Intramuscular Pressure in the Lower Leg in Deep Vein Thrombosis and Phlegmasia Cerulea Dolens

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The influence of deep vein thrombosis on intramuscular pressure was evaluated in 22 patients by means of the wick technique. Intramuscular pressure was measured in the anterior tibial and the deep posterior compartments in both legs before and during treatment. The intramuscular pressure was significantly ($p < 0.001$) higher in the thrombosed leg than in the contralateral leg (0–16 mmHg). The increase in intramuscular pressure was related to the extension of the thrombus. Iliofemoral thrombosis caused a significantly ($p < 0.001$) higher pressure (17–28 mmHg) than calf thrombosis (16–23 mmHg). A compartment syndrome was found to be a part of the entity phlegmasia cerulea dolens (rest pressure 47–56 mmHg). In the treatment of phlegmasia cerulea dolens, fasciotomy is suggested additional to other therapeutic procedures.

DEEP VEIN thrombosis may produce calf swelling, tenderness, and stretch pain (Homans' sign). These symptoms are also seen in other conditions such as cellulitis, stress fracture, tenosynovitis, and acute and chronic compartment syndromes. The differential diagnosis may be difficult, requiring phlebography and intramuscular pressure recordings.[1] Deep vein thrombosis is an uncommon cause of a compartment syndrome except in its more severe form, phlegmasia cerulea dolens.[1] Phlegmasia cerulea dolens is a condition with massive venous thrombosis. Experimental studies have shown that the massive intravenous thrombosis in phlegmasia cerulea dolens may be sufficient to cause nearly complete arrest of capillary blood flow.[2–5] The critical intramuscular pressure when this occurs is 30 mmHg.[6] Gangrene follows when an increased intramuscular pressure reaches the critical closing pressure of the small peripheral arteries.[4,7] This is a result of increasing interstitial (intramuscular) pressure.[3,4,6] Intramuscular pressure has so far not been determined in deep vein thrombosis and phlegmasia cerulea dolens in man. This study estimates intramuscular pressure in deep vein thrombosis including phlegmasia cerulea dolens to see whether there was a correlation between intramuscular pressure and the severity of clinical and phlebographic findings.

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Methods

Twenty-two patients, eight males and 14 females, with a symptom-giving unilateral deep vein thrombosis, were studied. The patients were selected at random. Their mean age was 63 (range 34–82) years. The diagnosis was established by phlebography. Ten patients had a calf thrombosis, and 12 patients had an iliofemoral thrombosis continuous with calf thrombosis. The patients with calf thrombosis had mild pain and swelling of the calf, three had a positive Homans' test. Eight patients with iliofemoral thrombosis had moderate pain and swelling of the whole leg. Homans' test was positive in four cases. Four patients with an iliofemoral thrombosis presented with the classic symptoms of phlegmasia cerulea dolens: sudden excrucial pain, massive edematous swelling of the whole leg, blue discoloration, absence of peripheral pulsations, and signs of dehydration. The symptoms and signs of the 22 patients are listed in Table I.

Phlebography

Antegrade and retrograde femoral phlebography was performed according to Gullmo[8] using contrast medium Conray Meglumine 282 (Astra Meditec, Sweden). In cases with iliofemoral thrombosis, femoral phlebography on the contralateral leg was performed to visualize the upper limit of the thrombus.

Intramuscular Pressure Measurement

The wick catheter technique[9,10] was used to measure intramuscular pressure. The pressure was measured in the anterior tibial and deep posterior compartments in both legs in the supine patient at rest and during a few seconds of passive tension of the calf muscles (Homans'

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maneuver). The healthy leg served as a control. The pressures were measured on the day of admission immediately after the phlebography and before treatment. The pressures were then measured daily for four days.

Treatment

Anticoagulant therapy. Heparin was administered in all patients. Patients with iliofemoral thrombosis were treated with 40,000 IE heparin daily in continuous I.V. infusion during five days. In patients with calf thrombosis, 5000 IE heparin was given six times a day for three days. An antiprothrombinolytic drug (Dicumarol) was given per os.

Surgical therapy. Eight patients (including three patients with phlegmasia cerulea dolens) with an iliofemoral thrombosis were operated upon. A venous thrombectomy and a temporary AV-fistula for six weeks to prevent rethrombosis was carried out. The four patients with phlegmasia cerulea dolens were given I.V. infusions of blood, plasma, and Ringer lactate to combat dehydration and shock.

