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POINT-OF-CARE ULTRASOUND IN DIAGNOSIS AND DECISIONS FOR PATIENTS WITH ACUTE RENAL FAILURE: CASE SERIES

POINT-OF-CARE ULTRASOUND NO DIAGNÓSTICO E NA DECISÃO TERAPÊUTICA DE PACIENTES COM INSUFICIÊNCIA RENAL AGUDA: SÉRIE DE CASOS

Yoshimi José Ávila Watanabe[1], João Victor Marques Guedes[1], Lívia Maria Rezende Carvalho[1], André Oliveira Baldoni[1], Alba Otoni[1*]

ABSTRACT: **Aim:** To evaluate POCUS as an auxiliary tool in the diagnosis and therapeutic decision of patients with acute renal failure. **Methodology:** We report a series of cases that illustrate the successful use of POCUS in nephrology practice, from October to December 2022. Six cases of patients admitted to an intensive care unit with different clinical manifestations related to acute kidney disease were included. All patients underwent renal ultrasound examinations using a mobile POCUS device. **Results:** It was demonstrated that POCUS was able to provide relevant clinical information in all the events studied, allowing for faster and more assertive decision-making in patients with different clinical presentations, such as: rhabdomyolysis, pre-renal injury, liver disease, heart failure with reduced ejection fraction (ICEFER), obstructive uropathy, and sepsis. **Conclusions:** POCUS is a promising tool in nephrology practice, offering significant advantages in terms of agility and safety for the care of patients with acute renal failure. Its use allowed a quick and accurate assessment of renal structures, helping in the diagnosis, monitoring, and management of various nephrological conditions.

KEYWORDS: Case reports. Acute kidney injury. Ultrasound.

RESUMO: **Objetivo:** Avaliar o point-of-care ultrasound como ferramenta auxiliar no diagnóstico e decisão terapêutica de pacientes com insuficiência renal aguda. **Metodologia:** Relatamos uma série de casos que ilustram o uso bem-sucedido do POCUS na prática nefrológica, no período de outubro a dezembro de 2022. Foram incluídos, seis casos de pacientes internados em centro de terapia intensiva com diferentes manifestações clínicas relacionadas a doenças renais agudas. Todos os pacientes foram submetidos a exames de ultrassonografia renal utilizando um aparelho móvel de POCUS. **Resultados:** Foi demonstrado que o POCUS foi capaz de fornecer informações clínicas relevantes em todos os eventos estudados, permitindo a tomada de decisão mais rápida e assertiva, em pacientes com apresentação clínica diversas como: na rabdomiólise, lesão pré-renal, doença hepática, insuficiência cardíaca com fração de ejeção reduzida (ICEFER), Uropatia obstrutiva e sepse. **Conclusões:** O POCUS é uma ferramenta promissora na prática nefrológica, oferecendo vantagens significativas em termos de agilidade e segurança. Sua utilização permitiu uma avaliação rápida e precisa das estruturas renais, auxiliando no diagnóstico, monitoramento e manejo de diversas condições nefrológicas.

PALAVRAS-CHAVE: Relatos de casos. Lesão renal aguda. Ultrassonagrafia.

[1] Department of Collective Health, Postgraduate Program in Health Sciences, Federal University of São João del-Rei (UFSJ), Divinópolis (MG), Brazil.

***Corresponding author**: Alba Otoni – *Email*: albaotoni@ufsj.edu.br.

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INTRODUCTION

Early diagnosis and adequate treatment of acute kidney injury (AKI) are essential to minimize permanent kidney damage and improve patient survival[1,2]. The literature reveals that in developed countries ultrasound (US) emerges as a pivotal tool in intensive care units (ICUs) for diagnosing AKI swiftly and non-invasively. It should be noted that although the benefits of US in AKI have shown great promise in the diagnosis and treatment, there is an imminent need for future research, with socialization of ways to use US, as well as the types of US, to standardization of techniques that may allow multifaceted renal US evaluation in critically ill patients for more accurate diagnosis and personalized intervention in AKI[3,4].

In Brazil, as in developed countries, although the benefits of US in AKI are known, the methods have not yet been standardized and depend on clinical evaluation and the judgment of the attending physician.

