Comparison of haemodynamic effects of oral prazosin, oral hydralazine, and intravenous nitroprusside in same patients with chronic heart failure¹

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SUMMARY The haemodynamic effects of oral prazosin and hydralazine were evaluated in patients with refractory heart failure and compared with those of intravenous nitroprusside in the same patients. Both oral agents were well tolerated and appeared to have beneficial haemodynamic effects. Prazosin and hydralazine produced similar increases in cardiac output associated with a similar decrease in systemic vascular resistance. Prazosin resulted in a more significant decline in left ventricular filling pressure and pulmonary vascular resistance than did hydralazine. Haemodynamic alterations induced by prazosin were similar to those induced by nitroprusside, which suggests a relatively balanced reduction of preload and afterload. With hydralazine, the increase in cardiac output without change in left ventricular filling pressure or pulmonary vascular resistance suggests minimal effect on preload but significant reduction in afterload.

A decrease in left ventricular afterload in patients with heart failure improves left ventricular function by increasing stroke volume and decreasing left ventricular filling pressure (Franciosa *et al.*, 1972; Chatterjee *et al.*, 1973a; Guiha *et al.*, 1974). This has been shown in heart failure associated with a variety of pathological states, such as coronary heart disease (Franciosa *et al.*, 1972; Chatterjee *et al.*, 1973a), mitral and aortic regurgitation (Chatterjee *et al.*, 1973b; Bolen and Alderman, 1976), and hypertensive heart disease (Majid *et al.*, 1971). Reduction of preload lowers left ventricular filling pressure but does not consistently result in increased stroke volume (Franciosa *et al.*, 1974; Mantle *et al.*, 1976).

Intravenously administered nitroprusside produces a rapid increase in cardiac output and fall in left ventricular filling pressure in certain patients with heart failure as a result of afterload and preload reduction. Because nitroprusside must be given parenterally, its usefulness is limited to patients in hospital. Thus, it would be clinically useful if oral agents with a similar mode of action were available to increase stroke volume and decrease pulmonary

congestion in patients with heart failure. In ambulant patients with heart failure, both hydralazine (Chatterjee *et al.*, 1976b; Franciosa *et al.*, 1977; Mehta *et al.*, 1978b) and prazosin (Awan *et al.*, 1977; Mehta *et al.*, 1978a) have shown promise in preliminary studies. However, in individual patients with heart failure, the haemodynamic response to vasodilators can vary (Chatterjee and Parmley, 1977). We therefore compared the haemodynamic and clinical effects of various vasodilator agents in the same patients. This study was designed so that the effects of two oral vasodilator agents, hydralazine and prazosin, could be evaluated, and the effects of these compared with those induced by intravenous nitroprusside in the same patients.

Patients and methods

The subjects were 11 male patients, aged 37 to 65 years, with symptoms and signs of clinical heart failure (New York Heart Association class III or IV) despite treatment with digitalis, diuretics, and salt restriction. The duration of heart failure ranged from 3 to 7 years before study. In all, heart failure was the result of coronary heart disease, documented by history, electrocardiogram, and previous coronary angiography. None complained of angina pectoris at the time of study. Each of these patients

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had areas of abnormal left ventricular wall motion observed during left ventriculography, and all had an enlarged heart. A left ventricular diastolic gallop was heard in seven patients. Basal râles were present in seven. All patients were in sinus rhythm, though three had occasional atrial or ventricular ectopic beats. These clinical observations were made before haemodynamic study.

HAEMODYNAMIC STUDIES

The procedure and drugs to be used were explained to the patients, and their informed consent was given. Investigations were performed in a special study room of the cardiac care unit, so that haemodynamic variables could be monitored and recorded for the duration of study. Digitalis was continued, but diuretic agents (hydrochlorothiazide 50 mg daily in six patients and frusemide 40 mg daily in the other five) and nitrates were withheld for two days before study. These agents were discontinued so that haemodynamic variables were affected primarily by the study drugs rather than the acute effects of diuretics and nitrates. The patients were kept at bed-rest for at least eight hours before and throughout the study period. A triple lumen flow-directed catheter was advanced to the pulmonary artery, and a 'teflon' catheter was introduced percutaneously into the radial artery to measure systemic blood pressure. Systemic and pulmonary arterial pressures and pulmonary artery wedge pressure were recorded on a VR-6 recorder (Electronics for Medicine, White Plains, NY) with Statham P231a strain gauge transducers. Systolic and diastolic pressures were averaged from at least 10 beats measured over two respiratory cycles. Mean pressures were obtained by electronic filtration. The occluded pulmonary artery pressure recorded during balloon inflation was taken as pulmonary artery wedge pressure and agreed closely with pulmonary artery diastolic pressure in each patient; either of these measurements was used as an index of left ventricular filling pressure. All pressure measurements were recorded with reference to midchest zero with the patient supine. Heart rate was averaged from recordings of a standard electrocardiographic lead. Cardiac output was measured in triplicate by thermodilution (Ganz and Swan, 1972) and reported as the average of these three determinations.

