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Research Article

ON THE OCCURRENCE OF DYSPNEA, DIZZINESS AND PRECORDIAL DISTRESS OCCASIONED BY THE POOLING OF BLOOD IN VARICOSE VEINS

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Varicose veins of the legs are known to have local secondary effects such as edema of the leg, eczema of the skin, ulceration and even hemorrhage. Sequelae such as thrombosis and phlebitis of the enlarged veins may in turn cause pulmonary emboli with their distressing pulmonocardiac symptoms. However, we can find no clear evidence in the medical literature that the pooling of blood in varicose veins leads to a decrease in the efficiency of cardiac and circulatory function.[1] It is our intention to present here evidence, both clinical and physiological, indicating that such a form of circulatory embarrassment occurs in varying degrees in persons who have varicose veins.

The failure in the past to recognize this type of decrease in circulatory function may be due in part to the fact that the symptoms are usually moderate in nature and seldom lead to actual cardiac failure. However, fatigue, dyspnea, dizziness, fainting and precordial distress are symptoms that may trouble the patient in whom the heart is burdened to maintain its compensation. These symptoms should be recognized as possibly being the effect of pooling of blood in varicose veins. Surgical treatment of such patients should restore their hemodynamics toward normal and thus bring relief from their symptoms, provided that the heart has not been permanently damaged. In the aged and in those with known heart disease, the added burden from varicose veins may be enough to provoke severe symptoms.

The erect posture imposes a certain strain on the circulatory system even in normal individuals. The increased hydrostatic pressure in the legs and in the lower parts of the body causes a dilatation of blood vessels and a local accumulation of blood. Asmussen, Christensen and Nielsen (3) have estimated that in normal persons standing still, 500 cc. of blood or even more accumulate in the legs. Consequent to such stagnation a smaller amount of blood is available in the central veins emptying back into the heart; this decrease in venous return lessens the filling of the heart and results in a decrease in the cardiac output when standing; a fall in blood pressure under these conditions may be followed by a sudden increase in pulse rate which is probably accomplished via the pressure-sensitive zones in the aortic arch and the carotid sinus and also by a compensatory contraction of the blood vessels in the abdominal viscera. The decrease in the cardiac output of normal, standing individuals has been observed by Asmussen (3), Grollman (4), and Sweeney and Mayerson (5). In fact, two normal subjects of Schneider and Crampton (6) became dizzy on quiet standing for fifteen minutes and one fainted.

The idea that varicose veins could cause undue dyspnea, dizziness and precordial distress originated in the practice of medicine when one of us was consulted by a middle-aged woman in sound health who complained of attacks of severe precordial pain on walking and sometimes on sudden standing. The clinical story suggested angina or coronary heart disease but careful examination of the heart disclosed no evidence of disease and the roentgenogram and the electrocardiogram of her heart were normal. The observation of her large varicose veins suddenly led to the idea that pooling in these veins might have caused such a

[1] Near the completion of this work we discovered in the lectures of John Gay in 1867 (1) a description of a varicose old lady who described a correspondence between the venous distention and her dyspnea. After surgical treatment her dyspnea was much relieved. Likewise, in November 1940, Lee and Freeman (2) described circulatory disturbances produced by extensive angiomata of the lower extremities associated with varicose veins. In one of their three cases, attacks of fainting on standing were prevented by the wearing of an elastic stocking and finally saphenous ligation brought permanent relief of symptoms.

decrease in venous return to the heart that inadequate filling of the heart resulted in a deficient coronary blood flow and so caused pain. Relief from this patient's symptoms was obtained by having her wear elastic stockings on both legs.

With this experience in mind, we next interviewed a large number of persons with varicose veins of sufficient size to allow considerable venous pooling. Two hundred and fifty patients in the Out-Patient Department of the Massachusetts General Hospital, so afflicted, were questioned. The surprising result of this was to find that 47 (18 per cent) of the 250 complained of undue shortness of breath that was relieved in the recumbent position; 19 of these 47 also suffered mild precordial pain, palpitation, or were uncomfortably aware of their heart action, and 3 were women who experienced attacks of sudden dyspnea, dizziness and precordial pain, simply on standing. These 47 patients were without gross signs of the known types of heart disease, although in some the blood pressure was slightly elevated.