There is a consensus that accurate decision-making in the management of AKI determines the best or worst prognosis for the patient [3,4]. Therefore, seeking tools that assist in the approach to these patients, with the aim of preventing complications and mitigating high mortality rates in AKI, unfortunately still common in patients admitted to the ICU, is extremely important for preserving the lives of critically ill patients with AKI [5,6].

A recent approach for diagnosing AKI is the use of bedside US, which allows the assessment of anatomy and renal function, in addition to identifying possible causes of AKI. Studies show that the correct use of point-of-care ultrasound (POCUS), also known as insonation, in the physical examination of renal patients can be decisive in establishing the diagnosis and adequate therapy [7]. Insonation, as the fifth pillar of physical examination, has high accuracy, sensitivity, and specificity. With the advancement of technology, portable equipment allows the use of bedside US, making it an accessible and dynamic tool [8]. In this context, the objective of this study was to evaluate POCUS as an auxiliary tool in the diagnosis and therapeutic decision of patients with acute renal failure.

METHODOLOGY

In this study we report a series of cases in which bedside US played a crucial role in the correct diagnosis and management of AKI cases with different causes, and was conducted during the second half of 2022 in the ICU of a large hospital complex in the mid-west region of the state of Minas Gerais, Brazil. To meet methodological accuracy, we use the CARE Guidelines: Consensus-based Clinical Case Reporting Guideline Development (2013) and the CARE Checklist to guarantee that we meet all the needed criteria to conduct this research properly[9,10].

The inclusion criteria were established: adult and older patients of both sexes who were admitted to the ICU in the second half of 2022 with evidence of renal impairment, which is subsequently referred to as kidney failure.

Insonation provided accurate information about renal anatomy, identifying obstructions, dilations and other changes that helped define the diagnosis. In addition, bedside US was useful in assessing possible pulmonary impairment, prior assessment of cardiac function, identifying vena cava distension, as well as its dynamic patency, allowing a more targeted therapeutic approach, especially for a patient who needed supportive dialysis.

In this perspective, the use of bedside US as an auxiliary tool in the management of AKI cases is promising, providing fast and accurate information that can directly impact the diagnosis and treatment of patients.

REPORTED CASES

All patients in the series of reported cases are part of a research in a health complex in the interior of Minas Gerais. This research was approved by the Research Ethics Committee of the institution in question and the Federal University of São del-Rei (CAAE number: 11780919.8.3001.5130).

CASE 01

Male, 38 years old, logger, with a history of cranial, cervical, thoracic, abdominal, upper limb and lower limb polytrauma. Admitted in November 2022, with trauma identified five days before the transfer, he had received free serum therapy, lower limb and upper limb fixation, due to fractures. Nephrology was called one day after admission when serum creatinine was found to be 7.02 mg/dL. The patient evolved with anuria, even after volume resuscitation was attempted. He required a chest tube due to pneumothorax, and regular renal dialysis therapy - he did not initially present with hemodynamic instability. He subsequently used vasoactive drugs, as well as antibiotics. He required image investigation with the use of iodinated contrast. Performed pulmonary, cardiac, and abdominal POCUS to monitor infusion, control and restriction of fluids, as well as indication of central and peripheral punctures of vascular accesses for central venous pressure (CVP); abdominal and thoracic double lumen catheter. Abdominal US showed no alterations in the urinary system. In frequent monitoring of renal therapies, POCUS information contributed to modulation (increasing the intensity and promoting the removal of fluids, monitoring the A and B lines in the lungs) of hemodialysis (HD) procedures, as well as planning the duration of renal therapy substitutes, accompanying the distension of the vena cava. The patient had a clinical and laboratory diagnosis of rhabdomyolysis, remained anuric for more than 55 days and required more than 20 HD sessions. There was a progressive regression of the presentations of lines A and B in lungs with improvement in diuresis, recovering their dynamic state (without oscillation of the vena cava or pulmonary interstitial expansion, lines B), and the suspension of renal replacement therapies (RRT) was proposed due to the recovery of renal function.

