Diagnostic value of the Pressure Relief Index in chronic venous insufficiency patients

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key words: venous insufficiency, diagnosis, pressure relief index

SUMMARY

We evaluated pressure relief index (PRI) values in patients with chronic venous insufficiency. The study group comprised 15 healthy subjects and 71 patients. We determined the venous pressure in the orthostatic position, during exersion and following exercise. We repeated the procedure after the placement of a pressure cuff, located above the ankles. We estimated the pressure at rest (p-s), the lowest pressure during exersion (p-min.), the time needed to obtain normal pressure values (RT), 90% of RT and the Pressure Relief Index (PRI). The following groups were formed: group I — 19 healthy limbs, group II — 17 limbs with superficial varices, group III — 4 limbs with superficial varices and varicose ulcers, group IV — 22 limbs with the postphlebitis syndrome, without varicose ulcers, group V — 43 limbs with the postphlebitis syndrome and ulcerations. Curves demonstrated the groups distribution of venous pressures. PRI values of healthy subjects amounted to an average of 1826 and were statistically higher, in comparison with the other groups ($p<0.001$). PRI values were as follows: group II — 915, group III — 377.5, group IV — 530.6, group V — 176.6. $p<0.05$ was considered as stastically significant. During the cuff test PRI values in group II increased to 1399.5, contrary to group III and IV values. A similar difference was observed between group V (PRI — 286.7) and group IV. PRI values below 300 consisted with a70% risk of varicose ulcerations.

Med Sci Monit, 1999; 5(4): 697-702

INTRODUCTION

Chronic venous insufficiency is caused by the insufficiency of venous valves, both superficial and deep. The diagnosis of CVI is based on the clinical examination, which unfortunately does not give the actual degree of venous insufficiency. Diagnostics by means of Doppler and venography remain possible in only certain centers.

Thus, the evaluation of lower limb venous pressures seems to be the method of choice. It enables the assessment of venous outflow at rest and during exersion (ambulatory venous pressure) [1,2, 3,4].

The aim of this study was to evaluate its diagnostic value in chronic venous insufficiency.

MATERIAL AND METHODS

The study group comprised 15 healthy subjects and 71 patients with chronic venous insufficiency. There were 56 women aged between 17 and 69 years (mean age — 48 years) and 18 men aged between 31 and 74 years (mean age — 49 years). We examined 19 healthy limbs and 86 patient limbs.

We performed lower limb Doppler of the superficial and deep system arteries and veins, as well as of the communicating veins by means of the UDP-83 Doppler ultrasound, with a frequency of 5 MHz. Patients with the arm/ankle index<1 were excluded from the study.

We measured the venous pressure by means of the Testar 2000 apparatus. Following the insertion of a

Received: 98.04.18
Accepted: 99.04.23

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Figure 1. Venous pressure curves for healthy subjects. Examination without compresing cuff (upper curve) and with compressing cuff (lower curve).

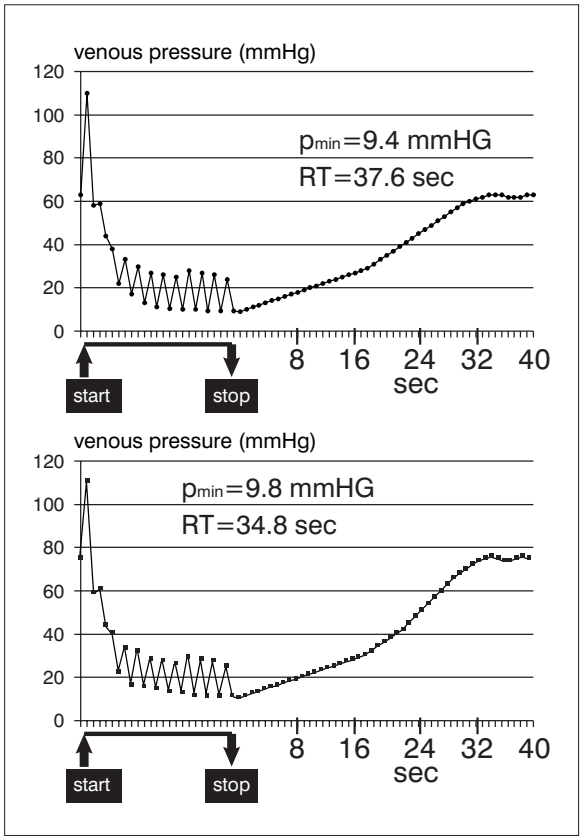
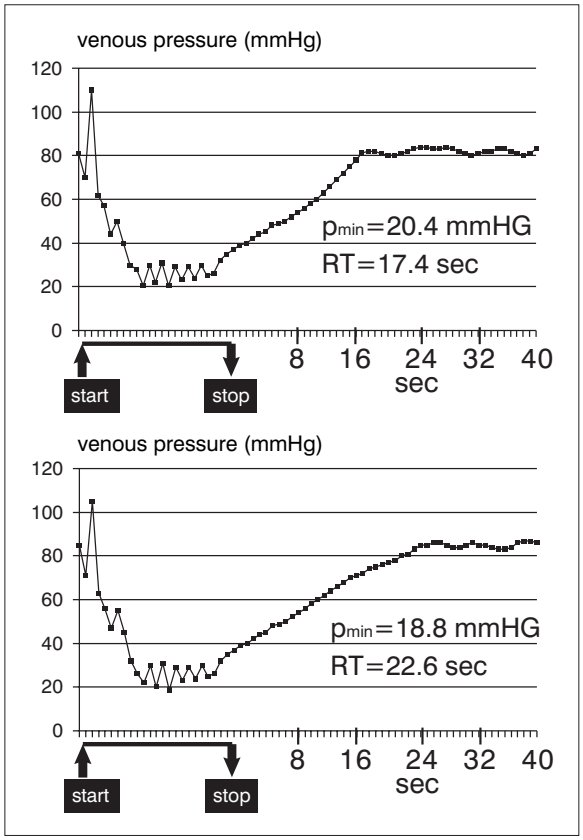