With this background in clinical evidence, we next turned to the laboratory for data that might explain these symptoms and also the changes that occur in the circulation of persons with large varicose veins.

METHODS

In this investigation we had planned to observe 12 normal persons and 24 patients with varicose veins, 12 of whom had symptoms such as described here and then repeat our studies after operative procedures to obliterate the venous reservoirs. However, certain practical considerations, including the sudden return of one of us (E. A.) to Denmark, have allowed us to complete our observations on only 7 normal and 12 varicose subjects. Of these 12, 5 had the symptoms mentioned; 7 returned for study after operation and 4 of these were with symptoms.

We first obtained normal, untrained subjects and confirmed the previous observations of Grollman, Asmussen, and Mayerson that the change from the recumbent to the upright position causes a decrease in the cardiac output in the tilted position. Conversely, Schneider and Crampton observed an increase in the cardiac output in changing from quiet standing to the recumbent position. Seven normal subjects were taken to the laboratory in the morning in a fasting state and placed in a recumbent position on a tilt table. After a rest period, the basal metabolic rate, vital capacity, pulse rate and blood pressure were measured. An estimation of the arteriovenous oxygen difference was made by the Grollman acetylene method (taking the samples at intervals of 18 and 23 seconds), and the cardiac output was computed from the basal oxygen consumption and the A–V oxygen difference. The subject then was tilted passively to a 45° angle and the observations were repeated. In most subjects an electrocardiogram was taken in both positions.

Twelve patients with rather large, untreated varicose veins were then studied; 5 of these 12 had the symptoms mentioned before, chiefly dyspnea and dizziness, and 1 woman described particularly severe attacks of shortness of breath, dizziness and fainting on getting suddenly out of bed.

Finally, 3 to 17 months after these patients had had high saphenous ligations and injections of sclerosing solutions for their varicose veins, we succeeded in getting 7 of them back to the laboratory and repeated our observations. The upper photographs of Figure 1 show the subject P. D. with large varicose veins; the lower photographs show his legs 6 months after this treatment.

RESULTS AND DISCUSSION

In our patients with varicose veins it is evident that an amount larger than 500 cc. of blood accumulates in their veins during standing and walking. Consequently, the same physiologic responses could be expected but in a greater order of magnitude. We likewise observed this decrease in the cardiac output in the tilted position of our normal but untrained subjects. The accompanying data best illustrate these responses. We did not undertake to estimate the amount of blood in the veins of the legs for several reasons. First, plethysmographic methods necessitating pressure about the thigh would necessarily introduce an error, and second, the approximate knowledge of the amount pooled in no way explains the physiologic response; it only indicates the degree of the response.

Figure 2 shows that the 7 normal subjects were practically the same age as the patients and that our results agree satisfactorily with the normal values established by Grollman and by Asmussen, Christensen and Nielsen. The cardiac index (cardiac output per square meter of body surface) is not only constant under fixed conditions but like the basal metabolism is predictable, according to Grollman, for normal individuals. It will be noted that the cardiac index and the stroke volume [2] are higher than normal when subjects with varicose

[2] The stroke volume is the amount of blood ejected with each systole and its value multiplied by the pulse rate gives the cardiac output in liters per minute.