Elevation of the leg to 45 degrees for one day in calf thrombosis and for three days in iliofemoral thrombosis and bandaging of the whole leg were used as a routine in all cases.

Results

The intramuscular pressures in 88 compartments of 44 legs in 22 patients were measured.

Control Leg

The intramuscular pressure was 6 (range 2–16) mmHg in the anterior tibial compartment and 3 (range 0–11) mmHg in the deep posterior compartment. During passive tension of the calf muscles (Homans' maneuver), the pressure increased significantly ($p < 0.001$) to 7 (range 3–17) mmHg in the deep posterior compartment.

Calf Thrombosis

A minor though significant ($p < 0.001$) increment in both the anterior tibial, 15 (range 7–23) mmHg and deep posterior compartment, 11 (range 6–23) mmHg was seen. Passive dorsiflexion of the ankle made pressure rise ($p < 0.001$) to 20 (range 10–30) mmHg in the deep posterior compartment (Fig. 1). After treatment the intramuscular pressure was normalized within 24 hours (Fig. 2).

Iliofemoral Thrombosis

The increment of pressure was more pronounced ($p < 0.001$) in iliofemoral thrombosis than in calf thrombosis. Thus, the pressure rose to 26 (range 21–28) mmHg in the anterior tibial and to 23 (range 17–26) mmHg in the deep posterior compartment. During Homans' maneuver the pressure rose ($p < 0.01$) to 30 (range 20–42) mmHg in the deep posterior compartment (Fig. 1). After treatment the intramuscular pressure was normalized within 48 hours (Fig. 2).

TABLE 1. *Patient Material with Regard to Type of Thrombus, Leg Swelling and Homans' Sign*

Type of thrombus	No	Calf Swelling (cm, mean ± SD)	Thigh Swelling (cm, mean ± SD)	Homans' Sign
Calf	10	1.7 ± 0.6	—	3
Iliofemoral	8	3.9 ± 1.1	4.6 ± 2.0	4
Iliofemoral with phlegmasia cerulea dolens	4	9.1 ± 1.8	12.3 ± 2.4	4

Calf and thigh swelling is expressed as increase in circumference (cm) compared with the contralateral leg.

Iliofemoral Thrombosis and Phlegmasia Cerulea Dolens

Markedly elevated ($p < 0.001$) pressure values were noted, 50 (range 47–56) mmHg in the anterior tibial and 48 (range 47–52) mmHg in the deep posterior com-

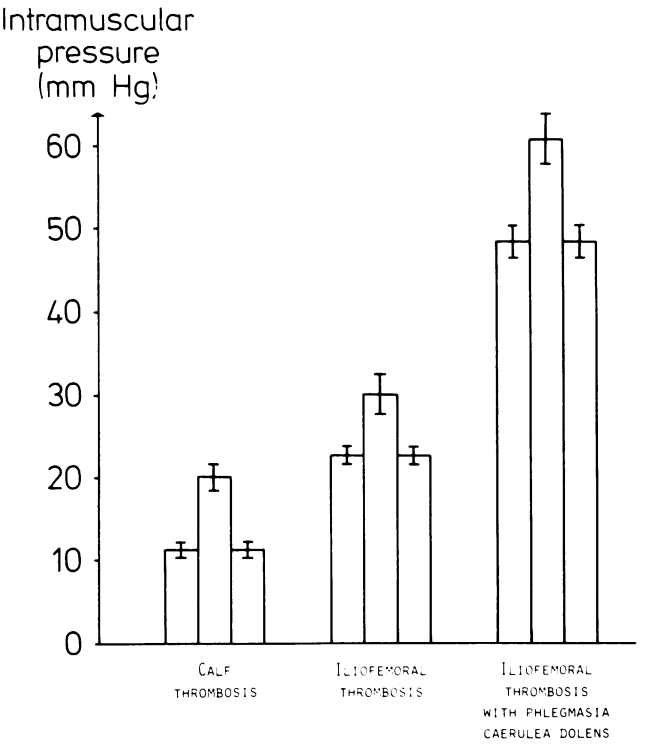

FIG. 1. Intramuscular pressure (mean ± SEM) in the deep posterior compartment before, during and after Homans' maneuver in patients with calf vein thrombosis (n = 10), iliofemoral thrombosis (n = 8) and iliofemoral thrombosis with phlegmasia cerulea dolens (n = 4).

