HYPERDYNAMIC LEFT VENTRICULAR FUNCTION IN CHRONIC HAEMODIALYSIS PATIENTS: POSSIBLE MECHANISMS

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Introduction

Cardiovascular diseases prevail as the primary cause of death in patients on chronic haemodialysis (HD) [1]. Heart failure ranks high among the aetiologies of this enhanced cardiac mortality [1].

The cardiac output in HD patients was reported to be low, normal or high. Normal cardiac output does not rule out impaired myocardial function and was found in HD patients with left ventricular (LV) dysfunction [2]. Recently, two groups examined left ventricular ejection fraction (LVEF), measured by radionuclide ventriculography, before and after HD [3, 4], and arrived at discordant results.

We hereby report the occurrence of hyperdynamic left ventricular function, assessed by radionuclide ventriculography, both before and after HD, and the evaluation of possible mechanisms involved in this phenomenon.

Material and methods

Ten randomly selected patients on chronic HD for one to twelve years (mean 3.1 ± 3.4 SD) were examined. Six were men and four women and their ages ranged from 33 to 74 years (mean 46 ± 7) and none were in overt clinical heart failure. For each patient the following parameters were measured immediately before and after dialysis: body weight, heart rate, blood pressure, serum calcium (Ca++) and phosphorus (Pi), pH, T3 and T4 (by standard methods), and the plasma norepinephrine, dopamine, renin and aldosterone (radioimmunoassay). The LVEF and relative end systolic and end diastolic LV volume were measured by radionuclide ventriculography. The LVEF measurements were repeated in six of the patients during consequent dialysis.

Mean and standard deviation were calculated. Regression lines and correlation coefficients between the different parameters were computed. Student’s t-test was used to assess significance with p < 0.05 considered as significant.
Results

The mean LVEF before dialysis was 75.4 per cent ± 3.6 (SD) and increased significantly (p < 0.05) immediately after dialysis to 79.1 per cent ± 2.7 (p < 0.05) after HD. The behaviour of the LVEF in each patient before and after HD is given in Figure 1.

![Graph showing LVEF before and after haemodialysis](image)

Figure 1. The LVEF of the 10 patients before and after haemodialysis (HD)

It is remarkable that all the patients exhibited LVEF above 70 per cent either before or after HD and three had LVEF over 90 per cent after HD.

The mean relative reduction of the LV end systolic volume was 36.4 per cent ± 3.3; p < 0.05. The values of the other parameters are given in Table I.

Significant positive correlation was found only between the change of the serum Ca++ and the LVEF (R = 0.45; p < 0.05).

Discussion

In the present study, in contrast to the previous non-invasive studies [3, 4] which showed LVEF values between 51 per cent and 76 per cent before HD (mean of 51 ± 8 in one [3] and 63 per cent ± 6 in the second [4]), we found LVEF values between 59 and 94 with a mean of 75.4 per cent ± 3.6 (and 76.8 per cent ± 4 in a repeat examination in six of the patients). Increased LVEF after HD, as noted in our patients, was found also by Scharf et al [3]
TABLE I. Values of the parameters measured in our patients before and after HD (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Before HD</th>
<th>After HD</th>
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<tbody>
<tr>
<td>HR</td>
<td>71.0 ± 8.1</td>
<td>78.6 ± 8.6</td>
</tr>
<tr>
<td>BP</td>
<td>148 ± 16.2/92.1 ±</td>
<td>124.4 ± 26.5/84 ± 13.4</td>
</tr>
<tr>
<td>WT</td>
<td>62.8 ± 6.1</td>
<td>61.7 ± 6.0</td>
</tr>
<tr>
<td>pH</td>
<td>7.41 ± 0.07</td>
<td>7.46 ± 0.03</td>
</tr>
<tr>
<td>Ca++</td>
<td>8.2 ± 1.1</td>
<td>9.42 ± 1.04</td>
</tr>
<tr>
<td>T4</td>
<td>6.77 ± 1.25</td>
<td>8.2 ± 1.5</td>
</tr>
<tr>
<td>Aldos</td>
<td>16.8 ± 27.1</td>
<td>23.4 ± 30.6</td>
</tr>
<tr>
<td>PRA</td>
<td>2.0 ± 2.4</td>
<td>1.9 ± 2.4</td>
</tr>
<tr>
<td>N-Epi</td>
<td>446.4 ± 297</td>
<td>410 ± 238</td>
</tr>
<tr>
<td>DOP</td>
<td>173.6 ± 182</td>
<td>170.6 ± 151</td>
</tr>
</tbody>
</table>