The following calculations were made:

$$CI \text{ (l/min per m}^2\text{)} = CO/BSA$$

$$SV \text{ (ml/beat)} = CO/HR$$

$$SVI \text{ (ml/beat per m}^2\text{)} = SV/BSA$$

$$LVSWI \text{ (g m/m}^2\text{)} = SVI \times (\overline{Ao} - LVFP) \times 0.0136$$

$$SVR \text{ (dynes s cm}^{-5}\text{)} = \overline{Ao} \times 80/CO$$

$$PVR \text{ (dynes s cm}^{-5}\text{)} = (\overline{PA} - LVFP) \times 80/CO$$

Index of myocardial oxygen demand = $SAP \times HR$. (Abbreviations: CI, cardiac index; CO, cardiac output; BSA, body surface area; SV, stroke volume; HR, heart rate; LVSWI, left ventricular stroke work index; SVI, stroke volume index; $\overline{Ao}$, arterial mean pressure; LVFP, left ventricular filling pressure; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance; $\overline{PA}$, pulmonary arterial mean pressure; and SAP, arterial systolic pressure).

Patients were evaluated clinically during the control period and hourly during drug administration.

STUDY PROCEDURE

General design

Before each of the three drug study periods, control haemodynamic recordings were obtained during a haemodynamically stable interval when pressures, cardiac output, and heart rate were unchanged ($\pm 10\%$) from initial baseline values over 30 minutes with repeated measurements. Haemodynamic recordings were then repeated during drug administration. These recordings included heart rate, systemic and pulmonary artery pressures, and cardiac output.

Nitroprusside administration

Nitroprusside was given by an infusion pump into a peripheral vein starting at $10 \mu\text{g/min}$. The infusion rate was increased by $10 \mu\text{g/min}$ increments every 10 minutes until either left ventricular filling pressure fell to 15 mmHg or less, cardiac output increased by 50 per cent or more, or systolic arterial pressure fell by 20 mmHg or more from the control value or to 100 mmHg. Haemodynamic measurements, outlined above, were made at each increment in dose. Nitroprusside infusion was then discontinued.

Prazosin administration

After re-establishment of a stable control interval, as noted above, 4 mg prazosin was administered orally. Haemodynamic measurements were made every hour for eight hours.

Hydralazine administration

After haemodynamically stable values were re-established, similar to those before nitroprusside or prazosin (Table 1), 100 mg hydralazine was administered orally. Haemodynamic measurements were made hourly for eight hours.

The order of the administration of the three vasodilators is shown in Table 1. Prazosin and nitroprusside were given in random order, but hydralazine was given to only seven patients who agreed to participate in the final phase of the study.

Table 1 Order of drug administration

Case no.	Drug study period		
	I	II	III
1	NP	P	H
2	NP	P	H
3	NP	P	—
4	NP	P	—
5	NP	P	—
6	P	NP	H
7	P	NP	H
8	P	NP	H
9	P	NP	H
10	P	NP	H
11	P	NP	—

Abbreviations: NP, intravenous nitroprusside; P, oral prazosin (4 mg); H, oral hydralazine (100 mg).

Data analysis

Mean values and standard error of the mean were calculated during each control and treatment period. Mean values in the control state and at the peak effect of each drug were compared. To test for the interaction, the repeated measures analysis of variance model was used. For the purpose of comparison of three drugs, in the seven patients who received all three drugs, Duncan's multiple com-

parison test was employed (Winer, 1971). A P value less than 0.05 was considered statistically significant.

Results

CONTROL STATE

All haemodynamic variables were comparable in the control state before administration of the three drugs.