CASE 02

Female, 60.4 years old, with known systemic arterial hypertension (SAH) comorbidities for more than 10 years, heart disease, hypothyroidism, transient ischemic attacks (TIA) (previous), early dementia, chronic kidney disease (CKD) class IV – V (not previously accompanied by nephrologist), admitted with CKD-EPI of 11.3 ml/min (creatinine at 4.03mg/dL on admission to the ICU). She evolved with diarrhea and dehydration, seeking emergency care, and she received excessive fluid intake in an emergency care unit. Nephrology was called for the following reasons: increased creatinine and fluid overload. US: with reduced-size kidneys, loss of cortico-medullary differentiation, without dilatation of the pyelocalyceal ureteric system. POCUS: kidneys slightly reduced in size for age and sex and left kidney not visualized (agenesis?). Lung with B lines and cardiac summary with distended vena cava (18 mm),

with little mobility, remaining turgid throughout the examination. Use was made of various antihypertensives including angiotensin receptor blocker (ARB), calcium channel blocker (CCB), levothyroxine, loop diuretic (oral), vitamin supplements, neuroleptics. Arterial blood gases with acidemia and low bicarbonate. Normocytic normochromic anemia. In view of this situation, it was recommended that the following procedures be applied under ultrasonographic monitoring: suspension of the ARB, instituted venous diuretic (with stress test), and replacement of parenteral bicarbonate. Evolving in the first 6 h: diuresis started and progressed satisfactorily, monitored via indwelling urinary catheter (IUC). In the first 12 h: improvement in the presentation of the B lines and the vena cava started a pattern with movement and distension (8-16 mm). Thus, the patient did not need supportive dialysis, and was subsequently referred to the nephrology unit for care.

CASE 03

Male, 22 years old; admitted with a history of frequent psychiatric disorders (psychotic outbreaks), hypothyroidism, use of illicit drugs (crack and marijuana), fulminant hepatitis and diagnosis of oliguric AKI. He was admitted to the ICU with mental confusion, psychomotor agitation, blood, urine and US biochemical markers compatible with the exacerbation of liver dysfunction. Transferred from another city, where he was undergoing psychiatric therapy with quetiapine, escitalopram and desvanlefaxine. Past history pathology: according to the mother, using methylphenidate since the age of 13 for attention deficit disorder with hyperactivity (ADHD). Evaluated by nephrology when he had a creatinine of 7.0 mg/dl, without hydroelectrolyte disturbances, without vasoactive amines, apparently with an adapted breathing pattern. Complementary laboratory test with marked elevation of transaminases, identifying creatine phosphokinase greater than 100,000. Diuresis of 60 mL/in in the previous 8 h. POCUS: normal kidneys, without distention or calyceal ureteral dilations, as well as the bladder: normal aspect, but empty. Chest: B lines, and vena cava with dilation (greater than 16 mm), but with mobility and distension. Volume resuscitation suggested, followed later by a stress test with EV diuretic. In this case, supportive dialysis was instituted, since severe acidemia was identified, being refractory to the adopted therapy. Only two sessions of RRT were performed, with prompt clinical recovery, reducing serum creatinine and increasing urinary volume. Liver function was progressively restored, without returning to normal values. He remained with severe hypoalbuminemia. He came off mechanical ventilation, slowly reestablishing the pulmonary US pattern. His prescribed neuroleptic drugs were adjusted.

CASE 04

Female, 72.3 years old, transferred from the city's emergency care unit. Carrier of SAH, diabetes mellitus (DM), and heart failure (HF) with decompensation (ICEFER), stable angina, peripheral vascular disease with indication for surgical intervention for more than 1-year, previous cerebrovascular accident (CVA). Thus, a patient with multiple comorbidities and using polypharmacy: Dapaglifosine, Valsartan, Atorvastatin, Furosemide (oral), Spironolactone, Allopurinol, Nebivolol, Betahistine, Gabapentin, and Insulin. Patient with severe cardiac decompensation, presenting compromised respiratory pattern with dyspnea and orthopnea. On summary clinical examination: patient with signs of congestion (hepatosplenomegaly, swollen jugular veins, lower limb edema), lucid, oriented, Glasgow 15. Laboratory test with creatinine 3.08 mg/dL and urea 110 mg/dL, K: 3.5 mEq/L. Gasometry without alterations of

