if it is not measured by peachimeters.

Keywords: Potentiometer, Solutes, Functional group, Urinary osmolarity

RESUMEN

Introducción: La orina posee múltiples compuestos químicos y sales que en muchas ocasiones están relacionadas con la clínica del paciente. Ese compuesto posee diversos grupos funcionales que condicionan el pH urinario acompañado del balance de electrolitos. Objetivo: El presente estudio tuvo como objetivo comparar el parámetro de pH obtenido por dos marcas de tiras reactivas con el método potenciométrico asociándolo además a la osmolaridad urinaria. Materiales y métodos: Se estudiaron 80 muestras de orina de pacientes aparentemente sanos, en la que no se consideró ningún criterio de exclusión. Para la medición del pH se emplearon dos marcas comerciales codificadas como TR1 y TR2 y un peachímetro marca Thermo Scientific Orion Lab Star PH111. Resultados: ninguna de las dos marcas coincidió con el valor de pH obtenido por el peachímetro, existiendo además variabilidad entre ambas para una misma muestra. No se observó correlación entre el pH medido por las tiras reactivas y la osmolaridad urinaria. La marca TR2 arrojó valores de pH en 16 de las 80 muestras, obteniendo en estas mismas muestras valores de pH entre 7.7 y 8.1 con el peachímetro. En 9 de estas 16 muestras mencionadas los valores de pH fueron por debajo de 6.5 con la marca TR1. Conclusiones: Se evidencia que existe mucha discrepancia a la hora de establecer el pH urinario por tiras reactivas cuando está cerca de 7, por tal razón es recomendable establecer un criterio para reportar solo este parámetro como acido o alcalino si no es medido por peachímetros.

Palabras claves: Potenciómetro, Solutos, Grupo funcional, Osmolaridad urinaria

INTRODUCCIÓN

Urine is an aqueous solution greater than 95% water, with a minimum of these remaining constituents, in decreasing order of concentration: urea sodium chloride, potassium, creatinine, other dissolved ions, inorganic compounds, proteins, hormones and metabolites (Figure 1) (Rodríguez *et al.*, 2018). The urine is sterile until it reaches the urethra, where the epithelial cells lining the urethra are colonized by facultative anaerobic bacteria. Other substances can be excreted in the urine due to injury or infection of the glomeruli of the kidneys, which can alter the ability of the nephron to reabsorb or filter the different components of the blood plasma (Kristin and Drury, 2013).

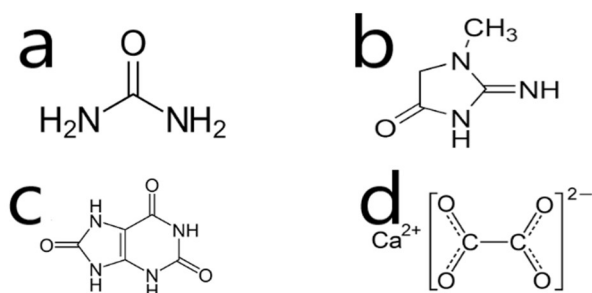


Figure 1. Molecular structures of a) Urea, b) Creatinine, c) Uric Acid and d) Calcium Oxalate present in urine. Its contractions are conditioned by various factors, including hydration and kidney paralysis. Investigation 2023-2024.

Figura 1. Estructuras moleculares de a) Urea, b) Creatinina, c) Ácido Úrico y d) Oxalato de Calcio presentes en la orina. Sus contracciones están condicionadas por diversos factores, entre ellos la hidratación y la paralogía renal. Investigación 2023-2024.

On the other hand, chemical analysis is carried out with reagent strips and generates results that are obtained in seconds; these, upon contact with the substances in the urine, produce chemical reactions that are reflected in changes in color proportional to the concentration of the substances and expressed in qualitative and semi-quantitative results. One of these parameters is pH. Generally urine is slightly acidic, its value ranging between 5 to 6.5; this parameter varies according to the blood

acid-base balance, kidney function and, to a lesser extent, diet, drugs and sample exposure time (Benitez *et al.*, 2013; Lippi *et al.*, 2013). Urine is alkaline when its pH is greater than 7, as occurs in vegetarian diets, ingestion of diuretics, respiratory alkalosis, vomiting, distal renal tubular acidosis or type I and in those cases where urea is converted into ammonia and the pH increases as it occurs in late processed urine and in infections by *Proteus* spp, which produces ammonia thanks to the action of urease (Hayi *et al.*, 2016; Kolouri *et al.*, 2017). On the other hand, when the urine has a pH less than 7 it is considered acidic and occurs due to high protein diets, diabetic ketoacidosis, *Escherichia coli* infections, fever, respiratory acidosis, aciduria due to mandelic and phosphoric acid, administration of drugs such as amphotericin B, spironolactone and NSAIDs (Diviney, 2021; Tasoglu, 2022). However, at the clinical laboratory level, a variety of commercial brands of reagent strips are used whose reports include that on some occasions the urine can have a pH of 7 (neutral), for this reason this study seeks to show that the urinary pH of 7, this is usually an erroneous value when reporting this parameter using test strips.