PEAK EFFECT

Maximal change in haemodynamic variables observed with nitroprusside, prazosin, and hydralazine are presented in Table 2.

The effects of nitroprusside were apparent soon after infusion was started and abated when the infusion was discontinued. The change in haemodynamic variables occurred half to one hour after prazosin administration and lasted for six hours. In all patients given hydralazine, the alteration in haemodynamics induced by nitroprusside or prazosin had abated and haemodynamics returned to control levels (Table 2). The interval between prazosin and hydralazine administration varied from 10 to 18 hours (mean 12 hours). The effects of

Table 2 Haemodynamic effects of nitroprusside, prazosin, and hydralazine in heart failure patients

Case no.		HR (beats/min)			MAP (mmHg)			MPA (mmHg)			LVFP (mmHg)			CI (l/min per m ²)		
		N	PR	H	N	PR	H	N	PR	H	N	PR	H	N	PR	H
1	C	88	79	76	95	105	79	39	39	35	32	27	27	1.14	1.15	1.38
	P	72	70	86	98	88	91	26	28	31	18	16	23	1.89	1.88	1.38
2	C	80	80	80	85	85	85	29	29	29	21	21	21	1.98	1.99	1.93
	P	80	88	80	78	83	88	22	26	28	16	17	20	2.38	2.39	3.13
3	C	74	79	89	120	138	115	38	39	38	24	28	24	2.10	2.14	2.59
	P	85	96	91	97	102	90	18	17	26	12	14	22	2.71	2.69	3.90
4	C	96	98	90	88	84	82	32	35	29	25	25	24	2.02	2.02	2.19
	P	82	90	84	71	80	72	14	26	29	11	16	19	2.42	2.25	2.94
5	C	108	105	105	73	74	76	35	37	35	30	24	30	1.69	1.92	1.70
	P	106	99	96	70	69	78	29	32	35	25	23	30	2.66	2.31	2.53
6	C	78	80	72	85	79	80	39	42	36	27	32	29	1.89	1.86	1.28
	P	68	68	75	70	68	77	20	34	37	12	22	28	2.69	1.89	1.77
7	C	89	77	88	78	87	78	33	39	34	26	30	26	2.14	1.68	2.10
	P	80	82	84	70	78	80	20	32	30	10	19	21	2.92	2.70	3.48
8	C	58	58	—	72	80	—	46	39	—	29	24	—	2.99	2.35	—
	P	56	56	—	62	66	—	23	26	—	14	17	—	3.16	2.67	—
9	C	87	83	—	103	99	—	53	51	—	38	34	—	2.92	2.58	—
	P	97	77	—	77	73	—	30	38	—	19	21	—	3.71	3.54	—
10	C	100	92	—	105	122	—	45	54	—	40	39	—	1.49	1.54	—
	P	84	80	—	93	96	—	37	28	—	28	19	—	3.03	1.84	—
11	C	70	70	—	100	100	—	47	48	—	23	25	—	1.97	2.14	—
	P	70	70	—	87	94	—	30	38	—	14	20	—	2.89	2.39	—
Mean (7 patients, 1-7)																
±SEM C		88	85	85	89	93	88	36	37	34	26	27	26	1.85	1.82	1.88
		4	4	3	6	8	5	1	2	1	1	1	1	0.13	0.12	0.18
	P	82	85	85	79**	81*	82	21*	28*	31	15*	18*	23**	2.52*	2.30*	2.73*
		5	5	3	5	4	3	2	2	1	2	1	2	0.13	0.13	0.34
Mean (all 11 patients)																
±SEM C		84	82	—	91	96	—	40	41	—	29	28	—	2.03	2.00	—
		4	4	—	4	6	—	2	2	—	2	2	—	0.16	0.15	—
		80	80	—	79*	82*	—	24*	30*	—	16*	19*	—	2.77*	2.41*	—
		4	4	—	4	4	—	2	2	—	2	1	—	0.14	0.15	—

Abbreviations: N, IV nitroprusside; PR, prazosin; H, hydralazine; HR, heart rate; MAP, systemic arterial mean pressure; MPA, pulmonary artery mean pressure; LVFP, left ventricular filling pressure; CI, cardiac index; LVSWI, left ventricular stroke work index; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance; C, control; P, peak effect; *P < 0.01 (peak vs control); **P < 0.02 (peak vs control).

hydralazine were observed at three hours and persisted for eight hours.

