Long-Term Changes in Pulmonary Haemodynamics after Continuous-Flow Left Ventricular Assist Device Implantation in Advanced Heart Failure Patients

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Background and Purpose

Pulmonary hypertension (PH) due to left heart disease (LHD) is a marker of poor prognosis in patients with advanced heart failure. Fixed PH with elevated pulmonary vascular resistance (PVR) is a major contraindication to heart transplantation. Continuous-flow left ventricular assist devices (cf-LVADs) can reduce pulmonary pressures in patients with advanced heart failure with reduced ejection fraction (HFrEF).The purpose of the study was to assess long-term effect of cf-LVAD on type II PH in HFrEF, and to evaluate the association of clinical and haemodynamic variables with PH persistence after LVAD implantation.

Population and methods

Retrospective analysis of pulmonary haemodynamics of 59 patients undergoing cf-LVAD implantation at our Institution. A right heart catheterization was performed before LVAD implant and 8, 20 and 30 months after the operation. Pulmonary pressures, gradients, PVR, and pulmonary arterial compliance (PAC) were measured or calculated and compared using one-way ANOVA in all patients. Univariate analysis were performed to assess the relation of clinical, haemodynamic and echocardiographic variables with PH persistence after LVAD implant.

Table 1. Population description

VARIABLES	Mean or No			
Age (years)	53.4			
M	55 (93%)			
F	4 (7%)			
BSA (m2)	1.9			
Diabetes	14 (23%)			
Smoke	12 (20%)			
Etiology	Ischaemic	Idiopatic	HCM	Post-CHT/RT
	26	30	1	2
Time of disease (years)	8.9			
Intermacs level at implantation	IM 1	IM 2	IM 3	IM 4
	1	12	10	19
Indication	BTT	BTC	DT	
	39	16	4	
Mechanical circulatory support	14 (23%)			
Frequent flyer	43 (72%)			

Results

Forty-eight patients (81%) had type II PH before LVAD implantation. Sixty-six percent of them (32/48) had PVR > 3 Wood Unit (WU), so combined post-capillary PH (CpC-PH).

After LVAD, mean pulmonary artery pressure changed from a mean value of 36 mmHg to 21 mmHg, PVR from 3.7 mmHg to 2.1 mmHg, pulmonary capillary wedge pressure (PCWP) from 26 mmHg to 13 mmHg, PAC from 1.5 to 2.7 ml/mmHg ($p<0.0001$ for all). These results were independent from pre-LVAD PH reversibility and PVR values.
The haemodynamic effect did not change up to three years of observation.

