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THE PAINFUL CHRONIC ANTERIOR LOWER LEG SYNDROME

A Prospective Clinical and Experimental Study

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A presumed painful chronic anterior lower leg syndrome was diagnosed in 51 patients (73 legs), 30 women and 21 men, aged 11 to 70 years, over a 2-year period. The duration of the syndrome varied from 1 month to 10 years. The patients' main complaint was pain when walking located in the medial ventral muscle compartment of the lower leg. In addition 10 of the patients (15 legs) had leg pain at rest as well and 12 (15 legs) had paresis of the extensor muscles. Thirty-four paired intracompartmental pressure recordings with the wick technique in 6 patients suggest that the more severe the syndrome the lower the pressure in the tibialis anterior muscle. Blind diathermic fasciotomy in 25 patients (36 legs) with a typical history relieved the pain and paresis completely or partly in 33 (92 per cent) out of 36 legs. No postoperative complications worth mentioning were observed. It is concluded that: 1) a chronic painful anterior lower leg syndrome should be suspected in patients with pain on walking and at rest located in the ventral part of the lower leg; 2) intracompartmental pressure measurements seem to be of little preoperative diagnostic value in non-selected patients; 3) blind diathermic fasciotomy of the anterior, medial compartment of the lower leg, including the extensor retinaculum, gives relief from pain and paresis in most patients with a typical history.

Key words: compartment syndrome; dogs; fascia; humans; leg; nerve compression syndromes; pain; tissue pressure

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Pain in the anterior muscle compartments of the lower leg on exertion can be caused by a muscle compartment syndrome. Muscle compartment syndromes are usually classified into acute and chronic forms. The acute syndrome is best known and it is usually characterized by a progressive increase in intracompartmental pressure, which, if not relieved by fasciotomy, may eventually lead to necrosis of the tissues in the compartment (Matsen 1975).

The course of the chronic syndrome is less dramatic and it is frequently overlooked; very few reports are found in the literature (Reneman 1975). The patient's main complaint is pain in the anterior part of the lower leg on exertion. The diagnosis can be made probable by excluding other causes, especially affections of the central nervous system and vascular disease. However, since increased intracompartmental pressure is supposed to be a central pathogenic factor in both acute and chronic compartment syndromes (Reneman 1968, Matsen 1975) it should be possible to arrive at a diagnosis by measuring the intracompartmental pressure.

The aims of the present prospective study were: 1) to evaluate the diagnostic usefulness of preoperative intracompartmental pressure measurements in patients with pain of

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unknown cause in the medial anterior muscle compartment of the lower leg on exertion and at rest, and 2) to see whether the pain could be relieved by surgical intervention, in this case blind diathermic fasciotomy as outlined by Reneman (1968).

PATIENTS AND METHODS

Patients

The investigation was carried out on 51 patients (73 legs) with pain of unknown cause in the anterior lower leg, who were referred to us in the period May 1976 to May 1978. The patients were non-selected and, unlike Reneman's material (1968), only 2 out of the 51 were military recruits. Twenty-nine patients (40 legs), 18 women and 11 men aged 14 to 70 years, underwent blind diathermic fasciotomy, whereas 22 patients (33 legs), 12 women and 10 men aged 11 to 67 years, were not operated on (Figure 1). Operative treatment is planned for only two of these.

Precipitating cause of the syndrome

Five patients reported trauma, including fractures, as the apparent precipitating cause of their leg pain, but the remaining 46 were not aware of any cause. Two patients had a unilateral chronic painful leg syndrome, with marked neurological findings, after a conservatively treated presumed non-traumatic subacute muscle compartment syndrome.