Figure 2. Venous pressure curves for patients with varices of superficial venous system. Examination without cuff (upper curve) and with cuff (lower curve).



0.5 mm in diameter needle into the dorsum of one of the foots veins, we linked it with Testar 2000 by means of a thin plastic drain filled with saline (1 mm in diameter). Following the stabilization of the venous pressure in the orthostatic position, each patient performed 10 sit-ups every 1.5 seconds. We measured the venous pressure until it returned to pre-exersion values. The parameters evaluated include: pressure at rest (p-s), lowest pressure during exersion (p-min.), the time needed to return to normal values (RT), and 90 % of RT. This enabled to determine the PRI — 90 % of the RT product as well as the difference between the initial pressure and the minimal venous pressure during exersion.

$$PRI = (p/s - p/min.)\ 90\%\ RT$$

We repeated this procedure after the placement of a pressure cuff (100 mmHg) above the ankles. Patients were divided into the following five groups:

Group I comprised 19 healthy limbs, patients were aged between 21 and 49 years (mean age — 31 years).

Group II comprised 17 limbs with superficial system varices, patients were aged between 19 and 72 years (mean age — 43 years).

Group III comprised 4 limbs with superficial system varices and varicose ulcerations, patients were aged between 33 and 50 years (mean age — 45 years).

Patients with insufficiency of the communicating veins and the postphlebitis syndrome comprised both the IV and V groups (with or without concomitant varicose ulcerations, respectively). Group IV patients were aged between 16 and 76 years (mean age — 51 years) and group V patients between 30 and 85 years (mean age — 55 years).

Statistical analysis

The statistical analysis of PRI value differences was performed by means of the students t-test and Wilcoxon test. $p<0.05$ was considered as statistically significant.

Figure 3. Venous pressure curves for patients with varices of superficial venous system and ulcera cruris. Examination performed without cuff (upper curve) and with cuff (lower curve).