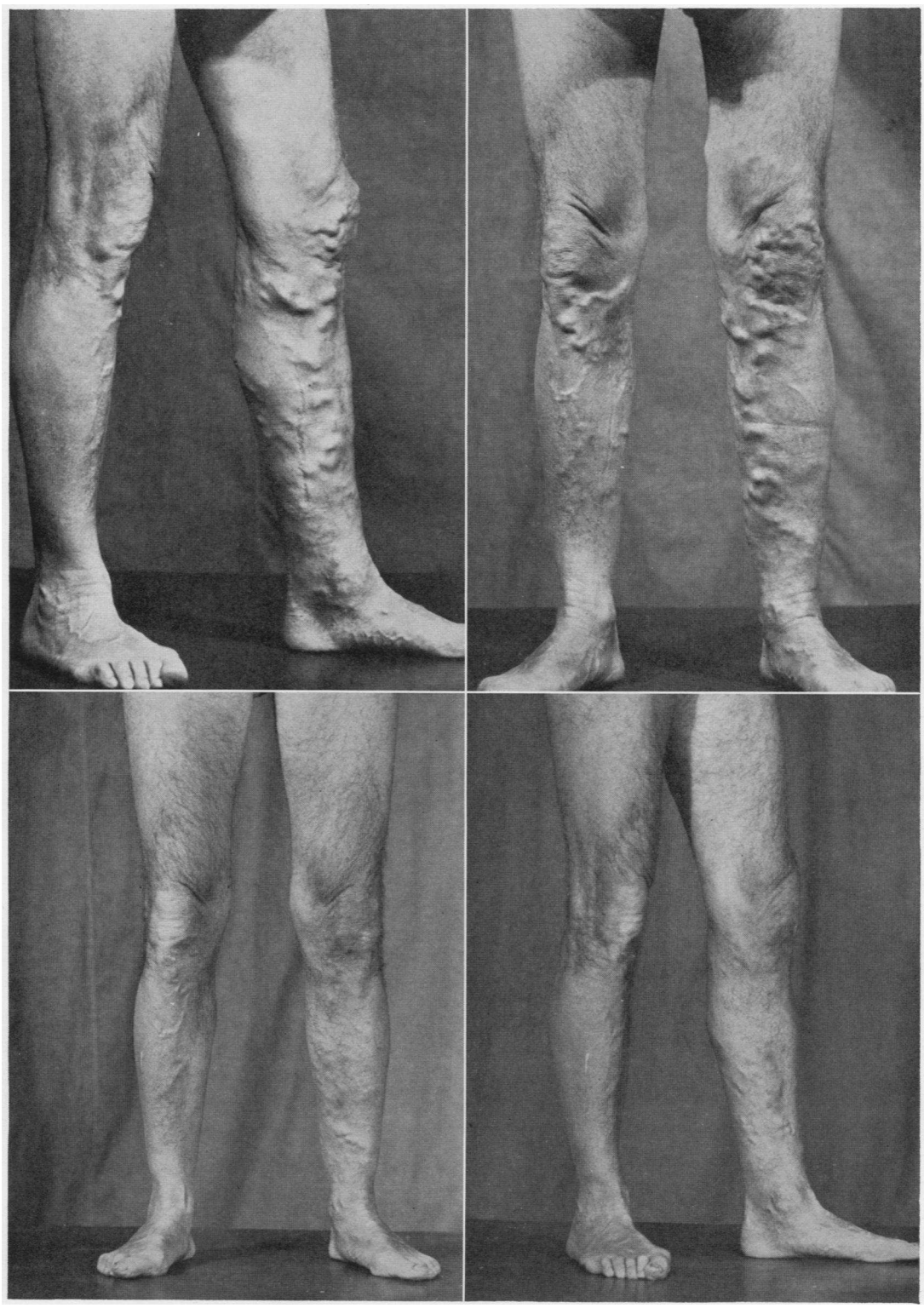
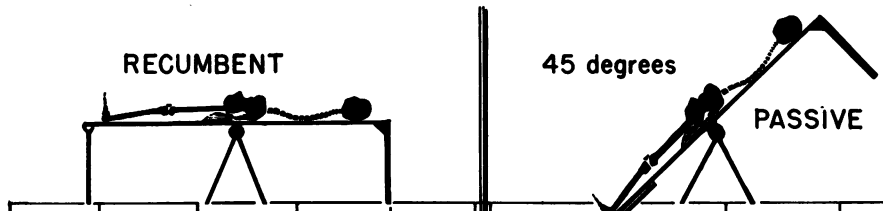


FIG. 1. SUBJECT P. D. WITH LARGE VARICOSE VEINS; THE LOWER PHOTOGRAPHS SHOW HIS LEGS 6 MONTHS AFTER SAPHENOUS LIGATION AND INJECTION



