Sudden Cardiac Death & Chronic Kidney Disease

"ESRD patients are prone to sudden death, stroke and myocardial infarction between dialysis sessions."[1]

CKD(DL-200-wp-A4)RevA2016

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Sudden Cardiac Death

Sudden cardiac death (SCD) is defined as death from an unexpected circulatory arrest, occurring within an hour of the onset of symptoms, or an unwitnessed, unexpected death in patients known to be well within the previous 24 hours without an obvious non-cardiac cause.[2]

For the 20 million Americans that suffer from chronic kidney disease (CKD), SCD statistics are alarming. These CKD patients have a four to 20 times greater risk of sudden cardiac death (SCD) than do persons in the general population.[3] As their glomerular filtration rates decline indicating progressively lower kidney function, the risk of sudden cardiac death proportionally increases.[2]

Moreover, it is estimated that the number of patients with End-Stage Renal Disease (ESRD) on hemodialysis will reach one-half million by the year 2020.[2,3] Sudden death among these patients accounts for 25% of all causes of mortality.[4] In 1998, the American Journal of Kidney Disease underscored the gravity of this disease with the following title on the cover of their journal, "Cardiovascular Disease, An ESRD Epidemic."[5]

Cardiovascular Collapse

Not only is cardiovascular disease (CVD) the leading cause of morbidity and mortality in patients with end-stage renal disease (ESRD), but cardiovascular collapse is a major cause of complications during a hemodialysis treatment. Congestive heart failure (CHF) in ESRD patients results from cardiac overload, anemia, severe hypertension and cardiac dysfunction. CVD mortality rates are about 30 times that of the general population, and in adolescents, CVD mortality rates are over 1,000 times that of their age-related peers.[6]

Multinational data from the Dialysis Outcomes and Practice Patterns (DOPPS) registry suggests that sudden death accounts for the highest proportion of hemodialysis deaths in the United States (33%) whereas lower proportions were observed in Japan (23%), Australia/New Zealand (19%) and Canada (18%).[7]

Identifying SCD in CKD Patients

However, determining the sudden nature of death is problematic particularly among End-Stage Renal Disease (ESRD) patients because:

- Most sudden deaths among CKD patients are unwitnessed. Therefore, clinical information collected around that time is often limited
- ESRD patients are often chronically ill with co-morbidities, and are frequently hospitalized.

CKD Sudden Death Pathophysiology

In the general population, coronary heart disease that leads to ventricular fibrillation or sustained ventricular flutter is the major cause of sudden death.

In the case of CKD patients, studies suggest fundamental differences in the causes and pathology of sudden heart disease. In these patients, their coronary artery disease involves multi-vessel arterial stiffening and calcification rather than an ischemic myocardium that might trigger a terminal arrhythmia and death. Rather, CKD patients, especially those on hemodialysis, are subject to a wide array of potential arrhythmic triggers.

When Does Sudden Death Occur

It has been observed that SCD in CKD occurs most frequently on days when hemodialysis is being administered, particularly on the first day after a three day weekend without dialysis.[2] Moreover, as illustrated in the graph below, the probability of sudden death increases in the time period immediately following dialysis.[8]

Sudden Death Risks Factors

In ESRD patients on hemodialysis, an increased risk of SCD has been linked to:

- Rapid ultrafiltration rate
- Low calcium during hemodialysis
- Low potassium (hypokalemia) or high potassium (hyperkalemia) levels in the blood

"Given the heightened risk of SCD in the CKD population and the abysmal long-term survival rate following a cardiac arrest, primary prevention of SCD should be a major priority."[2]

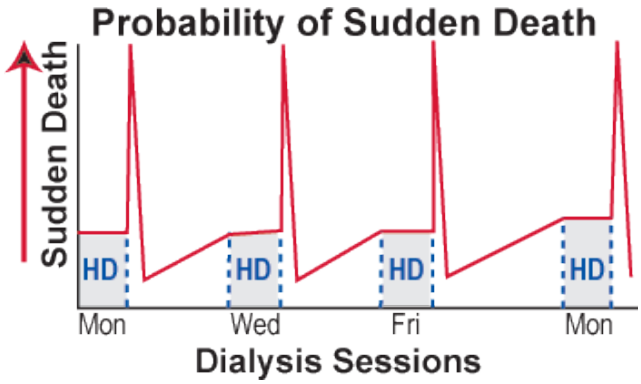

Fig. 1: The graph illustrates the spike in the probability of sudden death immediately following dialysis. ""35% of deaths occurred in the 1st 12-hour interval… 27% of these deaths occurred during dialysis and 33% occurred in the hour after the dialysis treatment (8)."" Critically low CI levels (<2 L/min/m^2) can occur in patients who do not feel well at the end of a dialysis session.

Measure Cardiac Output — Save a Life!