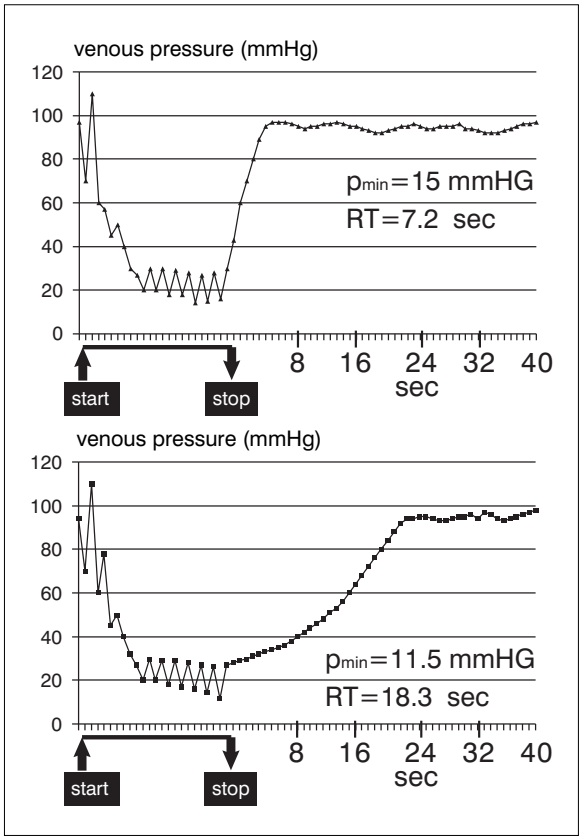
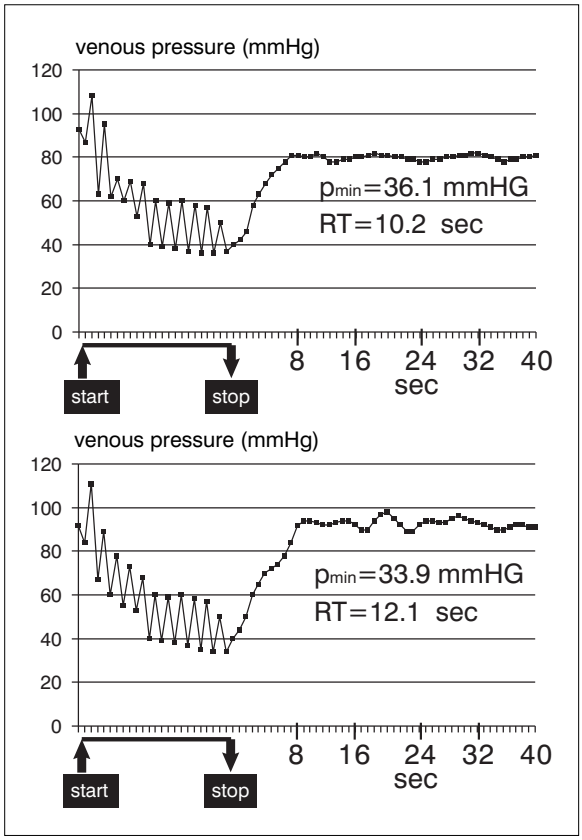


Figure 4. Venous pressure curves for patients with postphlebitis syndrome. Examination performed without cuff (upper curve) and with cuff (lower curve).



RESULTS

Figures 1–5 demonstrate mean venous pressure value curves at rest and during exersion in all five groups.

In healthy subjects the venous pressure curve drops to 9.4 mmHg during exersion with its slow rise towards initial values (37.6 sec.).

Pathology of the veins caused an increase in lower limb venous pressures, its decrease during exertion and shortening of the time of its return to initial values.

In patients with superficial varices (Figure 2), the venous pressure at rest was statistically higher ($p<0.05$) in comparison with healthy subjects and amounted to 81.3 mmHg. During exertion we noted a smaller pressure drop (20.4 mmHG), in comparison with healthy subjects ($p<0.05$) and shortening of the return time to initial values ($p<0.001$). The repetition of this test with a pressure cuff caused RT elongation ($p<0.05$). The time was significantly shorter than in healthy subjects.

Figure 3 demonstrates the venous pressure curve in patients with superficial varices and varicose ulcerations (group III).

We observed an increase in pressure while standing and a decrease during exersion with an even shorter RT (mean — 7.2 sec.; $p<0.001$). Differences between group IV and healthy subjects were similar to those seen in groups III and II. We observed no RT elongation during the test performed with the cuff and without it (Figure 4).

We observed the lowest pressure drop during exersion in patients with the postphlebitis syndrome and varicose ulcerations (group V) — an average 50.2 mmHg and the shortest RT (6.8 sec.). This in turn caused an increase of the curve following exercise (Figure 5). Similar to group IV results, its elongation had not been observed during the pressure cuff test ($p<0.05$).

Table 1 presents venous pressure results at rest, during exersion and following activity and the time needed to obtain initial pressure values, depending on the group.

Figure 5. Venous pressure curves for patients with postphlebitis syndrome and ulcera crusis. Examination performed without cuff (upper curve) and with cuff (lower curve).