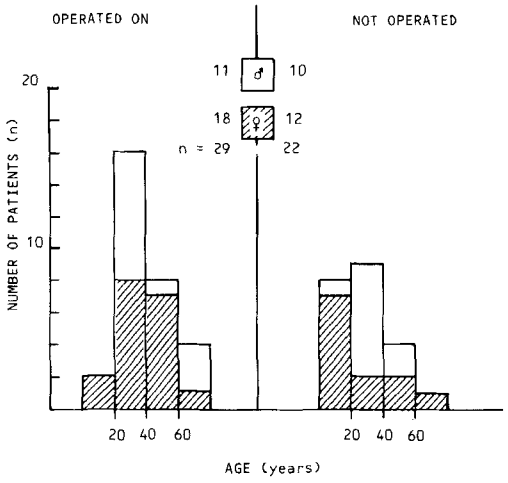

Figure 1. Histogram, left to right: In the 29 patients (40 legs) operated on the ages varied from 14 to 70 years, and in the 22 patients (33 legs) not operated on the ages varied from 11 to 67 years.

Duration of syndrome

The patients who were operated on had experienced leg pain for 3 months to 10 years, median 3 years, whereas those not operated on had had leg pain for 1 month to 5 years, median 1 year and 9 months.

Symptoms and findings

The patients' main complaint was pain on exertion in the anterior aspect of the lower leg. In addition two patients had pain on exertion anterior to the ankle joint and on the dorsum of the foot. Twenty-two had pains in both legs. Ten patients (14 legs) had leg pain at rest aggravated by walking. Nine patients reported previous episodes of oedema in the lower leg. Walking downhill sometimes aggravated the pain, and so did the use of high-heeled shoes (for women).

Slight paresis of the tibialis anterior and extensor hallucis longus muscles and wasting of the extensor digitorum brevis muscle were noted in 10 patients (12 legs), and severe paresis of the same muscles in 2 others (2 legs). However, pain in the leg often made muscle testing difficult. Hyperaesthesia or hypoaesthesia at the first dorsal web space, corresponding to the sensory part of the fibularis profundus nerve, was noted in 12 legs. The symptoms and findings in the operated patients are listed in Table 1. Neurological deficits were absent in the patients not operated on.

Before being referred to us 7 out of the 12 patients with lower leg extensor muscle paresis were examined by electromyography and the nerve conduction velocity in the deep fibular nerve was estimated. No significant pathological findings were observed except in one particular patient who had a unilateral chronic painful leg syndrome, with pain at rest and paralysis of the extensor muscles, after a conservatively treated presumed non-traumatic subacute muscle compartment syndrome. In this case the electromyogram showed denervation potentials in the affected tibialis anterior and the extensor digitorum brevis muscles. An attempt to measure the nerve conduction velocity in the deep fibular nerve in this patient failed.

Selection of patients and diagnosis

All patients who complained of pain of unknown cause in the anterior medial muscle

Table 1. Preoperative data in 40 legs (29 patients)

Type of leg pain	No. of legs	Neurological findings		
		Sensory	Motor	None
Pain on exertion	25	5	7	13
Pain at rest, aggravated by walking	14	6	6	3
Pain only after walking	1	1	1	0
Total	40	12	14	16

compartment of the lower leg, on exertion or at rest, aggravated by walking were included in the study. In addition, four atypical cases were included: three patients who complained of post-traumatic pain either in the anterior lateral muscle compartment, ventrally to the ankle joint or on the dorsum of the foot, and one patient who had leg pain only after and not on exertion.

After the first few patients had obtained relief from pain by blind diathermic fasciotomy (Sudmann 1977), the general practitioners and surgeons in the district were urged to refer such patients to our outpatient clinic. The diagnosis was assumed to be confirmed when fasciotomy gave relief from pain.

X-rays

X-rays of the lower leg, the ankle and the foot revealed no significant pathological findings. Four out of the six patients, who in addition to lower leg paresis also complained of low back pain, had a functional lumbar myelography with metrizamide done. This was normal in all four.

Pulse volume recordings

According to Darling et al. (1972) segmental pulse volume recordings are a valuable non-invasive diagnostic technique in vascular disease. We accordingly made pulse volume recordings (PVR) over the middle part of the tibialis anterior muscle in 12 randomly selected patients with a presumed chronic leg syndrome and in three normal subjects. The electronic equipment for these recordings was built as outlined by Aaslid (personal communication). The PVR obtained by this set-up seemed to be normal.