MATERIALES Y MÉTODOS

Research type and design

Descriptive and transversal research, who sought to carry out the comparison of the potentiometric method for pH measurement versus the reagent strip of two commercial brands using to carry out said comparison, osmometry (OSM), method considered a reference for evaluating the renal concentration and dilution capacity.

Biological Sample

80 urine samples from apparently healthy patients were analyzed. The sample collection was carried out considering all hygiene standards in a completely sterile screw-on urine collector. The urine sample was a partial urine, without any inclusion criteria or prior preparation.

Determination of osmolarity

Determination of osmolarity urinary is based on the measurement of osmotic pressure between the urine sample and a solvent. An osmometer was used (Advanced micro-osmometer model 3300, Advanced Instruments, Inc. Handling and use of the osmometer was carried out according to the manufacturer's instructions.

Determination of pH by reagent strips

A pH test strip is a strip of litmus paper with which you can measure the pH value of a liquid. The substance contained in the paper causes it to show a different color depending on the acidity. The official pH scale goes from 0 to 14, where 0 is very acidic and 14 is very alkaline. Some pH test strips can measure pH from 0 to 14, but there are also pH test strips that can only measure acidic or only alkaline substances.

Two brands of test strips were used, which for ethical reasons were called TR1 and TR2, which have the capacity to measurement of 10 parameters), which present an area to measure various pH scales with color variation in 0.5 intervals units. The handling and use of the strips reagents were carried out following the manufacturer specifications. The reading of the test strips were made visually according to the color scale provided by the manufacturer.

Statistical analysis

Descriptive statistics were applied expressing the data as means and standard deviation. For the comparison of the methods evaluated the test was applied by Tukey. The “r” of the line was calculated correlation.

RESULTADOS Y DISCUSIÓN

Table 1 shows the descriptive statistics of the pH values obtained by the pechimeter using the test strips from two commercial companies. According to the table, the average is different in all cases. A key aspect in this analysis is that all the pH values measured with TR1 and TR2 were different from

those obtained with the peachimeter, and were also different from each other for the same sample. With TR2, 16 of the 80 samples showed pH, when measured by the peachimeter it was between 7.6 and 8.1. Now, it is known that the most important difference between a pH test strip and a pH meter is the accuracy of the measurement (Delanghe and Speeckaert, 2014; Nouvenne *et al.*, 2014). However, at a clinical level it is more practical to use test strips. This widespread use has led to incorrect pH values being reported on some occasions (on many occasions' values of 7), due to the comparison to a color scale made by the analyst (Constable *et al.*, 2009; Erdogan-Yildirim *et al.*, 2011). This allows us to establish that pH test strips are therefore very useful for quickly determining whether a solution is acidic or alkaline, but are not suitable for making precise measurements (Siener *et al.*, 2021; Gnatova *et al.*, 2023).

Table 1. Statistical analysis of the pH obtained by the two methods

Tabla 1. Análisis estadístico del pH obtenido por los dos métodos

Methods	Poten.	TR1	TR2
N	80	80	80
Mean	6.5925	6.6163	6.5725
SD	1.2214	1.2192	1.1987
Variance	1.4918	1.4864	1.4370
C.V.	18.527	18.427	18.239
Minimum	4.5000	4.3000	4.0000
Median	6.8000	6.9000	6.7000
Maximum	8.4000	8.5000	8.6000

SD: standard deviation **CV:** Coefficient of variation

Source: Investigation 2023-2024

Figure 1 shows the relationship between pH and urinary osmolarity, in which there is a significant negative relationship ($r= 0.9431$ and $p<0.001$). This relationship is possible since osmolarity measures the concentration of solutes in a solution, that is, it is determined by the number of particles present in the solution. For this reason, it is common to observe pH values below 7 with high osmolarities compared to alkaline urine. For this reason, these two parameters can be associated since determination of urinary osmolarity is

considered the reference method to evaluate the kidney's ability to concentrate or dilute urine.