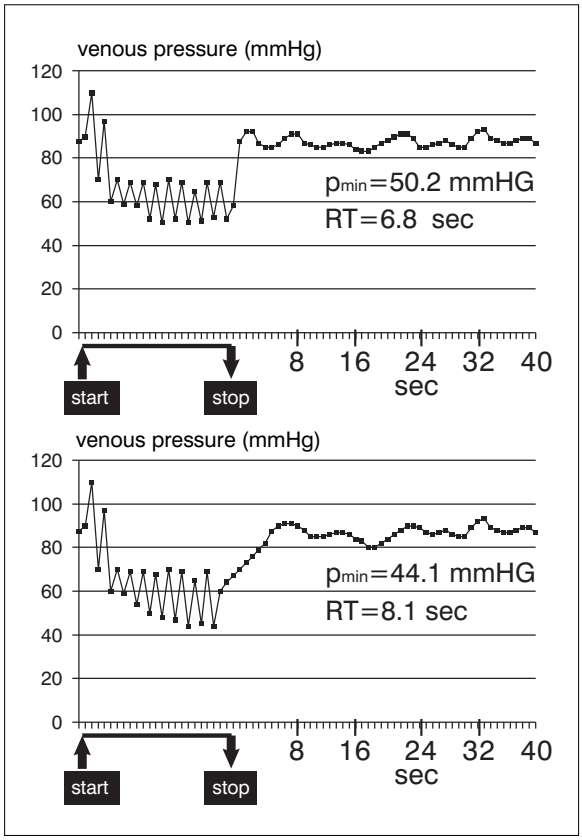
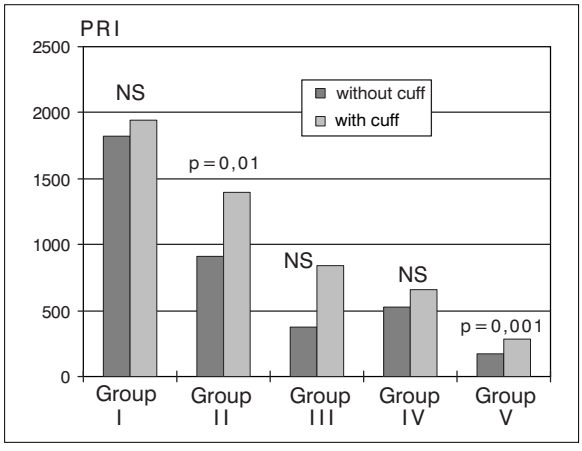


Figure 6. PRI calculated in the examination with and without cuff.



In healthy subjects the PRI during the test without the pressure cuff amounted to 1826. Differences between groups varied at a statistically significant level of $p<0.001$ (Table 2, Figure 6).

A PRI value of under 300 was connected with a 70 % possibility of varicose ulceration occurrence during the test without the pressure cuff. Varicose

Table 1. The values of venous pressures at rest and during exerase and RF in examined groups.

Groups of subjects	Examined parameter	Without cuff		With cuff	
		value	SD	value	SD
Group I	p_s	62.5	9.8	74	18.5
	p_{min}	9.4	4.7	9.8	2.1
	RT	37.6	7.9	34.8	7.5
Group II	p_s	81.3	14.7	84.9	14.2
	p_{min}	20.4	8.8	18.8	9.8
	RT	17.4	10.6	22.6	9.7
Group III	p_s	93.8	18.9	93.8	18.9
	p_{min}	15	14.9	11.5	10.6
	RT	7.2	4.7	18.3	4.3
Group IV	p_s	92.9	14.5	91.8	15.8
	p_{min}	36.1	18.2	33.9	16.4
	RT	10.2	6.4	12.1	6.9
Group V	p_s	87.5	17.9	87.4	17.1
	p_{min}	50.2	23.4	44.1	22.6
	RT	6.8	3.7	88.1	3.8

p_s – venous pressure measured at rest, given in mmHg
p_{min} – minimum venous pressure during exertion, given in mmHg
RT – return time of pressure to value at rest after the end of exercise, give in second

Table 2. PRI in analysed groups.

Examination		Group I	Group II	Group III	Group IV	Group V
without cuff	value	1826	915	377.5	530.6	176.6
	SD	605	518.3	190.6	525.3	150.8
with cuff	value	1943	1399.5	843.8	662.7	286.7
	SD	739	588.6	660.9	636.7	239.7

Table 3. Incidence of PRI (%) in analysed groups in examination performed without cuff.

PRI range	Group I	Group II	Group III	Group IV	Group V
0 – 100	0	0	0	0	100
101 – 200	0	4.17	4.17	33.3	58.3
201 – 300	0	0	0	57.1	42.9
301 – 400	0	0	12.5	62.5	25
401 – 500	0	15.4	0	46.1	38.5
501 – 800	0	20.8	4.2	70.8	4.2
801 – 1500	13.3	53.3	0	33.3	0
1501 – 3000	46.7	33.3	0	20	0

Table 4. Incidence of PRI (%) in analysed groups in examination performed with cuff.

