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EDITORIAL

Ultrasound unveiling: Decoding venous congestion in heart failure for precision management of fluid status

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Abstract

This editorial discusses the manuscript by Di Maria *et al*, published in the recent issue of the *World Journal of Cardiology*. We here focus on the still elusive pathophysiological mechanisms underlying cardio-renal syndrome (CRS), despite its high prevalence and the substantial worsening of both kidney function and heart failure. While the measure of right atrial pressure through right cardiac catheterization remains the most accurate albeit invasive and costly procedure, integrating bedside ultrasound into diagnostic protocols may substantially enhance the staging of venous congestion and guide therapeutic decisions. In particular, with the assessment of Doppler patterns across multiple venous districts, the Venous Excess Ultrasound (VExUS) score improves the management of fluid overload and provides insight into the underlying factors contributing to cardio-renal interactions. Integrating specific echocardiographic parameters, particularly those concerning the right heart, may thus improve the VExUS score sensitivity, offering perspective into the nuanced comprehension of cardio-renal dynamics. A multidisciplinary approach that consistently incorporates the use of ultrasound is emerging as a promising advance in the understanding and management of CRS.

Key Words: Cardio-renal syndrome; Fluid overload; Heart failure; Ultrasound assessment; Venous congestion; Venous excess ultrasound score

Core Tip: While conventional approaches of managing fluid overload in heart failure have long relied on clinical examination, there is room to incorporate patient phenotyping and predict the development of cardio-renal syndrome. We here discuss implementation of the multi-parameter Venous Excess Ultrasound scoring system, which is helpful in avoiding missteps in the assessment and therapeutic decision-making processes. Our aim is to emphasize the emerging role of these feasible, safe and low-cost tools that are easy to implement in clinical practice. Integrating echocardiographic parameters with thorough clinical assessments could provide a comprehensive approach to managing cardio-renal syndrome.

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INTRODUCTION

The article by Di Maria *et al*[1], recently published in the *World Journal of Cardiology*, emphasizes the significance of ultrasound as a diagnostic tool for assessing and managing fluid overload. Venous congestion and worsening of kidney function are common and often concomitant findings in patients with heart failure (HF). While they are traditionally approached with clinical experience, medical examination alone has been proven to be insufficient for assessing venous congestion and fluid overload status in complex scenarios. Implementing clinical practice with instrumental approaches is now becoming essential in HF and kidney disease, especially in acute-on-chronic conditions. Among these approaches, ultrasonography is emerging as the standard of practice for daily bedside evaluation and therapeutic decision-making. Advances in methodology are bringing ultrasound performance closer to that of right heart catheterization without any procedure-related risk. The intrinsic properties of ultrasonography (*e.g.* dynamism and reproducibility) may also confer the potential to reveal yet-hidden pathophysiological mechanisms linking volume overload in HF and kidney injury.

VENOUS CONGESTION AND CARDIORENAL INTERACTION

Overview and outlook

Whether HF may generate or precipitate impairment of kidney function, and *vice versa*, is undoubtedly a common finding affecting approximately 30-60% of HF patients[2,3]. The so-called cardio-renal syndrome (CRS) encompasses a broad spectrum of pathophysiologically distinct processes, where worsening renal function stands as the central tenet and ultimately drives the prognosis[4,5]. In this context, a thorough understanding of the role of venous congestion in shaping the development of CRS holds substantial promise for refining its management strategies. Recent insights are challenging the classical view of renal dysfunction in congestive HF as secondary to hypoperfusion, reduced systemic blood pressure, and/or impaired left ventricular function. As highlighted by the ESCAPE trial in 2008, the cardiac index does not account entirely for the baseline glomerular filtration rate (GFR)[6], resulting in somewhat unpredictable responses to loop diuretics among patients[7,8]. Similarly, a rise in the blood urea nitrogen/creatinine ratio in HF should not deter from treating congestion – when present – as the worsening of renal function frequently arises amid volume overloads. Both cardiac output and volume overload may indeed trigger a vicious cycle sustained by neurohormonal adaptations (*i.e.*, sympathetic nervous system and renin-angiotensin-aldosterone system) that ultimately increase cardiac work and afterload through an inotropic effect and arterial vasoconstriction, respectively. Whatever the *primum movens* is, the consequent reduction in renal perfusion exacerbates sodium retention and venous congestion[9,10]. Whether isolated or concomitant, right ventricular (RV) dysfunction poses further challenges as the rise in central venous pressure (CVP) has the potential to decrease GFR. Diuretic therapy plays a role in RV dysfunction, independently of cardiac output, with a double effect on renal venous pressure and ventricular interdependence[11,12]. However, the current extensive use of CVP for guiding fluid therapy lacks substantial evidence[13]. Finally, the decompensated HF scenario commonly involves splanchnic veins with a progressive rise in intra-abdominal pressure that further contributes to renal venous hypertension and a rise in cardiac filling pressure[14,15].