	Average Age years	Cardiac Index	Systolic Blood Pressure mm.	Stroke Vol. cc.	Blood Vol. per sq. m.	Decline in Cardiac out-put	Decline in Stroke Vol.	Decrease in Syst. B.P.	Increase in Pulse Rate
7 Normal Subjects	45	2.10-	125	65		5. %	14. %	0.3%	15. %
12 — Patients Varicose	48	2.91	140	80	3.30	21. %	39. %	8. %	25. %
Normal Grollman's		2.21-+2		62	2.53				
Asmussen		2.36			2.93				

FIG. 2. CIRCULATORY FUNCTIONS OF NORMAL SUBJECTS COMPARED WITH PATIENTS WITH VARICOSE VEINS

veins are recumbent. *The reason for this may be that with varices there is a greater blood volume and so in the recumbent position a greater amount of blood returns to the heart. This is suggested by the high average blood volume of 3.30 liters per square meter of body surface,* compared with the normals established by Gibson and Evans (7) using the same technique. Their values for normal males were 2.93 and for females 2.53. Our high value indicates an added load in the circulation.

From Figure 2 it is also evident that on tilting these subjects and filling their varicose veins the cardiac output fell about four times as much as it did in the normal subjects and the systolic blood pressure was somewhat lowered but never enough to suggest a postural hypotension. *Possibly it is this comparatively great fall from a higher than normal level of cardiac output which causes the symptoms described here.* Kerr (8) described relief of dyspnea and anginal pain by having his patients with a pendulous abdomen wear an abdominal belt. The situation may be analogous with the pooling of blood in the legs in one case, and in the abdominal cavity in the other. When tilted, the average cardiac indices in the normal persons and in those with varicose veins, both before and after operation, were still within the normal range (Table I). However, analysis of individual responses shows that in 4 of 6 patients the cardiac output in the tilted position is definitely lowered after the treatment for the varicose veins. This further supports the explanation that an actual reduction of the load in the circulation was accomplished by removal of the venous reservoir, and could explain the clinical fact that many patients note fewer symptoms of fatigue after the obliteration of their engorged veins.

Figure 3 shows the measurements of circulatory functions that were made several months after corrective operations for the varicosities of 7 subjects. In all but 1 subject (F. B.) high cardiac indices had been present and after removal of their venous reservoir this value became normal in 2 and lower in 2; also in 6 of the 7, the blood pressure when recumbent was lowered. Likewise the decreases in stroke volume and blood pressure on tilting became much less in all except 2 subjects. From the last column it can be noted that the increase in pulse rate on tilting became normal in all but these same 2 after operation. These 2 subjects deserve particular comment. M.MacD. had symptoms of dyspnea and dizziness and often fainted if she got out of bed and stood up suddenly. Following saphenous ligations she had no further such attacks and the decline in stroke volume on tilting was less. However, moderate varices in her right leg persist. The other subject, F. B., was an obese fireman who continued to be obviously short of breath on effort although he denied symptoms; tilting him occasioned a

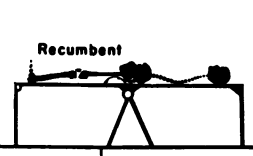
TABLE I

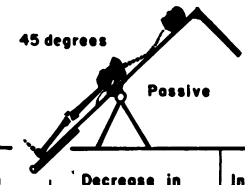
Showing all the data in this investigation

