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Venous function after fracture of the lower extremity

A 9-year follow-up of 150 cases

One hundred and fifty patients were examined 8–10 years after a fracture of the lower limb to evaluate whether the frequency of deep venous insufficiency (DVI) was influenced by the type of fracture. The evaluation included clinical examination, subjective complaints, venous pressure, plethysmography and doppler sonography. Symptoms and signs of DVI were more common in the fractured than in the uninjured limbs, while objectively diagnosed DVI did not differ between the groups. Only minor differences were present in the development of DVI between limbs with various types of fracture (hip fractures were not included in the study). High age and incompetence of the popliteal valves were more important in the development of DVI than the earlier fracture. The frequency of objectively measured DVI in the fractured limbs was 35 per cent and in the uninjured limbs 30 per cent.

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Damage to the deep veins and the development of deep venous thrombosis (DVT) after fractures of the lower limb are well known and documented (Bauer 1944, Jacob 1943, Sevitt & Gallagher 1959, Hjelmstedt & Sundström 1963, Hjelmstedt & Bergvall 1968, Culver et al. 1970, Nylander & Semb 1972, Miehle 1982). What this eventually means for the development of deep venous insufficiency (DVI), however, is poorly understood, and reports on this subject are scarce.

The purpose of our study was to evaluate the venous function of legs in patients who had previously had a fracture of the lower extremity, to compare these legs with the contralateral legs without fracture, and also to analyze whether the type and location of the fracture influenced the development of DVI.

Patients and methods

During 1973–74, 360 patients over 15 years of age were admitted to our hospital for fractures of the lower extremity. Fractures of the femoral neck, fractures of the patella, multiple fractures and bilateral fractures were not included in the study. During the follow-up period, 129 patients had died or moved from the area and could not be investigated. The remaining 231 patients were asked to attend a follow-up examination; 150 patients responded and were investigated (Table 1). Among the 81 patients who did not want to participate, the mean age, type of fracture and sex distribution were the same as in those included in the study. Fifty-eight of the 150 patients investigated were women.

The median age at the time of fracture was 38 (15–75) years and the median follow-up time 108 (93–126) months. During the initial treatment, only one patient (with femoral fracture) had clinically suspected and phlebographically proven DVT. Four patients had symptoms of pulmonary embolism during the fracture treatment, but in no case was this verified objectively, nor could DVT be demonstrated. These five patients were all treated with oral anticoagulants for 3–6 months.

The fractures were analysed in four groups: 26, femoral fractures, eight knee fractures, 53 fractures of the lower leg and 63 ankle fractures (Table 1). The more distal the fracture, the higher the mean age, but the mean immobilisation time did not differ between the groups. At follow-up, the end result of fracture treatment was estimated from the clinical findings and subjective complaints of the patients. The end result of fracture treatment was considered good when the patient had no sequelae, fair when the patient had some complaints from the leg but had normal or near normal function and poor when activity was reduced because of symptoms from the leg.

At follow-up, the patient records were reviewed. Patients answered a questionnaire concerning the subjective manifestations of venous disorders of the limbs during the follow-up period and their present

Table 1. Material according to type of fracture

	Location of fracture			
	Femur	Knee	Lower leg	Ankle
Total no.	26	8	53	63
Mean age at injury (years) and range	28 (15–72)	34 (16–62)	44 (16–72)	45 (15–75)
	*	*	ns	
	**			
	***			
Mean immobilisation time (weeks) and range	9.4 (1–30)	4.0 (3–12)	9.6 (1–53)	6.3 (2–16)
Type of fracture				
Open	1	1	3	0
Dislocated	23	4	34	22
End result of treatment				
Good	21	6	42	52
Fair	5	2	11	8
Poor	0	0	0	3

state of health. All patients were examined clinically. The presence of varicose veins, crural eczema, discoloration, swelling and leg ulcers was looked for.

Clinical DVI was considered present when the patient had had a leg ulcer during the follow-up period and/or at least two symptoms or signs of venous insufficiency, i.e. swelling, discoloration, crural eczema or a constant need for a pressure bandage or support hose.

Venous occlusion strain gauge plethysmography was performed according to Hallböök et al. (1970) and Hallböök & Göthlin (1971) in 299 limbs. The parameters used in the evaluation were reserve venous volume (RVV) in ml/100 ml tissue and maximum venous emptying (MVE) in ml/100 ml tissue/min. RVV less than 1.5 and MVE less than 30 were classified as pathologic.

Ambulatory venous pressure measurements were performed in 274 limbs. A dorsal foot vein was punctured percutaneously with a scalp vein needle and connected to a pressure transducer. The pressure fall and return time (from termination of exercise to restitution of pre-exercise pressure) were registered. The superficial veins were occluded during measurements with a rubber tourniquet, applying a slight pressure in order to avoid superficial venous insufficiency interfering with the results. A pressure fall of less than 30 mmHg and a return time less than 25 s were regarded as abnormal (Pollack & Wood 1949, deCamp et al. 1951, Kreisman 1974).