Nitroprusside and oral prazosin produced significant increases in cardiac index and left ventricular stroke work. Both agents decreased mean arterial, pulmonary arterial, and left ventricular filling pressures, and systemic and pulmonary vascular resistances. Heart rate was unchanged. Oral hydralazine administration significantly increased cardiac index and left ventricular stroke work, and decreased systemic vascular resistance and left ventricular filling pressure. Hydralazine did not affect heart rate, systemic and pulmonary arterial pressures, pulmonary vascular resistance, or systolic arterial pressure-heart rate product.

NITROPRUSSIDE VS PRAZOSIN

Comparison of the effects of these two vasodilator agents in all patients showed that they induced a similar increase in cardiac index (0.74 ± 0.11 vs 0.47 ± 0.09 l/min per m^2 , NS) and a fall in left ventricular filling pressure (11 ± 2 vs 10 ± 2 mmHg, NS). The fall in resistance in the systemic (791 ± 150 vs 640 ± 165 dynes $s\ cm^{-5}$) and pulmonary vascular (98 ± 29 vs 96 ± 24 dynes $s\ cm^{-5}$) beds was comparable (NS), as was the decrease in heart rate (3 ± 3 vs 2 ± 3 beats/min), arterial mean (12 ± 3 vs

14 ± 3 mmHg), and pulmonary artery mean pressures (15 ± 2 vs 11 ± 2 mmHg, NS). The increase in left ventricular stroke work (8.61 ± 2.10 vs 4.09 ± 1.96 g m per m^2) was however more with nitroprusside than with prazosin ($P < 0.007$). Decrease in arterial systolic pressure-heart rate product (1450 ± 250 vs 1254 ± 309 , NS) were also similar with both agents. Both drugs similarly affected the relation between left ventricular filling pressure and stroke work (Fig.).

NITROPRUSSIDE VS HYDRALAZINE

Cardiac index increased similarly (1.20 ± 0.47 vs 0.85 ± 0.19 l/min per m^2 , NS) with nitroprusside and hydralazine in the same seven patients. However, left ventricular filling pressure declined more with nitroprusside (12 ± 2 vs 3 ± 1 mmHg, $P < 0.0005$). The fall in systemic vascular resistance was similar with nitroprusside and hydralazine (673 ± 120 vs 533 ± 122 dynes $s\ cm^{-5}$, NS). Pulmonary vascular resistance fell more (88 ± 24 vs 58 ± 31 dynes $s\ cm^{-5}$, $P < 0.01$) with nitroprusside. Though changes in heart rate and mean arterial pressure were not different, pulmonary artery mean pressure fell more with nitroprusside than with hydralazine (14 ± 2 vs 3 ± 2 mmHg, $P < 0.001$). Left ventricular stroke work increased to a similar degree (8.28 ± 2.30 vs 5.67 ± 2.01 g m per m^2 , NS).

PRAZOSIN VS HYDRALAZINE

Comparison of the haemodynamic effects of the two oral agents in the same patients showed that cardiac

LVSWI (g m per m^2)			SVR (dynes $s\ cm^{-5}$)			PVR (dynes $s\ cm^{-5}$)		
N	PR	H	N	PR	H	N	PR	H
11-10	15-44	17-29	3160	3462	2665	233	396	220
28-56	26-29	14-84	1966	1774	2500	160	242	220
21-54	21-65	20-99	1908	1898	1957	180	179	184
25-08	24-38	36-18	1456	1543	1249	112	167	113
37-05	40-52	36-01	2078	2344	1615	242	187	197
36-86	33-54	39-63	1301	1379	839	81	41	37
18-03	16-54	19-19	1958	1868	1682	156	222	103
24-08	21-76	25-23	1319	1598	1101	56	200	153
9-15	12-43	10-12	1899	1694	1965	130	297	129
15-36	14-60	17-20	1644	1869	1927	94	244	124
19-11	14-86	12-33	2194	2072	3049	310	262	419
31-20	17-39	15-73	1269	1755	2122	145	310	248
17-00	16-91	16-88	1389	1973	1414	125	204	145
29-78	26-42	33-24	913	1101	876	130	183	99
30-14	30-86	—	1030	1456	—	243	273	—
36-83	31-77	—	839	1058	—	122	144	—
29-67	27-48	—	1585	1726	—	231	296	—
30-17	32-51	—	932	927	—	133	216	—
13-17	18-90	—	2805	3153	—	134	388	—
31-89	24-09	—	1221	2076	—	118	195	—
29-47	31-18	—	2030	1869	—	487	430	—
40-99	34-36	—	1204	1573	—	221	301	—
19-00	19-77	18-98	2084	2187	2050	196	250	200
3-44	3-62	3-18	203	226	225	26	29	40
27-28*	23-48*	26-01*	1410*	1574*	1516*	111*	198*	142
2-55	2-38	3-93	125	100	250	14	32	27
21-40	22-43	—	2003	3138	—	225	285	—
2-72	2-67	—	179	188	—	32	26	—
30-07*	26-10*	—	1279*	1514*	—	125*	204*	—
2-12	1-97	—	100	110	—	13	23	—

