**Name of Journal:** *World Journal of Cardiology*

**Manuscript NO:** 90142

**Manuscript Type:** EDITORIAL

**Venous Doppler flow patterns, venous congestion, heart disease and renal dysfunction: A complex liaison**

Di Maria A *et al*. Venous Doppler flow patterns and venous congestion

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**Author contributions:** Siligato R, Di Maria A, Bondanelli M, and Fabbian F contributed to this paper; Di Maria A, Siligato R, Bondanelli M, Fabbian F designed the overall concept, reviewed the literature, contributed to the discussion, wrote the initial draft, edited the subsequent versions, and approved the final version.

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**Received:** November 24, 2023

**Revised:** December 15, 2023

**Accepted:** January 3, 2024

**Published online:** January 26, 2024

**Abstract**

The *World Journal of Cardiology* published an article written by Kuwahara *et al* that we take the pleasure to comment on. We focused our attention on venous congestion. In intensive care settings, it is now widely accepted that venous congestion is an important clinical feature worthy of investigation. Evaluating venous Doppler profile abnormalities at multiple sites could suggest adequate treatment and monitor its efficacy. Renal dysfunction could trigger or worsen fluid overload in heart disease, and cardio-renal syndrome is a well-characterized spectrum of disorders describing the complex interactions between heart and kidney diseases. Fluid overload and venous congestion, including renal venous hypertension, are major determinants of acute and chronic renal dysfunction arising in heart disease. Organ congestion from venous hypertension could be involved in the development of organ injury in several clinical situations, such as critical diseases, congestive heart failure, and chronic kidney disease. Ultrasonography and abnormal Doppler flow patterns diagnose clinically significant systemic venous congestion. Cardiologists and nephrologists might use this valuable, non-invasive, bedside diagnostic tool to establish fluid status and guide clinical choices.

**Key Words:** Cardio-renal syndrome; Fluid overload; Venous congestion; Acute kidney injury; Ultrasound; Doppler flow patterns

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**Citation:** 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(1): 5-9

**URL:** <https://www.wjgnet.com/1949-8462/full/v16/i1/5.htm>

**DOI:** https://dx.doi.org/10.4330/wjc.v16.i1.5

**Core Tip:** Fluid overload and venous congestion, including renal venous hypertension, play a major role in the pathogenesis of acute and chronic renal dysfunction occurring in heart disease. Physical assessment sensitivity alone to determine fluid status is scarce, limiting success in clinical decision-making. Ultrasonography and venous Doppler flow patterns evaluation is a valuable, non-invasive, bedside diagnostic tool for establishing fluid status, and guide its treatment.

**INTRODUCTION**

The paper written by Kuwahara *et al*[1] analyzed the relationship between portal vein pulsatility (PVPR) and acute heart failure. The authors calculated the PVPR ratio in the right portal branch of 56 patients hospitalized with acute heart failure and 17 controls and found that reducing PVPR due to improving venous congestion was associated with better outcomes. PVPR was suggested to be a novel prognostic marker for hospitalized patients with acute heart failure.

Interestingly, the mean estimated glomerular filtration rate of the subjects investigated was between 39 and 47 mL/min/1.73 m2 in the three groups of patients with different PVPR values. The paper does not report whether the patients suffered only acute kidney injury or had an exacerbation of pre-existing chronic kidney disease. It is necessary to underline this problem because the vicious circle between heart and renal disease is a well-known clinical condition[2].

**CARDIO-RENAL SYNDROME**

The relationship between heart and renal disease is defined as cardio-renal syndrome (CRS), a term describing the complex interactions between heart and kidney dysfunction. CRS is a challenging and evolving field, and more research is needed to understand better the pathophysiology, diagnosis, prevention, and treatment of this complex condition. CRS is classified into five subtypes, depending on the primary organ involved and the acute or chronic nature of the condition[3].

The epidemiology of CRS is not well established, as few prospective studies have assessed the prevalence, incidence, risk factors, and outcomes of different CRS subtypes. [However, some estimates suggest that CRS is a common and severe complication of cardiovascular and renal diseases affecting people worldwide[4].](https://www.omicsonline.org/open-access/heartkidney-interaction-cardiorenal-syndrome-epidemiology-123636.html)

Aging, hypertension, diabetes, obesity, inflammation, oxidative stress, neurohormonal activation, and medications could contribute to the development of CRS. However, the cardiorenal connection is more complex than the hemodynamic model alone; it should be consider the effects of a network including the renin-angiotensin system, the nitric oxide, the reactive oxygen species, the inflammation, the anemia, and the sympathetic nervous system[5,6].

#### It could be argued that patients enrolled in the Kuwahara *et al*[1] study could be classified as acute or type 1 cardio-renal syndrome. In this clinical condition, acute worsening of heart function causes reduced kidney function. Acute renal dysfunction is diagnosed in 27%-40% of patients hospitalized for acute heart failure[7,8]; this clinical entity leads to higher morbidity and mortality, increasing the duration of admission[9]. Also, in internal medicine units, CRS type 1 is common, especially in elderly patients with stage 3-4 chronic kidney disease[10].