In 293 limbs, venous valve insufficiency was also recorded with the doppler ultrasound technique in the femoral and popliteal veins, as described by Barnes (1982).

Objective DVI was considered present when the plethysmography showed impaired outflow (MVE <30 ml/100 ml tissue/min), venous pressure measurements showed valvular insufficiency (return time <25 s), and/or the doppler recording showed insufficiency in the femoral or popliteal vein.

Arterial circulation was evaluated with the doppler technique and the arterial ankle/arm pressure index was measured. An index above 0.95 was regarded as normal.

Statistical evaluation was carried out with the chi-square method with Yates correction and Student's *t*-test. In the tables the symbols indicate statistical significance according to the following definitions: ***$p<0.001$, **$p<0.01$, *$p<0.05$, ns $p>0.05$.

Results

There were few significant differences between fractured and uninjured limbs (Tables 2 and 3). More fractured legs were swollen and had had leg ulcers during the follow-up. Clinical DVI was more common in fractured legs. In objectively measured parameters, there were no differences at follow-up. When the four different types of fractures were compared, clinical and objective DVI did not differ between the groups.

Legs immobilised for less than 8 weeks (106 legs) were compared to legs immobilised for more than 8 weeks (44 legs). Objective DVI did not differ between the groups. The detected

Table 2. Results of questionnaire and clinical examination

	Fractured legs[a] No.	%	Uninjured legs No.	%
Total no. of legs	150		150	
Questionnaire				
Treated for DVT during follow-up	3	*2*	3	*2*
Operated during follow-up	58	*39*	59	*39*
Varicose veins	20	*13*	17	*11*
Leg ulcer during follow-up	7*	*5*	1	*1*
Swollen leg	41***	*27*	17	*11*
Eczema of leg	8	*5*	5	*3*
Discoloration	22	*15*	18	*12*
Constant need of compression/support hose	5	*3*	1	*1*
Clinical findings				
Leg ulcer (active)	0		0	
Swollen leg	17*	*11*	7	*5*
Venous eczema	11	*7*	6	*4*
Discoloration	40	*27*	36	*24*
Varicose veins	84	*56*	79	*53*
Clinical DVI	38*	*25*	20	*13*

[a] Differences from the uninjured side.

Table 3. Results of objective measurements of DVI

	Fractured legs[a] No.	%	Uninjured legs No.	%
Total no. of legs	150		150	
Plethysmography				
Total studied	150		149	
RVV < 1.5 ml/100 ml tissue	19	*13*	27	*18*
MVE < 30 ml/100 ml tissue/min	28	*19*	24	*16*
Venous pressure				
Total studied	138		136	
Return time < 25 s	24	*17*	20	*15*
Doppler				
Total studied	147		146	
Insuff. femoral vein	10	*7*	6	*4*
Insuff. popliteal vein	14	*10*	10	*7*
Insuff. fem. and/or pop. vein	20	*14*	14	*10*
Objective DVI	52	*35*	44	*29*

[a] None of the differences from the uninjured side was significant.

DVT during fracture treatment and the clinically suspected pulmonary emboli were all in patients with long immobilisation.

Clinical and objective DVI did not differ between legs with dislocated and undislocated fractures. However, outflow obstruction was more common in limbs with undislocated fractures ($p < 0.05$) while insufficiency, as measured with doppler, was more common in legs with dislocated fractures ($p < 0.001$). Femoral fractures were commonly dislocated, and malleolar fractures were more commonly undislocated.

The pattern of fractures was similar in patients over and under 45 years of age. Both clinical and objective DVI were more common in the older age group (Table 4). Comparing legs with and without fractures in the different age groups, no difference could be demonstrated except that clinical DVI was more common in fractured legs in the younger age group.

The frequency of both clinical and objective DVI was higher ($p < 0.001$) in legs with a less than good end-result of fracture treatment. The frequency of venous outflow obstruction (MVE < 30) was the same in both groups, while valvular insufficiency, as measured with both venous pressure measurements and doppler, was higher in legs with a less than good end-result of fracture treatment.