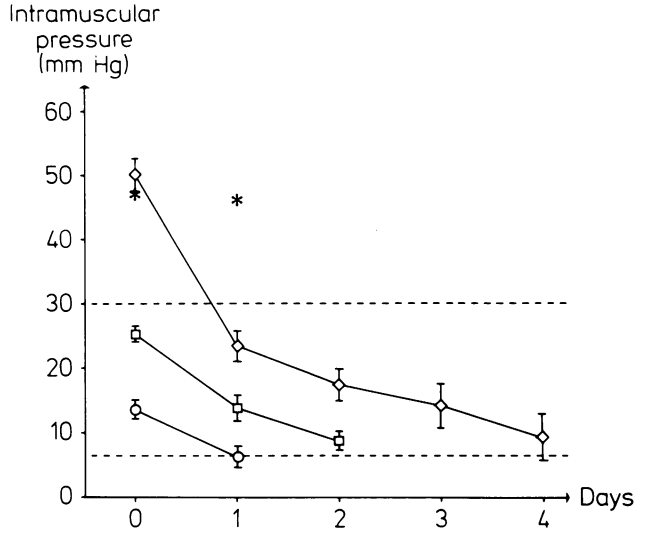

FIG. 2a. Intramuscular pressure (mean ± SEM) in the anterior tibial compartment in calf vein thrombosis (○ —— ○, n = 10), iliofemoral thrombosis (□ —— □, n = 8) and iliofemoral thrombosis with phlegmasia cerulea dolens (◇ —— ◇, n = 3) before and during treatment. *Represents one patient with iliofemoral thrombosis with phlegmasia cerulea dolens who developed gangrene. Upper and lower horizontal interrupted lines indicate "critical" and normal intramuscular pressure.

partment. During Homans' maneuver the pressure rose ($p < 0.05$) to 61 (range 53–68) mmHg in the deep posterior compartment (Fig. 1). After treatment the intramuscular pressure was gradually normalized within four days in all but one case (Fig. 2). This patient with phlegmasia cerulea dolens had a history of intermittent claudication. He did not improve after venous thrombectomy but deteriorated after 24 hours with increasing pain and no palpable distal pulsations in the leg. Intramuscular pressure remained markedly elevated, 47 mmHg, in the anterior tibial and 46 mmHg in the deep posterior compartment. The patient was reoperated to restore arterial blood flow. At reoperation a Fogarty catheter was passed into the femoral artery and down to the ankle but no thrombi were found, and blood flow did not improve. A femoropopliteal artery bypass reconstruction was performed together with a fasciotomy. The graft occluded immediately after operation and the patient had finally a femoral amputation due to gangrene of the lower leg.

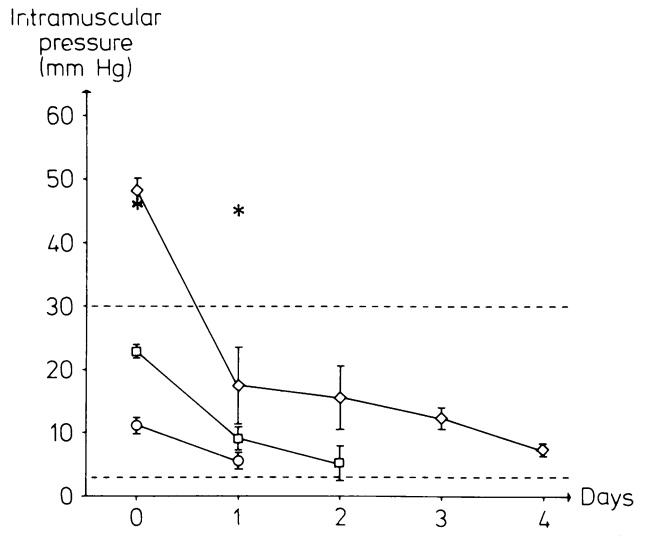

FIG. 2b. Intramuscular pressure (mean ± SEM) in the deep posterior compartment in calf vein thrombosis (n = 10), iliofemoral thrombosis (n = 8) and iliofemoral thrombosis with phlegmasia cerulea dolens (n = 3) before and during treatment. (Symbols as in Fig. 2a).