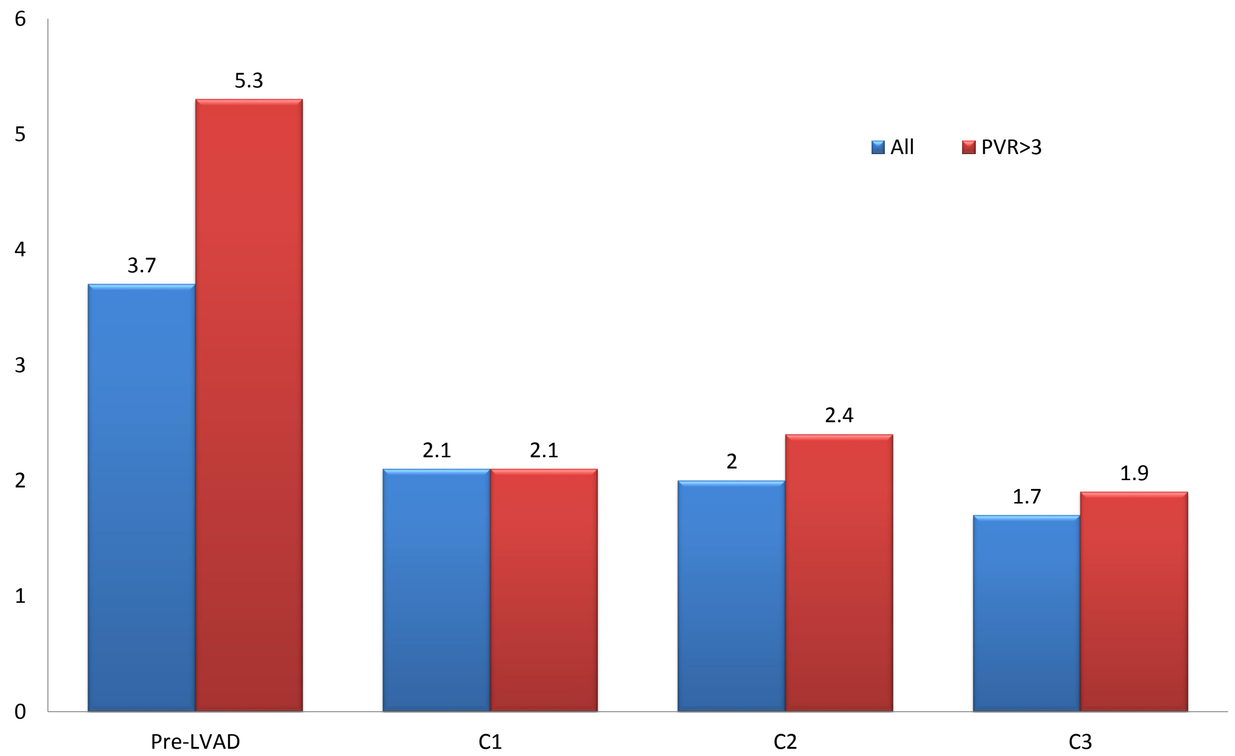
In ten patients (17%) we observed PH persistence after LVAD implant; all of them had elevated PCWP, without significant aortic insufficiency. Whenever pump speed optimization was possible, we subsequently observed PCWP and pulmonary pressures reduction.

Right ventricular dysfunction was the only variable associated with persisting PH after device implantation, while higher basal PVR or pre-implant PH irreversibility did not predict PH persistence after LVAD.

Table 2. Haemodynamics in CpC-PH patients (baseline and follow up)