Table 4. DVI related to age

	Age < 45 years (89 pat.)		Age > 45 years (61 pat.)	
	Fractured legs	Uninjured legs	Fractured legs	Uninjured legs
Clinical DVI	10/89	2/89	28/61	18/61
Plethysmography				
MVE < 30 ml/100 ml tissue/min	16/89	15/89	12/61	9/61
Venous pressure				
Ret. time < 25 s	4/84	2/75	20/57	18/60
Doppler				
Insuff. fem. vein	1/89	2/89	9/57	4/59
Insuff. pop. vein	3/89	1/89	11/57	9/59
Insuff. fem. and/or pop. vein	4/89	3/89	16/57	11/59
Objective DVI	18/89	17/89	34/61	27/61

Table 5. DVI in relation to sufficiency of popliteal vein as recorded by doppler

	Insufficiency of popliteal vein[a]	Normal popliteal vein
Total no. of legs	24	269
No. of fractured legs	14	133
Type of fracture:		
Femoral	6	20
Condylar	0	7
Lower leg	6	47
Malleolar	2	59
Clinical DVI	16***	43
Plethysmography		
MVE < 30 ml/100 ml tissue/min	1/24	48/269
Venous pressure		
Ret. time < 25 s	15/24***	27/235
Doppler		
Insuff. fem. vein	5/24**	11/269
MVE < 30 and/or ret. time < 25	15***	69

[a] Differences from the normal side

The fractures were equally divided between legs with and without insufficiency of the popliteal vein as measured with doppler (Table 5). Clinical DVI, pathologic return time in venous pressure recordings and insufficiency of the femoral vein were more common in legs with insufficiency in the popliteal vein compared to legs with normal popliteal vein. Six of eight limbs with leg ulcer during the follow-up period had insufficiency in the popliteal vein.

In 112 legs, an arterial ankle/arm index less than 0.95 was registered. No leg had an index less than 0.6. There were no differences in DVI between legs with pathologic and normal arterial index, although patients with an index less than 0.95 were somewhat older.

Discussion

Damage to the deep veins and the development of deep venous thrombosis are frequent after lower limb trauma (Nylander & Semb 1972, Hjelmstedt & Bergvall 1968). Bauer (1944) reported an 11 per cent incidence of clinically detected DVI after leg injuries of various kind; he concluded that DVI was 12 times as common after leg injury as in legs with DVT from other causes.

A few studies of phlebographically detected late changes of the deep veins after fracture of the lower extremity have been performed. In legs with thrombosis after tibial fractures, Bergvall & Hjelmstedt (1968) found that recanalization was a slow process, as a rule requiring 3–4 years. Recanalization was slower the more distally the thrombosis was located. Miehle (1982) found phlebographic post-thrombotic changes in 39 per cent of extremities with compound lower-leg fractures 6 months to 8 years previously.

Deep venous insufficiency developing after fractures has seldom been investigated. Støren & Auensen (1971) made a clinical evaluation of 52 patients with thrombosis after hip fracture 16 (1–32) months after injury. They found oedema in 48 per cent, skin induration in 21 per cent and leg ulcer in 2 per cent; 79 per cent of the patients had no subjective complaints. Willen et al. (1982) examined 38 patients with tibial fractures 13–17 years previously, using clinical examination and directional doppler measurement and in some cases phlebography; 15 patients had symptoms of DVI and in eight patients objective venous insufficiency was established; high energy trauma, long immobilisation and age over 45 years were significantly associated with venous insufficiency. Miehle (1982) found constant swelling of the leg in 13 per cent, eczema in 9 per cent, pigmentation in 29 per cent and leg ulcer in 3 per cent.

In contrast to the previous studies, we also evaluated the uninjured limbs and found very few differences at follow-up between the injured and uninjured limbs. Clinical DVI was more common in fractured limbs but objective DVI was not. We could not show any difference in development of DVI, clinical or objective, in relation to different types of fractures. A long immobilisation time did not affect the development of objective DVI. Limbs with dislocated fracture showed more venous valve damage as measured with doppler, but the limbs with undislocated fracture showed more outflow obstruction. Clinical and objective DVI did not differ significantly between groups.

Age seems to be one of the most important factors for development of DVI (Lindhagen et al. 1984 and Lindhagen et al. accepted for publication); DVI was more common in patients over 45 years of age than in younger patients, in both fractured legs and uninjured legs.

The importance of the popliteal valve for de-

velopment of DVI has been pointed out by Shull et al. (1979); ulceration did not occur, even in the presence of femoral vein occlusion, if the popliteal valves were competent. Our results confirm their findings, as do earlier studies from our group (Lindhagen et al. 1984, Lindhagen et al. accepted for publication).

In legs with insufficiency of the popliteal veins as measured by doppler, clinical DVI, pathologic venous pressure and insufficiency of the femoral vein were more common than in legs with normal popliteal veins. Of the eight legs with a leg ulcer during follow-up, six had insufficiency in the popliteal vein.

In conclusion, we found that clinical symptoms of DVI are more common in fractured legs than in uninjured ones, while objectively diagnosed DVI did not differ between the groups. High age and incompetence of the popliteal valve seem to be more important in the development of DVI than earlier fracture. The type of fracture seemed to affect the development of DVI to only a minor extent.

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