PRI range	Group I	Group II	Group III	Group IV	Group V
0 – 100	0	0	0	7.1	92.9
101 – 200	0	0	11.1	33.3	55.6
201 – 300	0	0	0	35.7	64.3
301 – 400	0	0	0	75	25
401 – 500	0	0	0	50	41.7
501 – 800	0	4.4	4.3	60.9	30.4
801 – 1500	10	35	5	45	5
1501 – 3000	35.2	47.1	5.9	11.8	0

ulcerations were present in 72% of tests with the pressure cuff.

Tables 3 and 4 present the incidence of PRI values in different groups.

In the following groups we observed a decrease in the incidence of PRI values similar to healthy subject results and an increase of low PRI values. PRI values were outside the limits (0–800) in all tested healthy subject limbs. During the test without the pressure cuff, postphlebitis syndrome patients (groups IV and V) presented no PRI values ranging between 800–3000. Only 5% of patients with the postphlebitis syndrome and varicose ulcerations presented PRI values ranging between 801–1500 (Test with the pressure cuff). Low PRI values (0–100) were always connected with postphlebitis syndrome and varicose ulceration limbs (100% of limbs during the test without the pressure cuff and 92.9% with the pressure cuff).

DISCUSSION

Barber in 1925, was the first who measured the venous pressure in the lower limbs. This enriched our knowledge concerning the pathology and physiology of the venous outflow from the lower limbs. In spite of modern techniques this form of venous pressure measurement remains a routine method. It informs the doctor about the character of the venous outflow, independently of the veins pathological level. Thus, one may determine venous insufficiency. We can obtain much more information analysing the venous pressure curves during exersion [5,6,7,8].

Contracting muscles which are enclosed by superficial fascia, compress the intramuscular venous sinuses and deep intramuscular veins by means of a muscle pump. When these venous valves are competent the blood is pumped into the deep veins. Venous valves prevent the flow of blood in the other direction as well as from the communicating to the superficial veins. The venous pressure decreases reaching minimal pressure values as a result of the muscle pumps functioning (mean pressure value — 9.4 mmHg). During the time of muscle relaxation, the venous blood flowed from the superficial system and subcutaneus tissue towards the deep veins [8,9,10]. When the muscles stops working the venous pressure increases, reaching the resting state in 20–35 sec. [6].

In patients with superficial venous valve insufficiency the decrease of pressure during muscle activity is lower than in healthy subjects (mean — 20.4 mmHg). Due to the constant flow of blood through the incompetent saphenous vein ostium, the time needed for pressure normalization lengthens. Cuff pressure of the saphenous vein causes venous pressure normalization [11]. During this study (pressure cuff placed above the ankle) we observed an elongation of RT, while the pressure curve was similar to that seen in healthy subjects. Thus, venous pressure measurements in patients with saphenous vein insufficiency confirm the diagnosis and predict the positive effects of surgery.

Patients with insufficiency of the communicating veins present with a blood flow from the deep to the superficial veins. Muscle contractions intensify the blood flow through the perforators and direct it towards the insufficient deep venous system. Thus, we observed a decrease of venous pressure during exersion. Hence, pressure normalization is rapid.

Each venous pathology modifies the time needed for pressure normalization and the depth of its drop.

The measurement of the PRI enables to distinguish healthy subjects from patients with venous insufficiency. Additionally, the pressure cuff test helps determine patients with superficial system insufficiency. We were able to assess the influence of the superficial venous system on the incidence of tibial ulcerations. PRI value differences between groups II and III unequivocally differentiated patients with superficial system varicose veins with ulcerations and those without ($p<0.05$). Both groups could have been differentiated by means of PRI values. The pressure cuff test intensified PRI value differences. Patients without ulcerations presented PRI values ranging from 915 (without the pressure cuff) to 1399.5 (with the pressure cuff) ($p<0.05$). The possibility to distinguish high risk tibial ulceration

patients from postphlebitis syndrome patients seems to be an important factor. According to Nicolaides et al. the venous pressure of <45 mmHg, during exersion is practically impossible (probability near 0). In cases of values exceeding 60 mmHg the risk amounted to 50%. Our study results demonstrated that when PRI values where under 300 the possibility of varicose ulcerations amounted to 70% [6].

Venous pressure measurements as well as the PRI possess great diagnostic and prognostic values.

Before undertaking the final decision concerning the treatment of patients with tibial ulcerations, one should perform a duplex scan or a venography.

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