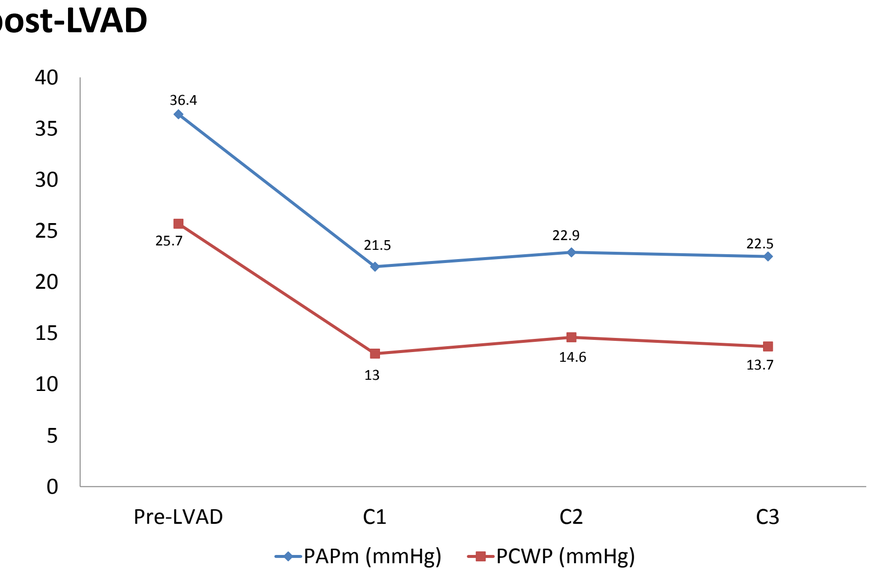
	Pre-LVAD (N 31)	Post-LVAD (C1, N 31)	Post-LVAD (C2, N 17)	Post-LVAD (C3, N 7)	P value
PVC (mmHg)	9 ± 4.7	7.9 ± 5.1	7.6 ± 3.4	5.1 ± 3.2	0.2
PAPs (mmHg)	68.2 ± 18.2	36.5 ± 10.6	39.7 ± 12.4	37.4 ± 11.7	0.0003
PAPd (mmHg)	27.8 ± 9.2	13.5 ± 6.4	14.8 ± 7	12.8 ± 4	0.003
PAPm (mmHg)	43 ± 11.9	22.7 ± 7.1	24 ± 8	22.5 ± 7	0.001
PCWP(mmHg)	28.9 ± 9.8	14.3 ± 6.6	15.5 ± 6.8	15 ± 4.9	0.001
CO (l/min)	2.9 ± 0.8	4.1 ± 0.8	3.6 ± 1	4 ± 0.7	0.0007
CI (l/min/m2)	1.5 ± 0.4	2.1 ± 0.5	1.9 ± 0.4	2.1 ± 0.3	0.001
TPG (mmHg)	14.3 ± 5.9	8.9 ± 4.4	8 ± 5	7.5 ± 2.2	0.05
DPG (mmHg)	-1 ± 5.4	-0.2 ± 4.9	-0.6 ± 3.2	-2.1 ± 3.5	0.5
PVR (WU)	5.3 ± 2.2	2.1 ± 1	2.4 ± 0.9	1.9 ± 0.5	0.02
PVC/PCWP	0.3 ± 0.1	0.6 ± 0.3	0.5 ± 0.2	0.4 ± 0.2	0.002
PAC (ml/mmHg)	1 ± 1	2.6 ± 1.2	2.3 ± 1.9	2.1 ± 1.1	0.001
Eart (mmHg/ml)	1.9 ± 0.7	0.7 ± 0.3	0.8 ± 0.4	0.8 ± 0.2	<0.0001

PVR pre and post-LVAD (baseline and follow up)



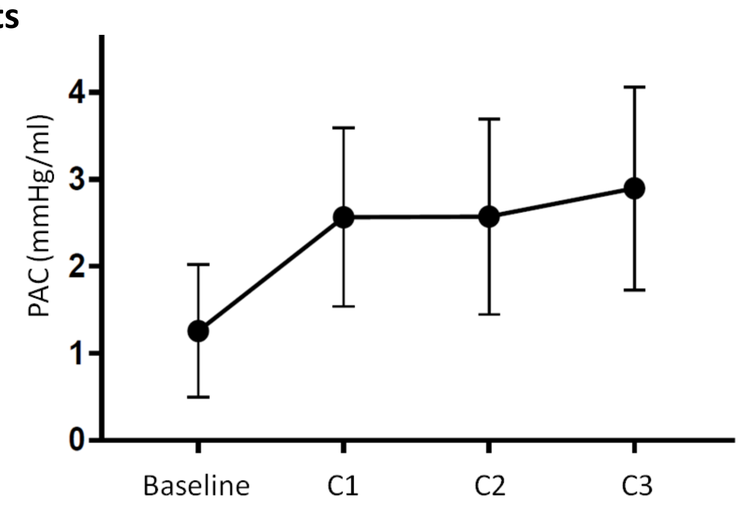
PAPm and PCWP post-LVAD

All patients



PAC pre and post-LVAD

All patients



Conclusions

Optimal left ventricular unloading by cf-LVAD induces long-lasting PH reversal in advanced HFrEF patients. Elevatet PVR alone may not be a sufficient indicator of pulmonary vascular disease in these patients. Right ventricular failure is a major limitation to immediate and long-term left ventricular and pulmonary unloading.

No off-label use of drugs or devices was made in the study
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