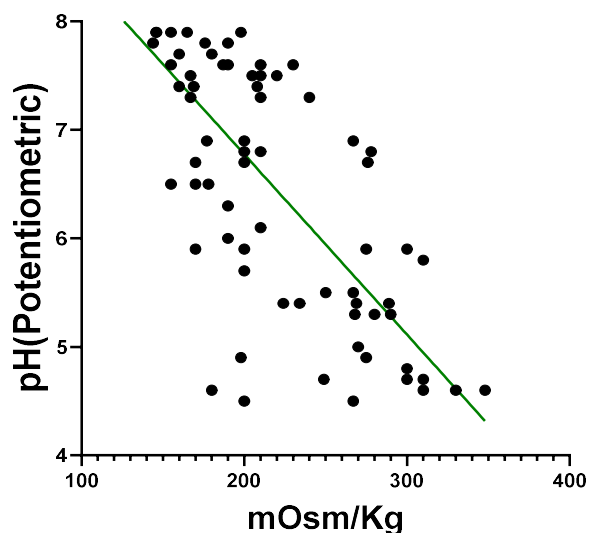


Figure 1. Association of pH by the potentiometric method and urinary osmolarity

Figura 1. Asociación del pH por el método potenciométrico y la osmolaridad urinaria

Figure 2a and 2b show that the relationship between urinary osmolarity and the pH value obtained by TR2 is more associated with the behavior obtained by the peachimeter. For TR2, I evidenced dispersion between various pH values for a specific value of osmolarity, that is, the same osmolarity value for several pH values. De Coninck *et al.*, (2018), in their study “Evaluation of a portable urinary pH meter and test strips”, used 77 aliquots of urine from healthy volunteers measuring urinary pH through the use of test strips, a pH meter portable and a laboratory pH meter (gold standard). The researchers indicate that the findings of this study support that the portable electronic pH meter is a reliable pH measurement device and appears to be more accurate compared to test strip readings.

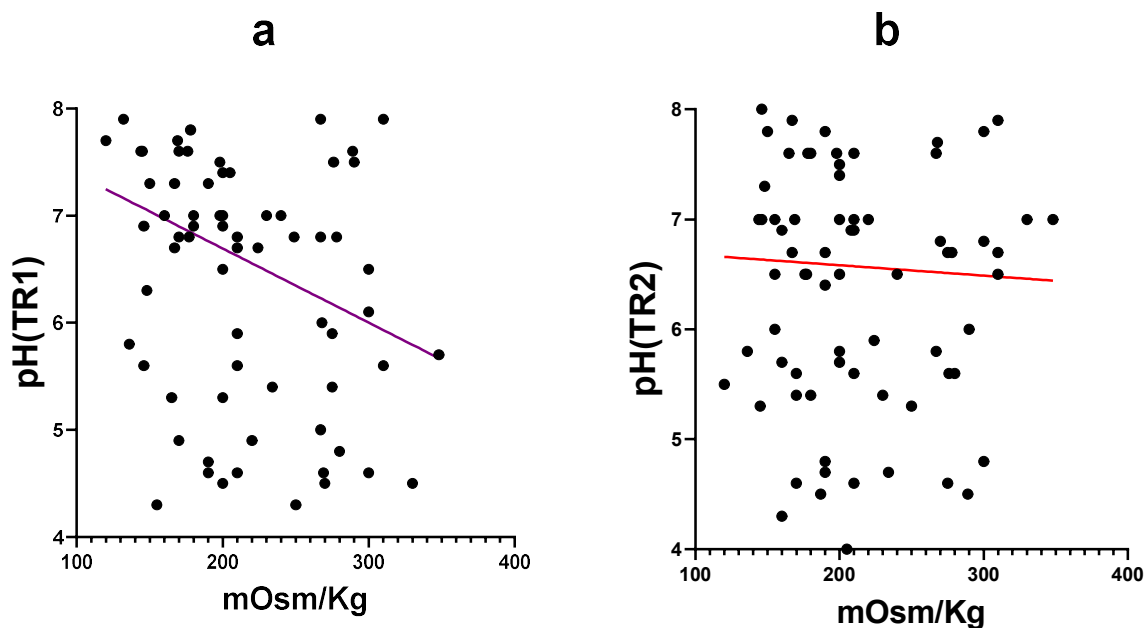


Figure 2. Relationship between the pH parameters obtained by test strip and urinary osmolarity

Figura 2. Relación entre los parámetros de pH obtenidos por tira reactiva y la osmolaridad urinaria

Raskin *et al.*, (2022), conducted a study comparing home monitoring methods for measuring the pH of feline urine, they found that portable pH meters are excellent for monitoring urine pH at home, as long as attention is paid to the maintenance of the electrodes. Urine can be collected at home and kept refrigerated, and pH can be reliably measured within 24 hours using the reference method or a portable pH meter. Finally, Johnson, Lulich and Osborne (2017) evaluated the reproducibility and precision of 4 portable pH meters, a test strip and pH paper to measure the pH of urine in dogs. They found that 3 of the 4 portable pH meters they had almost perfect agreement with the reference method. The test strip and pH paper had moderate to poor agreement with the reference method. They conclude that urine pH measurements should be performed by using a portable or benchtop pH meter when accurate measurements are crucial for diagnosis or treatment. Test strips and pH papers are useful for obtaining approximations of pH, but are not recommended when precise urine pH measurements are required.