Venous excess ultrasound assessment

The use of bedside ultrasonography for fluid status assessment is established in current practice but is still limited to a one-venous region focus, mainly on the inferior vena cava (IVC). This approach limits an accurate estimation of left ventricle preload as IVC dilation diagnostic efficacy was found to be suboptimal and fails to quantify the extent of upstream venous congestion such as liver, gut, and kidneys[16]. Recognizing venous congestion – and the underlying patterns – before clinically evident is an unmet clinical need that would substantially impact a patient's prognosis and healthcare system running. The question is whether ultrasound may accomplish that without highly specialized skills. Doppler flow patterns alone may aid in grading the extent of venous congestion without insights on the underlying cause. In 2020, the Venous Excess Ultrasound (VExUS) score was introduced as a multi-parameter score able to stratify congested HF failure for severity and the risk of developing acute kidney injury (AKI)[16,17]. This scoring system

includes a 4-step protocol, ranging from grades 0 to 3. It not only assesses the IVC diameter but also evaluates the severity of venous congestion in three target organs using color Doppler and pulsed-wave Doppler in hepatic, portal, and renal veins. Hence, it has the potential to greatly contribute to a deeper comprehension of the frequently overlooked issue of venous congestion[18]. A correlation between the VExUS score and AKI in patients with acute coronary syndrome was emphasized in a prospective study[19]. Notably, an enhancement in renal function was linked to an improvement in the VExUS score grade, as demonstrated in patients admitted to the intensive care unit who experienced more days free from renal replacement therapy[20]. Once validated, the VExUS score is expected to substantially enhance clinical practice by offering valuable insights for clinical decision-making[21]. Moreover, the VExUS score might offer the opportunity to phenotype HF and the related risk of AKI, including the elusive potential of right HF. In this context, integrating the VExUS Score with a focus on right heart ultrasound patterns would be relevant, as right heart dilation and dysfunction are likely associated with CRS, especially when stemming from severe congestion[11]. The VExUS score already exhibits substantial reliability in correlating with venous congestion, right atrial pressure, assessed through right catheterization, and portal vein flow[22-24]. However, the prognostic value of the VExUS score has not yet been validated, despite some insight from the monophasic intrarenal venous pattern and high pulsatility ratio of the portal vein[25,26].

CONCLUSION

The pathophysiologic mechanisms contributing to CRS remain widely unexplained and underscore the limit of a traditional approach based on clinical experience. The VExUS score is emerging as an intriguing tool for specifically evaluating venous congestion through ultrasonography, potentially offering an approach to unravel hidden pathophysiological aspects of CRS.

FOOTNOTES

Author contributions: Ramoni D conceptualization and writing the original draft; Carbone F and Montecucco F supervised and edited the entire work; All authors have read and approved the final manuscript.