Number	Age	Sex	Name	Weight	Height	Body surface	Blood volume	Lying horizontal basal								Tilted, passive 45°							Difference in positions			
								Basal metabolic rate	Arterio-venous O_2 difference	Cardiac output	Pulse rate	Stroke volume	Blood pressure	Vital capacity	Blood volume	Grollman's		Basal metabolic rate	Arterio-venous O_2 difference	Cardiac output	Pulse rate	Stroke volume	Blood pressure	Vital capacity	Cardiac output	Pulse rate	Stroke volume	Blood pressure systolic
																"Cardiac index"	"Cardiac index"										
			Normals	*kgm.*	*cm.*	*sq. meters*	*liters*	*cc. O_2 per minute*	*cc. per liter*	*liters per minute*		*cc.*		*liters*	*per sq. meter*			*cc. O_2 per minute*	*cc. per liter*	*liters per minute*		*cc.*		*liters*	*per cent*	*per cent*	*per cent*	*per cent*
1	30	F	A.C.	73	164	1.80		220	53	4.2	64	65	120/80	2.7		2.33	1.67	213	71	3.0	70	43	105/75	2.8	−28.6	+ 9.4	−33.9	−12.5
2	38	F	H.B.	63	173	1.75		200	46	4.4	52	85	110/70	3.2		2.51	2.06	218	64	3.6	75	48	115/85	3.3	−18.2	+44.3	−43.5	+ 4.5
3	38	F	M.H.	64	169	1.74		189	65	2.9	52	56	120/80	2.9		1.67	1.78	203	65	3.1	58	53	130/90	2.9	+ 6.9	+11.5	− 5.4	+ 8.3
4	52	F	I.D.	76	176	1.99		175	61	2.9	56	52	120/90	2.8		1.51	1.51	192	67	2.9	58	50	130/85	3.1	0	+ 3.7	− 3.8	+ 8.3
5	51	F	G.S.	80	156	1.80		180	47	4.0	80	50	160/100	1.4		2.22	2.56	223	48	4.6	80	58	155/110	1.5	+15.0	0	+16.0	− 3.1
6	57	M	P.C.	88	158	1.70		215			66		140/95	3.4			1.94	220	67	3.3	80	41	130/95	3.5		+21.2		− 7.1
7	48	M	B.D.	81	175	1.97		240	52	4.6	58	79	100/70			2.34		252										
	45		Average							3.8	61	65	125/85			2.10	1.92			3.4	70	48	127/90		− 5.0	+15	−14.0	− 0.3
			Varicose subjects before op.																									
1	44	F	E.C. ⊕*	75	163	1.81		244	40	6.1	68	90	125/80	2.8		3.37	2.70	256	52	4.9	88	56	140/90	2.7	−19.7	+29.4	−37.8	+12.0
2	65	M	T.S. ⊕	66	161	1.70	5.2	264			60		185/100	2.2	3.05		2.65	277	62	4.5	60	75	150/100	2.4		0		−18.9
3	40	F	S.D. ⊕*								68		130/80	2.7				Fainted			84		very low	3.2		+23.5		−>50
4	53	M	B.A.	64	156	1.64	6.2	248	39	6.4	80	80	135/70	3.2	3.90	3.90	2.82	260	54	4.8	84	57	115/80	3.2	−25.0	+ 5.0	−28.7	−14.8
5	36	M	F.K. ⊕	77	169	1.88	6.0	260	42	6.2	64	97	125/85	2.7	3.25	3.30	2.08	273	70	3.9	88	44	125/85	3.1	−37.1	+37.6	−54.6	0
6	43	F	G.B. ⊕*	75	165	1.82		234	43	5.4	58	93	150/80	2.4		2.97	2.42	246	56	4.4	72	61	130/80	2.3	−18.5	+24.2	−34.4	−13.3
7	50	F	M.MacD.*	80	168	1.90	6.3	315	54	5.8	64	91	170/105	2.5	3.31	3.05	2.26	340	80	4.3	82	52	150/105	2.7	−25.9	+28.1	−42.9	−11.8
8	48	F	R.B.	77	158	1.79	5.7	218	51	4.3	68	63	125/75	2.1	3.18	2.40		229			80		120/80	2.5		+17.7		− 4.0
9	47	F	A.M.	93	156	1.92	6.3	262	45	5.8	60	97	150/100	2.5	3.28	3.02	2.14	289	71	4.1	84	49	200/115	2.7	−29.3	+40.0	−49.5	+33.3
10	55	M	M.N. ⊕	70	180	1.89	5.9	236	48	4.9	74	66	120/80	3.4	3.18	2.59	2.65	237	47	5.0	98	51	115/90	3.6	+ 2.0	+32.4	−22.7	− 4.2
11	64	M	P.D. ⊕	71	173	1.84	5.5	217	47	4.6	58	79	150/90	4.3	2.99	2.50	2.34	234	55	4.3	80	54	120/90	4.4	− 6.5	+38.0	−31.6	−20.0
12	39	M	F.B.*	107	178	2.24	7.5	307	67	4.6	56	82	130/85	3.4	3.35	2.05	1.47	317	95	3.3	78	42	115/85	3.5	−28.3	+29.3	−48.8	−11.5
	48		Average							5.4	65	80	140/85		3.30	2.91	2.35			4.3	81	54	134/90		−20.9	+25.4	−39.0	− 8.3
			After op.																									
1		F	E.C.*	72	169	1.79		220	53	4.1	64	64	120/74	2.5		2.29	2.26	231	57	4.0	70	57	130/82	2.6	− 1.2	+ 9.3	−10.9	+ 8.3
4		M	B.A.	64	156	1.64	5.3	195	45	4.3	72	60	120/70	2.6	3.23	2.62	2.31	205	54	3.8	78	49	110/70	2.7	−11.8	+ 8.3	−18.3	− 8.3
11		M	P.D.	72	173	1.85	5.7	189	47	4.0	55	73	140/80	4.3	3.11	2.16	1.89	198	57	3.5	59	67	130/85	4.2	−12.5	+ 7.3	− 8.2	− 7.2
6		F	G.B.*	80	165	1.87		248	48	5.2	57	91	140/80	2.4		2.78	2.08	260	60	3.9	62	74	140/90	2.5	−25.0	+ 8.8	−18.3	0
7		F	M.MacD.*	82	168	1.92		272	44	6.2	64	97	145/105	2.4		3.23	2.92	286	49	5.6	82	68	125/90	2.5	− 9.7	+28.1	−29.9	−13.8
12		M	F.B.*	111	178	2.28	7.4	325	52	6.3	64	99	115/70	3.2	3.24	2.76	1.75	341	85	4.0	81	49	110/80	3.5	−36.5	+26.6	−50.6	− 4.3
5		M	F.K.	72	169			220			68		126/88	2.5							76		126/84	2.7		+11.0		0.0
			Average							5.0	63	80	129/81		3.19	2.64	2.20			4.1	72	60	124/83		−16.1	+14.2	−22.7	− 5.0