HR = Heart rate/min  
BP = Blood pressure mmHg  
WT = Weight, kg  
Ca++ = Calcium, mg/dl  
T4 = Thyroxine mcg/ml  
Aldos = Aldosterone, ng/ml  
PRA = Plasma renin activity, ng/ml/h  
N-Epi = Norepinephrine  
DOP = Dopamine

in patients without heart failure. However, Hung et al [4] reported that the LVEF was not significantly changed after HD in similar patients.

Our finding of a greater decrease in end systolic versus end diastolic volumes following HD implies that the increased contractility after HD is mediated by inotropic agents. Therefore, we measured the level of several inotropic agents such as catecholamines, Ca++, pH, thyroxine, renin and aldosterone. Only Ca++, which has a known inotropic effect [5] increased significantly and was correlated with the increase in the LVEF (Table I). However, it was in the low normal range before HD and could not be responsible for the basal high LVEF. Heart rate was not elevated before or after HD thus the Bowditch effect cannot be implicated in the hyperdynamic LV function.

The decrease in blood pressure after HD did not correlate with the change in LVEF so that reduced afterload does not seem a probable mechanism for the rise of LVEF following HD.

Therefore, we must conclude that neither the inotropic biochemical parameters measured by us, nor the heart rate and the changes in the blood pressure can explain the enhanced myocardial contractility in our patients. There could be, of course, other parameters not examined in the present study, which could
contribute to this phenomenon.

A plausible explanation for both the pre and post HD high LVEF values could involve a compensatory mechanism causing increased cardiac output [6]. The oxygen delivery capacity in end-stage renal failure is decreased due to severe anaemia and existence of an A-V fistula [7, 8]. Previous studies showed normal oxygen consumption in HD patients at rest and even during exercise [9]. In order to maintain this normal oxygen consumption in the presence of depressed O₂ carrying capacity, the cardiac output should increase.

One of the mechanisms for the achievement of a high cardiac output is increased LVEF, which may result from hypervolaemia causing an elevated preload. This mechanism may also explain the propensity for heart failure in these patients whose hearts work on the top of their ability with overloaded circulations. If we postulate that due to hypervolaemia, the LV works at the top of the descending limb of the Starling curve, then volume extraction could decrease preload and increase LVEF as found in our patients.

In conclusion, hyperdynamic left ventricular function may be found in HD patients without clinical heart failure, both before and after HD. The mechanisms involved are not clear but hypervolaemia, and possibly inotropic agents may play a role.

References

5 Ebashi S, Endo M. Prog Biophys Mol Biol 1969; 18: 123
8 Hurwich BJ. Nephron 1969; 6: 673

Open Discussion

DRÜEKE (Paris) The method used to estimate ejection fraction was, I suppose, the same as that used by Hung and collaborators in their publication in the New England Journal of Medicine one year ago. These Australian workers found, if I remember correctly, in five or six patients, a significantly decreased ejection fraction before haemodialysis and in the others a normal but not a high ejection fraction. I expect you have analysed this paper and could you tell us whether there were some important differences in your treatment in comparison with these Australian authors?

ELDAR We saw the paper by Hung and our results do differ. We could not find any reason for that.
JAHN (Strasbourg) Have you measured the pulmonary wedge pressure in these patients? In our experience it appears that hyperdynamic left ventricular function can be related to increased filling pressure and one can never know if there is some degree of fluid overload. Only the measurement of pulmonary wedge pressure or pulmonary arterial pressure can give a definite answer.

ELDAR Yes, this was a non-invasive study so we did not measure the pulmonary wedge pressure. However, we now have the possibility of measuring the blood volume and ventricular volume — not relative but the proper volumes — and we find some of our patients have hypervolaemia as you mentioned.