#### VENOUS CONGESTION ASSESSMENT

#### Using Doppler modalities during ultrasound investigations, the clinician could assess venous flow patterns relating the signal to the cardiac cycle. In the presence of hemodynamic changes within the systemic venous circulation leading to high venous pressure, venous Doppler profile abnormalities at multiple sites are detected (Figure 1). Clinically significant systemic venous congestion is diagnosed by abnormal Doppler flow patterns. Venous excess ultrasound (VExUS) score was studied in patients assessed with right heart catheterization, and proper atrial pressure was significantly associated with VExUS grade[11]. Organ congestion from venous hypertension could be involved in the development of organ injury in several clinical situations, such as critical diseases, congestive heart failure, and chronic kidney disease[12].

#### VENOUS CONGESTION IN DIFFERENT CLINICAL CONDITIONS

#### Fluid overload and venous congestion, including renal venous hypertension, are major determinants of acute and chronic renal dysfunction arising in heart disease[2]. Due to the limitations of traditional methods in evaluating venous congestion, detecting venous Doppler profile abnormalities (at multiple sites) related to elevated venous pressure is becoming very important in clinical assessment, mainly because it can be performed at the bedside[12].

#### In 2019, Husain-Syed *et al*[13] evaluated 205 subjects with suspected or pre-diagnosed pulmonary hypertension who underwent right heart catheterization. They also evaluated intrarenal venous patterns and concluded that the renal venous stasis index could predict the development of right heart failure.

#### In 2020, Spiegel *et al*[14] compared the morphology of hepatic veins, portal veins, and intra-renal veins waveform abnormalities VExUS for predicting major kidney events at 30 d in 114 adult patients admitted to an intensive care unit. They found that significant kidney events at 30 d were associated with abnormalities in hepatic and portal venous Doppler.

#### Severe venous congestion shown by flow abnormalities in Doppler patterns was associated with acute kidney injury (AKI) in 145 patients who underwent cardiac surgery. VExUS grade outperformed central venous pressure measurements[15].

#### Inferior vena cava and hepatic vein waveform, and portal vein pulsatility were investigated aiming at determining VExUS, in thirty CRS patients aged 59 years in order to evaluate the association between fluid overload and AKI. Authors found that improved renal function was related to improvement in VExUS grade[16].

#### Argaiz *et al*[17] suggested that in patients with acute left heart failure, the normalization of the size of the inferior vena cava, the restoration of its collapsibility, and the improvement of portal vein flow were related to the decrease in serum creatinine levels.

#### Hermansen *et al*[18] conducted a prospective, observational study to assess the connection between Doppler signals of renal perfusion and the development of AKI. Abnormal renal venous flow pattern on the first postoperative day and portal vein pulsatility fraction were associated with severe AKI development.

#### During 2023, at least four papers investigated the relationship between AKI and venous congestion. After cardiac surgery, abnormalities in intra-renal venous flow, portal vein pulsatility fraction, hepatic vein flow patterns, and central venous pressure were associated with the development of AKI[19]. In a prospective study evaluating subjects suffering from acute coronary syndrome, the increasing degree of VExUS was associated with AKI[20].

#### Patients admitted to intensive care units with a VExUS score greater than one were treated with diuretics more frequently than those with a VExUS score equal to or lower than 1. Moreover, subjects showing decreasing VExUS scores had more renal replacement therapy-free days in 28 d[21].

#### On the other hand, Andrei *et al*[22] could not detect any association between VExUS score and AKI and 28-d mortality.

**CONCLUSION**

Chronic kidney disease increases the risk of death during hospitalization in several clinical conditions, such as myocardial infarction[23], chronic obstructive pulmonary disease[24], stroke[25], and CRS[26]. [Some of the strategies that may be beneficial in order to improve outcomes include optimizing fluid balance, reducing congestion, improving hemodynamics, preserving renal perfusion, preventing or treating acute kidney injury, and using cardioprotective and renoprotective drugs](https://academic.oup.com/eurheartj/article/31/6/703/419179). Managing kidney failure and different clinical conditions, particularly those involving the heart, requires a multidisciplinary approach that addresses the underlying causes and the specific features of each subtype. Cardiologists and nephrologists should correctly manage the complex fluid problem due to its centrality in everyday clinical practice. Physical assessment sensitivity alone to determine fluid status is scarce, limiting success in clinical decision-making. Ultrasonography and venous Doppler flow pattern evaluation are valuable, non-invasive, bedside diagnostic tools for establishing fluid status and guiding the treatment of venous congestion[27].

**ACKNOWLEDGEMENTS**

We thank Claudia Righini and Donato Bragatto, Biblioteca Interaziendale di Scienze della Salute, Ferrara, Italy, for their valuable support.

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**Footnotes**

**Conflict-of-interest statement:** All the authors declare that they have no conflict of interest to disclose.

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**Provenance and peer review:** Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review started:** November 24, 2023

**First decision:** December 7, 2023

**Article in press:** January 3, 2024

**Specialty type:** Cardiac and cardiovascular systems

**Country/Territory of origin:** Italy

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Liu Y, China **S-Editor:** Liu JH **L-Editor:** A **P-Editor:** Yu HG

**Figure Legends**



**Figure 1 Venous Doppler profiles are detected at multiple sites in normal conditions and in the case of venous and severe venous congestion.**



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