clinical importance. No history of bleeding from the gastrointestinal tract. Attempt to hospitalize for clinical-cardiological compensation, without success due to lack of vacancies in the public health system. She was decompensated when admitted to intensive care, with arrhythmia and swelling, POCUS: systemic congestion: evident and turgid vena cava distention, pulmonary B-lines and the presence of myocardial injury was suspected (since she presented slowing of the cardiac muscles and severe enlargement of cardiac chambers). 22 mm vena cava distension. Renal replacement therapy (RRT) was instituted with slower and successive modalities in order to remove volume. The patient performed more than nine sessions in intensive regimen. Lost more than 15 liters in sequential procedures. In US control with a cardiologist: the patient presented an important change in clinical and cardiological dynamic behavior, improving Doppler dynamics in controlled trans esophageal echo. The patient maintained a deficit in the glomerular filtration rate (GFR), with improvement, allowing the optimization of cardiac and endocrinological therapy, without persisting in continuous dialysis.

CASE 05

Male, 65 years old, without previous serious comorbidities, with known and controlled reports of DM and SAH. Smoker and social drinker, according to information collected. Transferred from another city with abdominal distention, suprapubic pain and severe azotemia. Admitted with high residual waste (serum creatinine 15 mg/dL), agitation, leading to mental confusion. Report of sudden reduction in urinary output and failure of relief catheter. US: large bladder distention, associated with uretero-pyelo-calyceal dilation with compression of the cortical region, bilaterally. He had stage 3 AKI with severe azotemia and anuria. Bedside US was performed, enabling the diagnosis of obstructive uropathy. The urinary tract was cleared with a more aggressive urological intervention, requiring a three-way probing and continuous irrigation. He received care from nephrology for water management and connection of urology in the intervention (in his city of origin, they were unable to progress the bladder catheter). Evolutionary, significant diuresis was observed, marked reduction of serum K^+, requiring electrolyte management. Conventional US suggested computed tomography (CT) as a bladder mass had been identified, which possibly interrupted the regular urinary flow. CT: identified expansive bladder cancer (CA), affecting the ureters bilaterally. Patient did not undergo RRT, requiring urological surgical treatment later.

CASE 06

Male, 52.7 years old, transferred internally to the unit with a previous diagnosis of liver cirrhosis and progressing to a diagnosis of endocarditis. Nephrology was called when the patient was in intensive care, two weeks after hospitalization and two days in the ICU. He was on controlled mechanical ventilation, IUC, and azotemia with a urinary volume of 70 mL/in 24 h. Laboratory blood test result with K of 5.7 mEq/L and creatinine of 3.5 mg/dL with Hb of 12 mg/dL. With a history of recent empyema and use of several antibiotics: Ampicillin, Oxacillin, Gendamycin with previous use of Ciprofloxacin, Clindamycin and sodium piperacillin and sodium tazobactam. At the time of evaluation using Vancomycin and Meropenem. Previous history of chronic alcoholism and several hospitalizations with liver impairment (cirrhosis with probable alcoholic etiology), smoker. In use of vasoactive drugs, hemodynamically unstable, without recent fever, but with compromised general status due to malnutrition. The patient did not respond to the stress test with furosemide, HD support was initiated

with a slower scheme, compatible and programmed nutritional intake, if the hemodynamic state allowed the removal of volume by ultrafiltration. POCUS lung with B lines and pleural effusion, heart with expansion of the cardiac chambers, associated pericardial effusion and expanded vena cava (15 cm), distended throughout its path, with reduced mobility. Suggested the presence of an image attached to the valve structure (endocarditis?). The use of antibiotics was modulated and blood cultures were collected. In this case, the outcome of the patient's evolution, due to infectious and cardiac complications, was progression to death.