* Patients with symptoms.

⊕ = electrocardiographs taken in both positions.





Name	Sex	Mons. after Op.	"Cardiac Index"		Blood Pressure		Decrease in Stroke Vol %		Decrease in Syst. B.P.%		Increased Pulse Rate %	
			with Varices	after Operation	with Varices	after Operation	with Varices	after Operation	with Varices	after Operation	with Varices	after Operation
E.C.	♀	17	3.37	2.29	125	120	37.8	10.9	+ 12.0	+ 8.3	29.4	9.3
B.A.	♂	11	3.90	2.62	135	120	28.7	18.3	14.8	8.3	5.0	8.3
P.D.	♂	6	2 50	2.16	150	140	31.6	8.2	20.0	7.2	38.0	7.3
G.B.	♀	3	2.92	2.78	150	140	34.4	18.3	13.3	0	24.2	8.8
M.M.	♀	6	3.05	3.23	170	145	42.9	29.9	11.8	13.8	28.1	28.1
F B.	♂	5	2.05	2.76	130	115	48.8	50.6	11 5	4.3	29.3	26.6
F K.	♂	16	3.30	—	126	126	54.0	—	0	0	37.6	11.0
Averages			3.03	2.64	140	129	39.7	22 7	14.2	6.7	27.3	14 .2

FIG. 3. CIRCULATORY FUNCTIONS BEFORE AND AFTER SAPHENOUS LIGATION FOR VARICOSE VEINS

great fall in stroke volume but this was compensated by a considerable increase in the pulse rate. The explanation for both these subjects may be that the obliteration of the varices is incomplete.

Table I contains all the data in our investigation and from this we have prepared Figures 2 and 3. Referring to Table I one notes that the changes in blood volume per square meter of body surface suggest that less blood is actually present in circulation after the venous reservoirs are removed, however, this comparative data is too limited for interpretation. The vital capacity of these subjects showed no consistent changes. Electrocardiograms were done in the recumbent and tilted positions on the 7 subjects indicated. There was a slight lowering of the T-wave in Lead II in the tilted positions of T. S. and F. K., a known physiologic change (9). However, in S. D. there was marked lowering of T_1 and T_2 and slurring of QRS_3 and fifteen minutes after the graph was taken she fainted and the blood pressure became unobtainable. This may have been a reaction to postural hypotension as an exaggerated response to her peripheral pooling. In a recent careful study of 3 patients with postural hypotension, Stead and Ebert (10) did not state that their subjects were without varicose veins.