Discussion

Occlusion of the femoral vein in dogs causes a syndrome essentially identical to phlegmasia cerulea dolens in man.[4,11-13] The classical signs and symptoms of pain, cyanosis, shock, massive edema, loss of pulses, and venous gangrene are all present. The venous occlusion is followed by a marked increase in intramuscular pressure to about 40 mmHg.[4,11] This means that the pressure difference across the arterial wall in the extremity decreases to 15–20 mmHg. Burton[7] has stated that the "critical closing pressure" for arteries is approximately 20 mmHg. This explains why loss of arterial pulsation or abolished arterial blood flow is observed after venous occlusion.[4,12,13] Hargens et al.[6] concluded that capillary perfusion is reduced at an intramuscular pressure of 30 mmHg. In the present investigation it was found that the intramuscular pressure in calf vein thrombosis and in iliofemoral thrombosis was below 30 mmHg. This agrees with the hypothesis by Mubarak and Hargens[1] that deep vein thrombosis is an uncommon cause of a compartment syndrome. In iliofemoral thrombosis causing phlegmasia cerulea dolens, on the other hand, markedly increased intramuscular pressures were found well above 30 mmHg. This means that a compartment syndrome in the lower leg is a part of the entity phlegmasia cerulea dolens. The present data showed that the increment of intramuscular pressure was correlated to the extension of the thrombus. Therefore, it seems logical that the massive venous thrombosis in connection with phlegmasia cerulea dolens[5,14] is followed by a pronounced increase in intramuscular pressure. It has been shown previously that also proximal venous occlusion in healthy controls raises the intramuscular pressure in the lower leg.[10]

Pain is one of the classic signs in phlegmasia cerulea dolens. The pain is very likely due to the increased intramuscular pressure that leads to ischemia. Similarly, Mubarak et al.[9] registered that patients undergoing osteotomy felt pain when the intramuscular pressure

reached approximately 30 mmHg. In the present study it was noted that passive dorsiflexion of the foot (Homans' maneuver) caused pain in patients with deep vein thrombosis when there was a marked shortlasting increase in intramuscular pressure. This finding indicates that pain in connection with high intramuscular pressure is not only due to ischemia. It seems reasonable to assume that the pressure increase also might activate pain receptors.

Different therapeutic approaches have been tried for phlegmasia cerulea dolens (Bülow & Sager,[5] Brockman & Vasko[15]). Venous thrombectomy appears to be the most specific form of treatment since venous outflow is restored. Venous thrombectomy has also given the best results.[16-21] Venous thrombectomy with an AV-fistula was used in three of the four patients with phlegmasia cerulea dolens in the present series. Two patients had an uneventful postoperative period and were completely recovered. Intramuscular pressure showed normal values four days after operation. The third patient was initially well after venous thrombectomy but then underwent an unsuccessful course and was finally amputated. It should be noted that the intramuscular pressure remained high in this patient. One can only speculate whether the outcome would have been different if fasciotomy had been performed in the early course along with the venous thrombectomy. Fasciotomy may be of benefit by reducing intramuscular pressure and thus decrease the pressure difference across the wall of the artery, allowing a greater arterial inflow. Fasciotomy has been recommended by some authors.[3,18,22,23] Elastic bandaging of the leg was also used in the four patients. This treatment has been questioned.[12,15] It should be noted, however, that the fourth patient in the present series was treated with heparin, elastic bandaging, and elevation only with a normalized intramuscular pressure within two days and complete recovery. Anticoagulant therapy has been used to prevent further thrombosis or rethrombosis.[15] The efficacy of intravenous administration of heparin and elevation of the limb has been demonstrated.[24] Elevation to promote venous return seems to be a sound method for reducing venous engorgement.[15] Despite therapeutic efforts, amputation is common, about 50%, in phlegmasia cerulea dolens, and the mortality rate is about 25–30%.[15,18] The choice of treatment, perhaps particularly early fasciotomy, may be of great importance for the amputation rate. In the present material, amputation was necessary in one out of four patients. In the present series it has been shown that intramuscular pressure is increased in DVT. The increment of the intramuscular pressure in the lower leg is dependent on the extension of the thrombus. Thus, there is a very marked increase of the intramuscular pressure in iliofemoral thrombosis with phlegmasia cerulea dolens, causing a compartment syndrome. In these cases intramuscular pressure measurements are suggested to evaluate the need for fasciotomy.

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