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Cardiovascular Impact of Nocturnal Hemodialysis

Cardiovascular events are the leading cause of morbidity and mortality in end-stage renal disease (ESRD) patients. Hypertension and elevated arterial stiffness are increasingly recognized as important risk factors in uremic populations. Conventional hemodialysis (CHD) [3 times per week, 4 hours per session] only delivers 10% to 15% of renal function in an unphysiological intermittent mode. Because it occurs nightly, and is sustained over a longer dialysis time, the uremic clearance provided by nocturnal hemodialysis (NHD) [5-6 sessions per week, 6-8 hours per session] far exceeds that of CHD. This summary will highlight recent results describing the impact of NHD on the cardiovascular system.

Arterial and ventricular adaptations of nocturnal hemodialysis

In contrast to the effects of CHD, the Toronto experience has demonstrated regression of left ventricular (LV) hypertrophy along with superior blood pressure control following NHD. We studied 28 patients undergoing NHD for a minimum of 2 years duration and compared these patients to 13 self-care conventional hemodialysis patients (Chan CT et al, 2002). Blood pressure, extra-cellular fluid (ECF) volume and left ventricular mass index (LVMI) were assessed before and after conversion from CHD to NHD. Systolic blood pressure was reduced from 145 ± 20 to 122 ± 13 mm Hg, ($p<0.001$) and diastolic blood pressure from 84 ± 15 to 74 ± 12 mm Hg ($p=0.02$) in spite of the withdrawal of vasoactive medications (from 1.8 per patient to 0.3 per patient, $p < 0.05$). LVMI decreased from 147 ± 42 to 114 ± 40 g/m^2 ($p = 0.004$). ECF volume was not reduced after conversion from CHD to NHD suggesting that the achieved cardiac improvement occurred via mechanisms other than enhanced volume removal.

In another study of 18 consecutive patients converted from conventional to nocturnal home hemodialysis, we found that as the dialysis dose per session (Kt/V) increased after two months, mean arterial pressure decreased from 102 ± 3 to 90 ± 2 mm Hg (Chan CT et al, 2003). There was an associated decrease in calculated total peripheral resistance (from 1967 ± 235 to 1499 ± 191 dyne.s.cm^{-5}; $p<0.01$) and plasma norepinephrine levels (from 2.66 ± 0.4 to 1.96 ± 0.2 nmol/L; $p=0.04$). During conventional hemodialysis, endothelium-dependent vasodilatation could not be elicited but this was restored after a two-month period of nocturnal hemodialysis. In addition, brachial artery responsiveness to nitroglycerin improved (from 6.9 ± 2.8 to 15.7 ± 1.6%; $p<0.05$). Importantly, no significant change in weight and by corollary, extracellular volume, was demonstrated.

Impaired neural control of heart rate, elevated arterial stiffness and hypertension are probably central in the development of high cardiovascular mortality rate in ESRD patients. We hypothesized that NHD would increase arterial baroreflex sensitivity (BRS) for heart rate changes of hypertensive ESRD patients through an afferent vascular

mechanism. Ten consecutive hypertensive ESRD patients (age: 42 ± 4 years) receiving CHD were studied before and 2 months after conversion to NHD (Chan CT et al, 2005). Regression slopes relating RR interval responses to increases or decreases in systolic blood pressure were averaged to derive spontaneous BRS for heart rate for each patient. The stroke volume/pulse pressure (SV/PP) ratio was used to estimate total arterial compliance. NHD lowered systolic blood pressure (from 143 ± 4 to 120 ± 6 mm Hg, P=0.001). Both BRS (from 4.76 ± 1.1 to 6.91 ± 1.1 ms/mm Hg p=0.04) and total arterial compliance (from 0.98 ± 0.13 to 1.43 ± 0.2 mL/mm Hg, P=0.02) were higher following conversion to NHD. Increases in BRS correlated with increases in the SV/PP ratio (r=0.845; P=0.002). These findings are consistent with the concept that NHD increases BRS via greater afferent baroreceptor responsiveness to pulsatile vascular pressure.

Cardiovascular disease is the leading cause of mortality in ESRD patients. A randomized controlled trial is currently underway through the National Institute of Health (NIH)-sponsored Frequent Hemodialysis Network. The cardiovascular effects of NHD will be compared with standard therapy. We speculate that given our current data, nocturnal hemodialysis will translate into lower cardiovascular event rates in ESRD patients.

References

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Chan CT, Jain V, Picton P, Pierratos A, Floras JS. Nocturnal hemodialysis increases arterial baroreflex sensitivity and compliance and normalizes blood pressure of hypertensive patients with end-stage renal disease. *Kidney Int* 2005;68:338-44.

Additional Reading:

Chan CT, Mardirossian S, Faratro R, Richardson RM. Improvement in lower-extremity peripheral arterial disease by nocturnal hemodialysis. *Am J Kidney Dis* 2003b;41:225-9.

Commentary by Todd S. Ing, MD

Dr. Chan and his colleagues convincingly demonstrated the beneficial effects of long and frequent nocturnal hemodialysis treatments on the cardiovascular system. These desirable effects are missing from the conventional, thrice weekly (4 hours per session) hemodialysis regimen.