

## Cardiac Output and Renal Function: An Association

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### Abstract

In this article, we discussed a clinical problem known as cardio renal syndrome (CRS). In CRS, both, the affected cardiovascular system, either low output or high output failure leads to the renal dysfunction or vice versa. As already known, the heart failure is the leading cause of readmission in the US and worldwide. The patients suffering with cardiac failure need extra care, as they may develop various complications. Cardiac output is affected in heart failure and does have an impact on the renal function. High cardiac output and low cardiac output, both can lead to renal dysfunction. In conclusion, we will also highlight some information about the prevention of the renal damage associated with the CVS. However, future research is recommended to understand more about the exact pathophysiology involved in this association.

**Keywords:** Cardiac output renal; Cardiac output kidney; Heart output kidney; Heart output renal; Cardiac renal; Heart renal

### Introduction

*"I had been living with dialysis for three years or so, and the new kidney felt like a reprieve, a new gift of life. I felt alive again and I guess that has had an effect on my use of colour".* Peter wright [1].

The following anecdote is described by one of the authors (IG), and is written word for word. He describes,

*"Once I was working in a hospital and saw a patient with heart failure. After his condition worsened, he also developed renal failure. I told him about his condition and he replied to me in a depressive tone, "Doctor! The heart failure was enough for me, why I also developed renal failure?" "I was shocked at that time and it triggered a thought that why does that happen, and how it can be prevented."* Obviously, this is a striking mystery, enough to astound anyone dealing with these kinds of patients. Imagine a new clinician handling these kinds of patients alone... the condition can not only be fearful for the clinician but can be lethal for the patient. This review is our attempt to bring our attention toward this phenomenon called cardio renal syndrome (CRS).

CRS is an umbrella term used in the medical field that defines disorders of the heart and kidneys whereby "acute or chronic dysfunction in one organ may induce acute or chronic dysfunction of the other" [2,3].

As we already know that kidney failure causes heart dysfunction [4], but we want to know that how the heart dysfunction and cardiac output effects the kidney? What are the markers, which could be raised before serum creatinine rise in blood so that we can diagnose and prevent disease [5]. Because it is a mini-review, the size of this paper does not allow us to focus on all the answers that are not fully known. However, this review surely can be helpful for a new clinician and a researcher, who is not fully aware of this medical condition. Therefore, any new clinician who deals with a situation similar to the one faced by one of the co-authors (IG), should not be surprised and in fact should be able to deal with the patients suffering from cardio renal syndrome and treat the patients successfully.

### Some Studies Relevant to the Theme of Cardiac Output and its Effect on Kidneys

To conduct this mini review, we searched databases like PubMed, google scholar, Embase and Cochrane library. A total of 500 articles

were initially reviewed. Then out of those a total of 26 articles were finally selected, later only 15 met our inclusion/exclusion criteria. All the articles were included according to their relevance with "effect of cardiac output on renal function". Keywords included but not limited to cardiac output renal, cardiac output kidney, heart output kidney, heart output renal, cardiac renal, heart renal. The inclusion criteria included all the articles relevant to the theme of cardiac output and renal failure. Moreover, all the articles published after the year 2009 were selected. All the animal studies, case reports and case studies were excluded to keep the data minimum to fit for a mini-review. All the papers before the year 2009 were excluded.

Congestive heart failure is the leading cause of 30-day hospital readmission in the US. The problem almost costs 17 billion US dollars to medicare alone every year. Not only it is the leading cause of re-hospitalization, it is in fact one of the most common causes of mortality seen in the hospitals in the USA and worldwide. The death associated with heart failure could be due to many reasons. In this article, we will highlight how the heart output can be deleterious to the patient's wellbeing.

As already mentioned, the heart failure patients are increasingly hospitalized and the mortality in these patients is increased, exceptionally in the patients with kidney dysfunction. Studies conducted in the recent past, suggest that kidney function and renal congestion, are one of most important factors to determine the prognosis. Kidney congestion in heart failure results from low cardiac output (forward failure), tubuloglomerular feedback, increased intra-abdominal pressure or increased venous pressure [6-8]. Thus, multiple factors might be involved in worsening of renal function, including low cardiac output.