Intracompartmental pressure measurements

First we estimated intracompartmental pressure in five patients (10 legs) either by the manometer-needle technique as outlined by Reneman (1968) or by a needle threaded with a nylon wick as outlined by Aukland et al. (1975). However, the measurements were often invalidated by subfascial bleeding caused by the needle (in one patient in four out of five measurements). Furthermore, the needle nylon wick technique required about 15 to 20 minutes to obtain equilibrium. Finally, neither of the methods allowed continuous measurement or the recording of pressure fluctuations on muscular exertion and they were therefore abandoned. After our experiences with these pressure measurements we changed the technique as follows.

Equipment. Portex plastic epidural catheters (type 100/380/300, Portex Ltd., Kent, England) were suitably tailored and threaded by hand with a polyglycolic acid wick made from Dexon sutures (Davis & Geck, Hampshire, England) as outlined by Mubarak et al. (1976). The wick catheters were resterilized in an automatic formaldehyde autoclave. The wick catheter was connected to the sterile, disposable dome on a standard AE 840 physiological pressure transducer (A/S Mikro-elektronikk, Horten, Norway). The catheter and the dome were first filled with heparinized isotonic saline and the catheter was then introduced subfascially through a standard 16 gauge blunt epidural needle which was thereafter withdrawn. We were able to feel when the needle pierced the fascia. The transducer was operated in conjunction with standard Beckman pressure recording electronic systems (Beckman Instruments Inc., Ill., USA). The patency of the wick was checked by tapping the skin over the wick with a finger. If it was patent, immediate pressure jumps would be expected.

Canine studies. The accuracy and response of the Dexon-wick catheter technique was tested in two anaesthetized (pentobarbital 25 mg/kg body weight i.v.) and intubated Samoyed dogs each weighing about 10 kg. We measured pressure in the anterolateral leg compartment as outlined by Mubarak et al. (1976). No physiological pressure

fluctuations were recorded there and so we also measured subfascial pressure in the distal part of the left lumbar region 3 cm lateral to the lumbar spinous processes.

Pressure at rest and pressure fluctuations during the respiratory cycle were recorded. In addition we infused subfascially close to the wick either canine plasma or high molecular weight dextran (Macrodex, Pharmacia, Uppsala, Sweden) in order to increase intracompartmental pressure to a maximum of about 90 mmHg. During the infusion the pressure was registered by the wick technique. Finally we repeated this experiment and recorded pressure fluctuations with the wick technique and with a small solid-state pressure probe (prototype, A/S Mikro-elektronikk, Horten, Norway) simultaneously (see Figure 2). In these experiments we assumed intracompartmental pressure to be equal to the height of the infusion column (Mubarak et al. 1976). At the end of each measuring session we made a skin incision and verified that the wick, probe and infusion needle had penetrated into the muscle.

Human studies. Since we had no Dexon-wick pressure measurements in presumed normal individuals for reference we selected the following patients for intracompartmental pressure measurements because they could serve as their own controls: One group of four male patients of athletic build aged 20 to 45 years who had leg pain on exertion, and one group of two male patients aged 63 and 70 years who had leg pain at rest as well and paresis of the lower leg extensor muscles. One patient in each group was bilaterally affected, but the syndrome was marked only in one leg. In these patients we obtained paired measurements from the right and left legs simultaneously and since one leg was presumably normal (or markedly less affected) this was used as the control. In two additional patients we were not able to obtain paired measurements.

One wick was introduced into each leg in the middle part of the tibialis anterior muscle 3 cm lateral to the tibial crest. The protruding part of the catheter was carefully taped to the skin. Pressure recordings were obtained from the right and left legs simultaneously with the patient prone (resting pressure), sitting, standing plantigrade and standing on the toes and on the heels. Thereafter pressure was recorded immediately after the patient had walked about 1000 steps for 10 minutes in a corridor. Finally pressure was recorded in one leg at a time during and immediately after standardized exertion of the extensor muscles as outlined by Reneman (1968). According to Reneman (1968), valuable diagnostic results can be obtained by determining intracompartmental pressure at rest (P_r), immediately after exercise (P_0) and, for example, 6 minutes later (P_6). Selected pressure increments, that is, $\triangle P_0$ (P_0 minus P_r) and $\triangle P_6$ (P_6 minus P_r), are supposed to be more valuable diagnostic parameters than the absolute pressure recorded (Reneman 1968).