Probably the most significant observation we made was the increase in pulse rate on tilting. Comparison of the two last columns in Figure 3 indicates this response. The definite rise in pulse rate on tilting is of course a compensatory mechanism to offset the fall in stroke volume and to maintain the cardiac output. The average increase in pulse rate of all 7 before ligating the veins is twice that after ligation. By application of the previous formula,[3] this indicates to us that circulatory efficiency has been definitely increased by removal of the blood pool in the varicose veins.

CONCLUSIONS

We believe that undue fatigue, shortness of breath, dizziness, fainting, and precordial distress may be occasioned by the pooling of blood in varicose veins. These clinical investigations offer evidence that the circulatory efficiency is decreased by such extensive pooling and that removal of this peripheral blood reservoir restores the hemodynamics of the subjects toward normal and relieves their symptoms.

We are indebted to Dr. W. H. Forbes for doing the blood volume determinations and his advice.

[3] See footnote 2.

PROTOCOLS

Case 1.[4] E. C.: A 44-year old woman managing a farm. She had bilateral varicose veins for at least 12 years and complained of some undue shortness of breath, fatigue, and occasional dizzy spells while at work. Following ligation and injection she was greatly improved and noted less fatigue and shortness of breath.

Case 2. T. S.: A 65-year old gardener who said his varicose veins had been present for 35 years. They were particularly large on the left side and extended to the groin. He denied discomfort in any way.

Case 3. S. D.: A 40-year old Polish housewife who had bilateral varicose veins for 7 years. She spoke little English, but no history of dyspnea, dizziness, or fainting was obtained. However, on tilting her she had a fall in blood pressure and fainted, making further study impossible.

Case 4. B. A.: A 53-year old Hebrew storekeeper with large bilateral varices of 7 years duration. He worked standing each day and denied symptoms except some aching in the legs. However, he wore supportive bandages most of the time.

Case 5. F. K.: A 36-year old meat smoker (the man in the glass house at the World's Fair) who for 3 years had huge varicose veins reaching both knees. He denied symptoms but after operation he observed that he could then walk 5 to 10 miles without fatigue or shortness of breath.

Case 6. G. B.: A 43-year old housewife who for 19 years had large varicosities of both legs, more extensive on the right where they reached the groin. She complained of undue shortness of breath and often sighed heavily and was frequently dizzy. Following ligation and injection she was greatly improved and had a greater tolerance for work.

Case 7. M. MacD.: A 50-year old housewife who had large varicose veins coursing up both legs to the groin. For 20 years these had troubled her. She complained of shortness of breath and also of sudden attacks of precordial pain and dizziness when she got out of bed and stood up. On several occasions she had fallen in a faint. After ligation of her veins she was greatly improved and no longer had such attacks. However, moderate varices in the right leg persisted.

Case 8. R. B.: A 48-year old Polish housewife who had bilateral varicose veins of 10 years duration. She did not complain.

Case 9. A. M.: A 47-year old Russian émigré woman with large varicosities extending above both knees. These had been present many years and she had no cardio-respiratory symptoms.

Case 10. M. N.: A 55-year old Irish workman who had had a large pattern of varicose veins extending above his knees for the previous 20 years. He was a tense, restless fellow smoking 40 cigarettes daily and denying symptoms referable to his circulatory system.

Case 11. P. D.: A 64-year old retired fireman with the varicosities shown in Figure 1. He was without particular complaint, but said he felt better and fatigued less after their obliteration.

Case 12. F. B.: A 39-year old obese railroad fireman who had bilateral varicosities for 20 years. They were larger on the right and reached above the knee. He denied symptoms but was obviously short of breath on slight effort.

[4] We consider cases 1, 3, 6, 7, and 12 to have the symptoms described.

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