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Author/ Publication year	Country	Study Type	Population	Sample size	Main findings
Ronco, et al. [2]	Italy	Review Article	NA	NA	Helps in better understanding of the disease, prevention and treatment of the disease.
Virzi et al. [3]	Italy	Review Article	NA	NA	Both hemodynamic and non-hemodynamic mechanisms are involved in development of CRS.
Bagshaw et al. [4]	Edmonton, Alta, Canada	Review Article	NA	NA	Factors affecting Cardiac function and treatment response in CRS type 3 due to AKI.
Ronco et al. [5]	Italy	Review Article	NA	NA	Tubular damage biomarkers become positive, even before a rise in serum creatinine is called subclinical AKI and We should consider subclinical AKI as AKI and we should start to treat the sub-clinical AKI.
Afsar et al. [6]	Turkey	Review Article	NA	NA	Renal congestion is a major factor for worse outcomes in Heart failure patients
Tobias et al. [9]	Germany				Responders to Volume challenge with septic induced AKI can be benefited from an optimized environment
Goren et al. [10]	Israel	Review Article	NA	NA	To prevent the perioperative AKI IV fluids, vasopressor and appropriate blood management is required.

**Table 1:** Relevant studies showing the effect of cardiac output on renal function.

In sepsis, in which the patient has low cardiac output and worsening of the renal function. When the patient is given fluids, the renal function improves [9]. Goren et al. reported that acute kidney injury is also present in surgical patients specifically in the emergency and major surgeries i.e. cardiac and transplantation surgeries. In these cases an anesthetist is required to identify the patients at risk of AKI to correct anemia or hypovolemia. Hypotension should be avoided, because even short interval of mean arterial pressure reduction of less than 55 mm Hg to 60 mm Hg carries a risk of AKI postoperatively. These kinds of studies also point toward an idea that the kidney function is dependent on the cardiac output [10].

Evidence supports that HTN is associated with acute worsening of renal function, with preserved and reduced ejection fraction. Some conditions leading to hypertension include a reduction in functional kidney mass, excess aldosterone or angiotensin production, and increased resistance to blood flow in the renal arteries. All of these conditions raise the total blood volume that ultimately increases the cardiac output. Therefore, it's not only the reduced cardiac output which leads to renal dysfunction. Increased cardiac output can also be associated with the kidney dysfunction [11].

From the discussion above, the association of kidney with heart is very clear. Many other studies have also mentioned about this association [12-14]. The risk is not just confined with heart failure alone. Ischemic heart disease can also affect the kidneys [15]. A lot of published literature is available on the subject, and it will continue to grow and expand our knowledge in the future. Yet there will always be some gaps in our knowledge. We concluded that increase or decrease in cardiac output deteriorates renal function. In this study we found out that the mortality is increased in the patients with heart failure if there is low cardiac output. Similarly, it is observed in the case of sepsis, that the low cardiac output can lead to kidney damage. In cases of major surgeries and transplantation, the renal function is disturbed, when there is low cardiac output and causes increased mortality. We also found out that it's not only low cardiac output that affects renal function, but the high cardiac output also affects renal function in the hypertensive patients.

## Conclusion

The association of heart with kidney has long been discussed. It is a well-known fact that, the Low renal function can have an effect on the cardiovascular system. However, is this association in reverse? For example, does the heart problem affect the renal function or not? We highlighted this aspect of this pathophysiological association.

This study point toward the notion that, if we want to prevent the kidney damage, then we have to stabilize the cardiac output. If we optimize the cardiac output, the mortality can be decreased. We suggest more research needs to be conducted about this topic as many factors relevant to cardio renal syndrome and the effect of low cardiac output on the kidney still remain unknown (Table 1).

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