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REFERENCES

1 **Di Maria A**, Siligato R, Bondanelli M, Fabbian F. Venous Doppler flow patterns, venous congestion, heart disease and renal dysfunction: A complex liaison. *World J Cardiol* 2024; **16**: 5-9 [PMID: 38313388 DOI: 10.4330/wjc.v16.i1.5]
2 **Heywood JT**, Fonarow GC, Costanzo MR, Mathur VS, Wigneswaran JR, Wynne J; ADHERE Scientific Advisory Committee and Investigators. High prevalence of renal dysfunction and its impact on outcome in 118,465 patients hospitalized with acute decompensated heart failure: a report from the ADHERE database. *J Card Fail* 2007; **13**: 422-430 [PMID: 17675055 DOI: 10.1016/j.cardfail.2007.03.011]
3 **Smith GL**, Lichtman JH, Bracken MB, Shlipak MG, Phillips CO, DiCapua P, Krumholz HM. Renal impairment and outcomes in heart failure: systematic review and meta-analysis. *J Am Coll Cardiol* 2006; **47**: 1987-1996 [PMID: 16697315 DOI: 10.1016/j.jacc.2005.11.084]
4 **Damman K**, Valente MA, Voors AA, O'Connor CM, van Veldhuisen DJ, Hillege HL. Renal impairment, worsening renal function, and outcome in patients with heart failure: an updated meta-analysis. *Eur Heart J* 2014; **35**: 455-469 [PMID: 24164864 DOI: 10.1093/eurheartj/eht386]
5 **Ahmad T**, Jackson K, Rao VS, Tang WHW, Brisco-Bacik MA, Chen HH, Felker GM, Hernandez AF, O'Connor CM, Sabbisetti VS, Bonventre JV, Wilson FP, Coca SG, Testani JM. Worsening Renal Function in Patients With Acute Heart Failure Undergoing Aggressive Diuresis Is Not Associated With Tubular Injury. *Circulation* 2018; **137**: 2016-2028 [PMID: 29352071 DOI: 10.1161/CIRCULATIONAHA.117.030112]
6 **Nohria A**, Hasselblad V, Stebbins A, Pauly DF, Fonarow GC, Shah M, Yancy CW, Califf RM, Stevenson LW, Hill JA. Cardiorenal interactions: insights from the ESCAPE trial. *J Am Coll Cardiol* 2008; **51**: 1268-1274 [PMID: 18371557 DOI: 10.1016/j.jacc.2007.08.072]
7 **Kemp CD**, Conte JV. The pathophysiology of heart failure. *Cardiovasc Pathol* 2012; **21**: 365-371 [PMID: 22227365 DOI: 10.1016/j.carpath.2011.11.007]

8 **Brisco MA**, Coca SG, Chen J, Owens AT, McCauley BD, Kimmel SE, Testani JM. Blood urea nitrogen/creatinine ratio identifies a high-risk but potentially reversible form of renal dysfunction in patients with decompensated heart failure. *Circ Heart Fail* 2013; **6**: 233-239 [PMID: 23325460 DOI: 10.1161/CIRCHEARTFAILURE.112.968230]

9 **Scagliola R**, Brunelli C. Venous Congestion and Systemic Hypoperfusion in Cardiorenal Syndrome: Two Sides of the Same Coin. *Rev Cardiovasc Med* 2022; **23**: 111 [PMID: 35345278 DOI: 10.31083/j.rcm2303111]

10 **Marsh DJ**, Postnov DD, Sosnovtseva OV, Holstein-Rathlou NH. The nephron-arterial network and its interactions. *Am J Physiol Renal Physiol* 2019; **316**: F769-F784 [PMID: 30759020 DOI: 10.1152/ajprenal.00484.2018]

11 **Testani JM**, Khera AV, St John Sutton MG, Keane MG, Wiegers SE, Shannon RP, Kirkpatrick JN. Effect of right ventricular function and venous congestion on cardiorenal interactions during the treatment of decompensated heart failure. *Am J Cardiol* 2010; **105**: 511-516 [PMID: 20152246 DOI: 10.1016/j.amjcard.2009.10.020]

12 **Naeije R**, Badagliacca R. The overloaded right heart and ventricular interdependence. *Cardiovasc Res* 2017; **113**: 1474-1485 [PMID: 28957537 DOI: 10.1093/cvr/cvx160]

13 **Bednarczyk JM**, Fridfinnson JA, Kumar A, Blanchard L, Rabbani R, Bell D, Funk D, Turgeon AF, Abou-Setta AM, Zarychanski R. Incorporating Dynamic Assessment of Fluid Responsiveness Into Goal-Directed Therapy: A Systematic Review and Meta-Analysis. *Crit Care Med* 2017; **45**: 1538-1545 [PMID: 28817481 DOI: 10.1097/CCM.0000000000002554]

14 **Mullens W**, Abrahams Z, Skouri HN, Francis GS, Taylor DO, Starling RC, Paganini E, Tang WH. Elevated intra-abdominal pressure in acute decompensated heart failure: a potential contributor to worsening renal function? *J Am Coll Cardiol* 2008; **51**: 300-306 [PMID: 18206740 DOI: 10.1016/j.jacc.2007.09.043]

15 **F Gnanaraj J**, von Haehling S, Anker SD, Raj DS, Radhakrishnan J. The relevance of congestion in the cardio-renal syndrome. *Kidney Int* 2013; **83**: 384-391 [PMID: 23254894 DOI: 10.1038/ki.2012.406]

16 **Beaubien-Souligny W**, Rola P, Haycock K, Bouchard J, Lamarche Y, Spiegel R, Denault AY. Quantifying systemic congestion with Point-Of-Care ultrasound: development of the venous excess ultrasound grading system. *Ultrasound J* 2020; **12**: 16 [PMID: 32270297 DOI: 10.1186/s13089-020-00163-w]