Table 1 - Summary of the cases of patients with AKI and the use of bedside insonation in an intensive care unit from October to December 2023

Case	Age	Sex	Cause of AKI	Cr_S/mg/dL	Vena Cava	Main POCUS Contributions	Clinical Outcomes
1	38	M	Rhabdomyolysis	7.02	18 mm	POCUS: Contributed to the modulation of HD procedures; (increase the intensity and promote the removal of liquids, monitoring the A and B lines in the lungs) and planning the times of RRT, following the distension of the vena cava.	Progressive regression of A and B line presentations in lungs; improvement in diuresis, recovery of the dynamic state (without oscillation of the vena cava or pulmonary interstitial expansion, B lines), suspension of RRT due to the recovery of renal function.
2	60.4	F	Pre-renal	4.03	18 mm	POCUS: kidneys slightly reduced in size for age and sex and left kidney not visualized. Lung with B lines and cardiac summary with distended vena cava, with little mobility, remaining turgid throughout the examination. Procedures: ARB suspension, intravenous diuretic (with stress test), replacement of parenteral bicarbonate, being monitored with US.	Started diuresis with satisfactory progression. In the first 12 h: improvement in the presentation of the B lines and the vena cava started a pattern with movement and distension (8-16 mm). Did not need dialysis support.
3	22	M	Hepatic	7.0	16 mm	POCUS: normal kidneys, without distention or calyceal ureteral dilations, as well as the bladder: normal appearance, but empty. Chest: B-lines, and vena cava with dilation, but with mobility and distention. Procedures: Volemic rescue suggested, followed later with stress test with intravenous diuretic. Support dialysis was instituted, since severe acidemia was identified, refractory to the adopted therapy.	With only two sessions of RRT, there was prompt clinical recovery, reducing serum creatinine and increasing urinary volume
4	72.3	F	ICEFER	3.08	22 mm	POCUS: systemic congestion: evident and turgid vena cava distension, pulmonary B-lines and the presence of myocardial injury was questioned. 22 mm pit distension. Procedures: Instituted RRT with slower and successive modalities in order to remove volume.	The patient maintained the GFR deficit, with improvement, allowing the optimization of cardiac and endocrine therapy, without persisting in continuous dialysis.
5	65	M	Obstructive uropathy	15.0	N	POCUS: obstructive uropathy. Procedures: Urinary tract clearance with more aggressive urological intervention is suggested, requiring three-way probing and continuous irrigation and nephrology care for water management and connection of urology in the intervention	A large amount of diuresis was observed, a marked reduction in serum K^+, requiring clinical care from nephrology.
6	52.7	M	Sepsis	3.51	15 mm	POCUS: lung with B lines and pleural effusion, heart with expansion of the heart chambers, associated pericardial effusion and expanded vena cava (15 mm), distended throughout its path, with reduced mobility. Procedures: The presence of an image attached to the valve structure (endocarditis?) is suggested. Use of antibiotics was instituted and blood cultures were collected.	Due to infectious causes, evolved to death.

* AKI: acute renal injury; CrS/mg/dL: serum creatinine in milligrams per deciliter; POCUS: point-of-care ultrasound; RRT: renal replacement therapy; ICEFER: heart failure with reduced ejection fraction; GFR: glomerular filtration rate.

DISCUSSION

Nephrology has used US to promote the best approach during the propaedeutic phases and also in the therapeutic decision-making process [11]. In this study, among the nephrological procedures in which US was especially beneficial and its use was mandatory, US occurred in the identification of distinct anatomical diseases of the urinary tract, especially in cases 1, 2, 3, and 6 in which the kidneys were with anatomical morphology. Without the use of POCUS/bedside insonation, the diagnostic delay could imply in late approaches and definitive damage to the renal function with consequent worsening of the general condition and worse prognosis for the affected patients.

Another specific situation in which the performance of POCUS directly implied the clinical prognosis, could be observed in case 5, where obstructive uropathy was identified early as the cause of AKI. The information obtained with POCUS contributed to a safe, non-invasive diagnosis and enabled a quick and effective therapeutic indication. As described in the literature, for patients who present with a sudden worsening of renal function, associated with impaired diuresis, in which there is oliguria or anuria, as in the case of the patient in case 5, a rapid diagnosis was essential, since the resolution, urological clearance, meant the prompt restoration of renal function [12,13]. The positioning of the probe used, as well as bladder emptying and urinary flow, could be followed by the online US procedure.