Fig. Effect of intravenous nitroprusside, oral prazosin, and hydralazine on the relation between left ventricular filling pressure (LVFP) and left ventricular stroke work index (LVSWI) in patients with heart failure. Intravenous nitroprusside and prazosin have similar action on the LVFP LVSWI relation, whereas hydralazine increases LVSWI without affecting LVFP.

index increased similarly (0.48 ± 0.09 vs 0.85 ± 0.19 l/min per m^2 , NS) with prazosin and with hydralazine. However, left ventricular filling pressure fell more with prazosin than with hydralazine (8 ± 2 vs 3 ± 1 mmHg, $P < 0.005$). The fall in systemic vascular resistance (744 ± 194 vs 533 ± 122 dynes $s\ cm^{-5}$, NS) and pulmonary vascular resistance (46 ± 25 vs 58 ± 31 dynes $s\ cm^{-5}$, NS) was similar with the two drugs. Changes in heart rate and arterial mean pressure were not significantly different (NS). However, pulmonary arterial mean pressure fell more with prazosin (7 ± 1 vs 3 ± 2 mmHg, $P < 0.01$). The increase in left ventricular stroke work was also similar (4.05 ± 2.28 vs 5.67 ± 2.01 g m per m^2 , NS), but arterial systolic pressure-heart rate product decreased more with prazosin ($P < 0.05$). The effects of the oral vasodilators on the relation between filling pressure and stroke work also differed (Fig.).

CLINICAL EFFECTS

All patients tolerated treatment with nitroprusside and oral vasodilators without any major side effects during the study. With prazosin two patients had nausea initially which gradually disappeared. Two other patients developed mild headache while receiving hydralazine and required aspirin for relief. No episodes of hypotension, tachycardia, or myocardial ischaemia (angina or ST segments changes) were observed in any patient. In five patients, diastolic gallop disappeared and basal râles decreased with both prazosin and hydralazine.

Discussion

Our study was designed to compare the acute haemodynamic effects of one parenteral and two oral vasodilator agents in the same patients with heart failure. Baseline clinical evaluation and haemodynamic recordings were made after the systemic and pulmonary arterial pressures and cardiac output had become stable with bed rest. Prazosin and nitroprusside were given in random sequence; hydralazine was given last to all seven patients. Though a sufficient time interval was provided between the different agents to allow the pressures and cardiac output to return to baseline level, it is possible that the residual effect of one agent may possibly have affected the actions of another. The fixed doses of prazosin (4 mg) and hydralazine (100 mg) were selected after preliminary studies in other patients with variable dose regimens.

Our results support previous observations (Franciosa *et al.*, 1972; Chatterjee *et al.*, 1973a; Guiha *et al.*, 1974) that intravenous nitroprusside produces haemodynamic improvement in patients with

chronic heart failure: stroke work increases at a lower left ventricular filling pressure. In the same patients, orally administered prazosin (4 mg) resulted in a similar improvement in the relation between left ventricular filling pressure and stroke work, in association with a fall in systemic and pulmonary vascular resistance. Oral hydralazine (100 mg) also increased stroke work with a decrease in systemic vascular resistance. Compared with prazosin and nitroprusside, the fall in left ventricular filling pressure with hydralazine was minimal.