"The ability to monitor cardiac output is one of the important cornerstones of hemodynamic assessment ...in particular in patients with pre-existing cardiovascular comorbidities."[9]

Proactive Patient Care

Cardiovascular complications in ESRD patients can be averted or reduced through periodic exams by the patient's nephrologist, and routine screening of cardiac function with the Transonic HD03 Monitor.

Cardiac Function Stressed

The rapid removal of large volumes of fluid during hemodialysis severely tests the limits of a patient's cardiac function. Cardiac output decreases an average of 20% during the hemodialysis treatment causing less and less blood flow to be available to sustain the body's vital functions. HD03 cardiac output measurements monitor a heart's response to fluid removal during dialysis.

Central Hemodynamic Profiling (CHP)

Cardiovascular parameters can change dramatically during dialysis. Therefore, multiple cardiac measurements are advised during a dialysis session for patients at risk for SCD in order to create a CHP (Fig. 5) to track the heart's response to the stress of a dialysis treatment. CHP Monitoring identifies:

- Dramatic 20-30% CO drop during dialysis due to inaccurate dry weight estimation and/or medication that places patients at high risk for cardiovascular complications and sudden death following the dialysis session (Fig. 2).
- Prolonged high levels of access flow (>1,600-2,000 ml/min) that can lead to cardiomegaly and high output cardiac failure. This can be identified by an access flow to cardiac output ratio (AVF/CO) exceeding 25-30% (Fig. 3).
- Cardiac Index of <2 L/min/m^2.

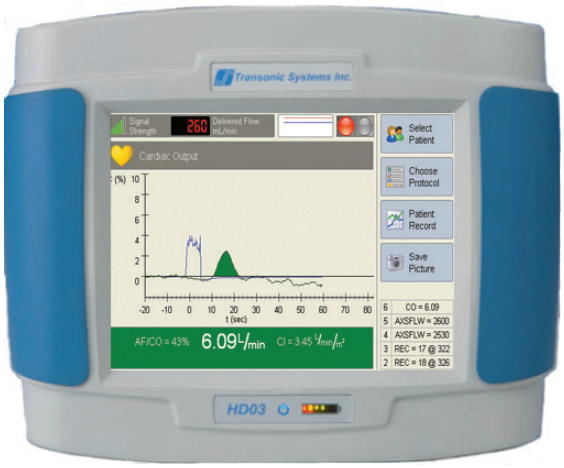

Fig.3: HD03 Hemodialysis Monitor displaying a CO screen.

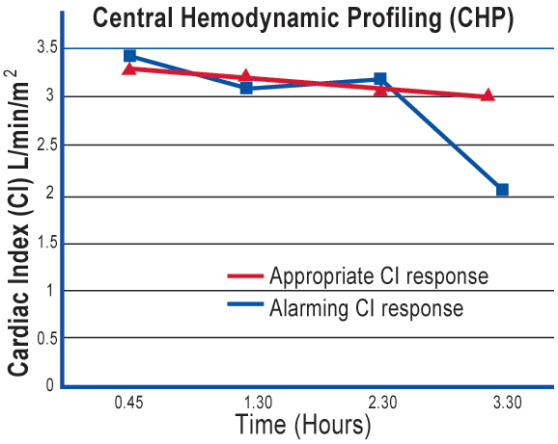

Fig. 5: Central Hemodynamic Profiling (CHP): four measurements taken during a single hemodialysis session shows Cardiac Index responses to the hemodialysis treatment. Acceptable CI results range between 2.5 - 4.2 L/min/m^2.

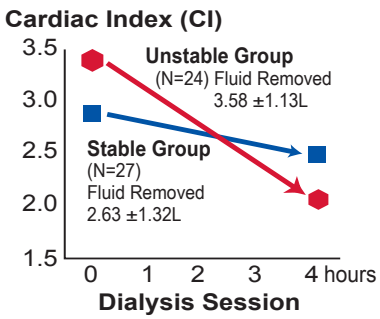

Fig. 2: Inadequate dry weight estimation increases the risk of cardiac failure.[1,9]

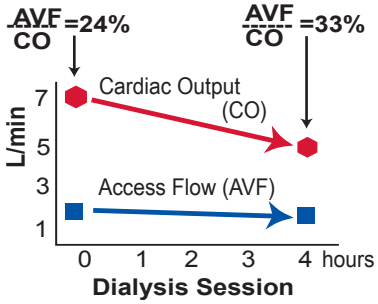

Fig. 3: One third of CO is redirected from the systemic circulation to the AV fistula placing patients at cardiac risk.

Deterioration of CO & CI during Hemodialysis

Case Report, courtesy of Dr. T.A. Depner

Routine Flow-QC® Cardiac Function screening commenced 40 minutes into the hemodialysis session for a patient with ischemic heart disease. The first Cardiac Output measurement was 4.3 L/min with a Cardiac Index of 2.5. When the cardiac function test was repeated two hours later, the patient's Cardiac Output had dropped to 2.7 L/min and his Cardiac Index was 1.6. The nephrologist was alerted, the patient's hemodialysis prescription was adjusted, and his cardiac condition was closely monitored.

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