17 **Bhardwaj V**, Vikneswaran G, Rola P, Raju S, Bhat RS, Jayakumar A, Alva A. Combination of Inferior Vena Cava Diameter, Hepatic Venous Flow, and Portal Vein Pulsatility Index: Venous Excess Ultrasound Score (VEXUS Score) in Predicting Acute Kidney Injury in Patients with Cardiorenal Syndrome: A Prospective Cohort Study. *Indian J Crit Care Med* 2020; **24**: 783-789 [PMID: 33132560 DOI: 10.5005/jp-journals-10071-23570]

18 **Longino A**, Martin K, Leyba K, Siegel G, Thai TN, Riscinti M, Douglas IS, Gill E, Burke J. Prospective Evaluation of Venous Excess Ultrasound for Estimation of Venous Congestion. *Chest* 2024; **165**: 590-600 [PMID: 37813180 DOI: 10.1016/j.chest.2023.09.029]

19 **Viana-Rojas JA**, Argaiz E, Robles-Ledesma M, Arias-Mendoza A, Nájera-Rojas NA, Alonso-Bringas AP, De Los Ríos-Arce LF, Armenta-Rodriguez J, Gopar-Nieto R, Briseño-De la Cruz JL, González-Pacheco H, Sierra-Lara Martinez D, Gonzalez-Salido J, Lopez-Gil S, Araiza-Garaygordobil D. Venous excess ultrasound score and acute kidney injury in patients with acute coronary syndrome. *Eur Heart J Acute Cardiovasc Care* 2023; **12**: 413-419 [PMID: 37154067 DOI: 10.1093/ehjacc/zuad048]

20 **Rihl MF**, Pellegrini JAS, Boniatti MM. VExUS Score in the Management of Patients With Acute Kidney Injury in the Intensive Care Unit: AKIVEX Study. *J Ultrasound Med* 2023; **42**: 2547-2556 [PMID: 37310104 DOI: 10.1002/jum.16288]

21 **Rola P**, Miralles-Aguiar F, Argaiz E, Beaubien-Souligny W, Haycock K, Karimov T, Dinh VA, Spiegel R. Clinical applications of the venous excess ultrasound (VExUS) score: conceptual review and case series. *Ultrasound J* 2021; **13**: 32 [PMID: 34146184 DOI: 10.1186/s13089-021-00232-8]

22 **Damman K**, Navis G, Smilde TD, Voors AA, van der Bij W, van Veldhuisen DJ, Hillege HL. Decreased cardiac output, venous congestion and the association with renal impairment in patients with cardiac dysfunction. *Eur J Heart Fail* 2007; **9**: 872-878 [PMID: 17586090 DOI: 10.1016/j.ejheart.2007.05.010]

23 **Longino A**, Martin K, Leyba K, Siegel G, Gill E, Douglas IS, Burke J. Correlation between the VExUS score and right atrial pressure: a pilot prospective observational study. *Crit Care* 2023; **27**: 205 [PMID: 37237315 DOI: 10.1186/s13054-023-04471-0]

24 **Yoshihisa A**, Ishibashi S, Matsuda M, Yamadera Y, Ichijo Y, Sato Y, Yokokawa T, Misaka T, Oikawa M, Kobayashi A, Yamaki T, Kunii H, Takeishi Y. Clinical Implications of Hepatic Hemodynamic Evaluation by Abdominal Ultrasonographic Imaging in Patients With Heart Failure. *J Am Heart Assoc* 2020; **9**: e016689 [PMID: 32750309 DOI: 10.1161/JAHA.120.016689]

25 **Torres-Arrese M**, Mata-Martínez A, Luordo-Tedesco D, García-Casasola G, Alonso-González R, Montero-Hernández E, Cobo-Marcos M, Sánchez-Sauce B, Cuervas-Mons V, Tung-Chen Y. Usefulness of Systemic Venous Ultrasound Protocols in the Prognosis of Heart Failure Patients: Results from a Prospective Multicentric Study. *J Clin Med* 2023; **12** [PMID: 36835816 DOI: 10.3390/jcm12041281]

26 **Kuwahara N**, Honjo T, Sone N, Imanishi J, Nakayama K, Kamemura K, Iwahashi M, Ohta S, Kaihotsu K. Clinical impact of portal vein pulsatility on the prognosis of hospitalized patients with acute heart failure. *World J Cardiol* 2023; **15**: 599-608 [PMID: 38058398 DOI: 10.4330/wjc.v15.i11.599]

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