Another important contribution of POCUS to the assistance of patients with AKI in this study was for those patients who required RRT, cases 1, 3, and 4. The installation of the central access and/or evaluation of the arteriovenous fistula were guided by the information from the bedside insonation and the aid of this tool for carrying out the procedures enabled safe access for HD and mitigated possible vascular complications, frequent during installation or use of abrupt start of access for RRT. These procedures, performed without imaging tests, limit the assessment of vascular access by the team and may compromise not only the vascular system but also the quality of the RRT offered [14].

In addition to these uses, bedside insonation/POCUS from pulmonary and cardiac studies to identify volume status was also successfully used in this study. As stated by Woodward et al. (2019)[15], clinical evaluations identifying fluid overload in patients on RRT do not reflect the reality of patients undergoing these therapies[16]. These events were present and documented in cases 2, 4, and 6.

Fluid management in patients with organ failure must be carried out under strict control. Both excessively liberal administration and inadequate restriction of intravenous or oral fluids in intensive care to critically ill patients can be deleterious [17-20]. If intravenous fluid replacement is excessive, cardiac output will increase[18]. If replacement or recomposition is improper, with amounts smaller than necessary, tissue and organ damage may occur due to low perfusion[21]. Therefore, fluid recomposition and administration in cases 1, 3, and 4 was guided by the POCUS results, contributing to effective fluid management and favorable patient outcomes.

It is important to highlight that for all the patients involved in this survey, the fact of quantifying and qualifying the cardiac response and the volumetric recomposition, as described by Woodward et al., 2019, guided the medical prescriptions, allowing a better understanding of the patient's response to intravenous volume management and the need for adjustments [15,22].

The recomposition of liquids for this special group of patients, can manifest pitfalls at the time of intravascular recomposition. Hence the need for continuous monitoring of the tidal volume in the dynamics of restriction or increase in the amount of colloid and/or crystalloid to be administered [12,23]. In the cases of patients 1, 2, and 4, POCUS was essential to guide the appropriate therapeutic approach to the hemodynamic state of the patients, providing rapid intervention in order to preserve and even restore renal function.

In view of the use of POCUS to improve clinical practice, considering the findings of this study and according to Corradi, Bell and De Rosa (2024)[3], a basic algorithm for adopting POCUS in clinical scenarios involving AKI can be suggested:

a) Acute urinary tract obstruction: B-Mode US reveals dilation of the excretory tract. Increased Resistive Index (RI) indicates compression of parenchyma and renal vessels.
b) Trauma: Elevated renal RI correlates with occult bleeding and predicts hemorrhagic shock. Doppler RI may not accurately predict augmented renal clearance.
c) Sepsis-associated AK: Doppler RI can complement AKI diagnosis by reflecting alterations in intra-renal microvascular flow. Contrast-enhanced US assesses renal vascularization.
d) Acute respiratory distress syndrome (ARDS): ARDS predisposes to AKI due to decreased renal perfusion. Renal Doppler indices may predict AKI severity in COVID-19 patients.
e) Heart failure: Renal venous congestion and elevated RI are associated with worsening renal function in HF patients. Renal venous Doppler aids in differentiating cardiorenal syndrome.
f) Cardiac Arrest: RI may help assess renal perfusion post-cardiac arrest; renal RI increases with ischemia–reperfusion injury after resuscitation.
g) Acute Kidney Injury: RI normalization indicates recovery from AKI. Elevated RI is a risk factor for CKD progression.

CONCLUSION

From the reports of these cases, it was identified that the use of POCUS was essential to complement the rapid diagnosis of AKI. It also offered details of the volume status of the patients, revealing the hemodynamic conditions in real time and enabling a more individualized and assertive therapeutic decision for the patients. As the first impact on the routine of the ICU based on the observation of the POCUS functionality for the care of patients with AKI, the POCUS protocol was implemented with the aim of phenotypic identification with both pre-renal, intrinsic, and/or post-renal associated impairment.

However, it is important to emphasize that even in the face of these important findings, additional studies are needed to validate the cost-effectiveness of this procedure and establish specific guidelines for the use of bedside US in the approach to patients with AKI.

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