CONCLUSIONS

The analyzes show that although the test strips are very useful due to their versatility in being able to measure various parameters including pH, multiple errors must be considered in those cases in which they mark a value close to neutrality or pH 7. For this reason it is recommended to carry out quality controls with more advanced measuring instruments in those samples where the pH value is not really clear with reagent strips.

Conflict of interests

The author declares that he has no conflicts of interest.

REFERENCIAS

1. Benítez-Fuentes R, Jiménez-San Emeterio J. Infección del tracto urinario. *Pediatr. integral*. 2013;17(6):402-11.
2. Constable P.D, Gelfert C, Fürll M, Staufienbiel R, Stämpfli HR. Application of strong ion difference theory to urine and the relationship between urine pH and net acid excretion in cattle. *Am. J. Vet. Res.* 2009; 70:915–925. <https://doi.org/10.2460/ajvr.70.7.915>.
3. De Coninck V, Keller EX, Rodríguez-Monsalve M, Doizi S, Audouin M, Haymann JP, Traxer O. Evaluation of a Portable Urinary pH Meter and Reagent Strips. *J Endourol.* 2018;32(7):647-652. doi:10.1089/end.2018.0202.
4. Delanghe J and Speeckaert M. Preanalytical requirements of urinalysis. *Biochem Med (Zagreb).* 2014; 24(1):89-104. doi:10.11613/BM.2014.011
5. Diviney J, Jaswon MS. Urine collection methods and dipstick testing in non-toilet-trained children. *Pediatr Nephrol.* 2021; 36(7):1697-1708. doi:10.1007/s00467-020-04742-w
6. Erdogan-Yildirim Z, Burian A, Manafi M, Zeitlinger M. Impact of pH on bacterial growth and activity of recent fluoroquinolones in pooled urine. *Res Microbiol.* 2011;162(3):249-252. doi:10.1016/j.resmic.2011.01.004
7. Gnatova N, Abidullina A, Streltsova O, Elagin V, Kamensky V. Effect of pH, Norepinephrine and Glucose on Metabolic and Biofilm Activity of Uropathogenic Microorganisms. *Microorganisms.* 2023;11(4): 862. doi:10.3390/microorganisms1104086
8. Hayi AD, Birnie K, Busby J, Kohn RR, Chang FE. The Diagnosis of Urinary Tract infection in Young children (DUTY): a diagnostic prospective observational study to derive and validate a clinical algorithm for the diagnosis of urinary tract infection in children presenting to primary care with an acute illness. *Health Technol Assess.* 2016;20(51):1-294. doi:10.3310/hta20510
9. Johnson KY, Lulich JP, Osborne CA. Evaluation of the reproducibility and accuracy of pH-determining devices used to measure urine pH in dogs. *J Am Vet Med Assoc.* 2007; 230(3):364-369. doi:10.2460/javma.230.3.364
10. Kristin JS and Drury DG. Comparison of 3 methods to assess urine specific gravity in collegiate wrestlers. *Journ Athl Train.* 2003; 38(4):315-319.
11. Kolouri S, Daneshfard B, Jaladat AM, Tafazoli V. Green Urine in Traditional Persian Medicine: Differential Diagnosis and Clinical Relevance. *J Evid Based Complementary*

- Altern Med. 2017; 22(2):232-236. doi:10.1177/2156587216641828
12. Lippi G, Becan-McBride K, Behúlová D, Bowen RA, Church S, Delanghe J. Preanalytical quality improvement: in quality we trust. Clin. Chem. Lab. Med. 2013; 51(1):229-41.
 13. Nouvenne A, Ticinesi A, Morelli I, Guida L, Borghi L., Meschi T. Fad diets and their effect on urinary stone formation. Transl. Androl. Urol. 2014;3:303–312. doi: 10.3978/j.issn.2223-4683.2014.06.01.
 14. Raskin RE, Murray KA, Levy JK. Comparison of home monitoring methods for feline urine pH measurement. Vet Clin Pathol. 2022; 31(2):51-5. doi: 10.1111/j.1939-165x.2002.tb00279.x.
 15. Rodríguez JV, Colla C, Gines MB, Schröder G. Determinación de la concentración de solutos en orinas de pacientes caninos: comparación de osmometría versus densidad urinaria (refractometría y tiras reactivas). Analecta Vet .2018; 38(1): 45-49. 22.
 16. Siener R, Bitterlich N, Birwé H, Hesse A. The Impact of Diet on Urinary Risk Factors for Cystine Stone Formation. Nutrients. 2021;13:528. doi: 10.3390/nu13020528.
 17. Tasoglu S. Toilet-based continuous health monitoring using urine. Nat Rev Urol. 2022;19(4):219-230. doi:10.1038/s41585-021-00558-x



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