Even in the same patient, the mechanism of action of the three vasodilators appeared to be different. Nitroprusside, by direct action, dilates both arterial and venous beds equally, resulting in a decrease in afterload as well as preload (Miller *et al.*, 1976). Prazosin also has been shown to have a balanced dilator action on arterial and venous beds (Miller *et al.*, 1977). The actions of prazosin are mediated by vascular alpha-receptor blockade (Graham and Pettinger, 1979). Because of their similar vasodilator effects, intravenous nitroprusside and oral prazosin have similar afterload- and preload-reducing effects in patients with congestive heart failure (Mehta *et al.*, 1978a). Hydralazine, on the other hand, is a potent dilator of the arterial bed with only minimal effects on the venous bed (Franciosa *et al.*, 1977). In addition, hydralazine has a positive inotropic action (Khatri *et al.*, 1977). Because of the lack of a significant venodilator action, hydralazine administration does not decrease left ventricular filling pressure in patients with congestive heart failure, though systemic vascular resistance falls greatly (Chatterjee *et al.*, 1976b; Franciosa *et al.*, 1977; Mehta *et al.*, 1978b). Our study shows that the decrease in afterload induced by the two oral vasodilators (prazosin and hydralazine) in the same patients is similar.

The exact mechanism of the increase in cardiac output after vasodilator therapy in patients with heart failure is not known. It has been suggested (Sonnenblick and Downing, 1963; Cohn, 1973) that cardiac output increases as a result of increased myocardial fibre shortening in the failing ventricle consequent upon vasodilator-induced reduction in systemic vascular resistance. Indeed, in this study, the high systemic vascular resistance associated with chronic heart failure fell with all three vasodilator agents. We have shown that in the failing heart, the pulsatile flow component (characteristic impedance) of the vascular load is increased (Pepine *et al.*, 1978), in addition to the mean or steady flow component (systemic vascular resistance). These findings suggest that the compliance of the aorta is reduced in patients with heart failure. Preliminary studies in our laboratory show that in patients with

heart failure nitroprusside decreases the pulsatile as well as the mean flow component of the vascular load (Pepine *et al.*, 1975). These observations suggest that the beneficial action of nitroprusside may be related to altered aortic compliance (Pepine *et al.*, 1975). The oral vasodilators compared in this study may also alter the distensibility of the aorta and thereby effect improved ventricular function by reducing the pulsatile component of vascular load. Inotropic actions of hydralazine (Khatri *et al.*, 1977) may also be partly responsible for increased cardiac output. Whatever the precise mechanism of action in patients with heart failure both oral agents compared in this study improved left ventricular function. Furthermore, this haemodynamic improvement was observed at doses that were well tolerated in these patients.

Comparison of the haemodynamic effects of a single dose of oral prazosin (4 mg) and of hydralazine (100 mg) with nitroprusside in the same patients with heart failure showed that the effects of prazosin were similar to those of nitroprusside. In a given patient, prazosin, like nitroprusside, effectively decreased left ventricular filling and pulmonary arterial pressures and increased cardiac output. Left ventricular stroke work increased less with oral prazosin than with intravenous nitroprusside. This may be because of the greater effectiveness of nitroprusside or the dose of prazosin used (Mehta *et al.*, 1978b). In contrast, oral hydralazine only increased cardiac output in the same patients. Though the increase in cardiac output was similar to that induced by prazosin, hydralazine caused no significant fall in left ventricular filling pressure. The absence of a significant fall in left ventricular filling and pulmonary arterial pressures with hydralazine may result from its lack of vasodilator effect on capacitance vessels (Chatterjee *et al.*, 1976b; Franciosa *et al.*, 1977; Mehta *et al.*, 1978b). We (Mehta *et al.*, 1978b) and others (Chatterjee *et al.*, 1976a; Pierpont *et al.*, 1978) have shown that a venodilator agent added to hydralazine lowers left ventricular filling pressure without altering cardiac output. Thus, hydralazine combined with a venodilator agent mimics the effects of intravenous nitroprusside; however, oral prazosin alone, like nitroprusside, improves left ventricular function.

Effective orally administered vasodilators are actively being sought for the management of ambulant patients with heart failure. This study shows that patients with the symptoms and signs of high left ventricular filling pressure and low cardiac output may benefit from the use of prazosin. On the other hand, hydralazine may be effective in those patients with low cardiac output but normal

or only slightly increased left ventricular filling pressure.

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