Muscle biopsies and fasciotomy

Peroperative biopsies were taken from the proximal part of the tibialis anterior muscle in eight randomly selected patients. The biopsies were placed in isotonic saline before frozen section, and stained by ATPase and ordinary methods. There were no significant pathological findings.

Blind diathermic fasciotomy over the tibialis anterior muscle was performed as outlined by Reneman (1968). By means of a fairly long probe we passed an insulated wire beneath the fascia from a small proximal to distal skin incision. Then we passed the probe and the wire back through the subcutaneous tissue to the proximal side. The fascia was thus encircled by an insulated diathermic sling. We made a small cut through the insulation at the distal end of the sling so that the wire could cut the fascia when the sling was pulled from the proximal end. The cut in the fascia was elongated proximally and distally (including the extensor retinaculum) with a pair of scissors. The deep fibularis nerve was not looked for (in the distal wound).

Indications for operative treatment and follow-up

Fasciotomy was considered the treatment of choice in patients with 1) neurological deficits, 2) with leg pain at rest and 3) with leg pain on exertion which hindered the patient's normal physical activity. Thirty-one (61 per cent) out of 51 patients fulfilled these criteria and were advised to undergo operative treatment. Twenty-nine out of the 31 have now been operated on and the postoperative observation periods vary from 8 months to 2½ years.

RESULTS

Intracompartmental pressure recordings

Canine studies. With the Dexon-wick catheter technique we registered a negative intracompartmental pressure of 2–3 mmHg in the leg. Pressure measurements in the back varied with the respiratory cycle from about

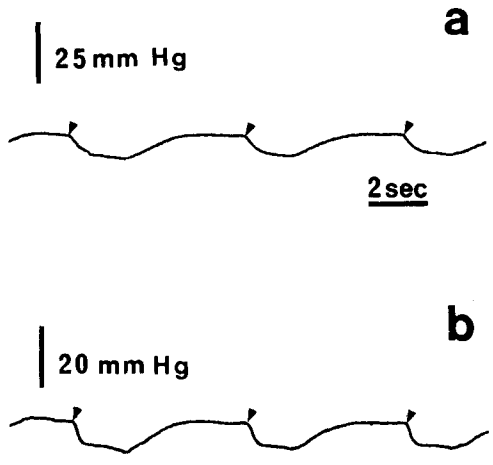

Figure 2. Simultaneous registration of intracompartmental pressure as measured with the Dexon-wick technique (a) and a solid-state pressure probe (b) during respiration. It should be noted that this registration was obtained during graduated infusion. Arrowheads indicate start of inspiration.

zero to + 4 mmHg. The pressure was highest immediately after expiration and fell rapidly to about zero on inspiration. The response of the wick was slightly slower than that of the solid-state pressure probe (Figure 2). The pressure measured with the wick technique correlated well (r = 0.99) with the height of the infusion column (Figure 3) and with the solid-state pressure probe (r = 0.98, Figure 4).

Human studies. Although they were carefully taped to the skin of the leg, some Dexon-wick catheters slid out on muscular exertion. When this happened the pressure fluctuations on exertion were reduced as compared to intracompartmental recordings in the same leg. A new wick was then inserted in the usual way. Two pressure increments, ΔP_6, after standardized extensor muscle exertion (Reneman 1968), were invalidated by a blood clot in one contralateral catheter.

The pressure varied considerably according to the patient's position and activity, ranging from −4 to +124 mmHg. The resting pressure varied from −2 to +16 mmHg (Figure 5).

In the four athletic patients aged 20 to 45 years with leg pain on exertion we found that the pressure in the more painful leg was

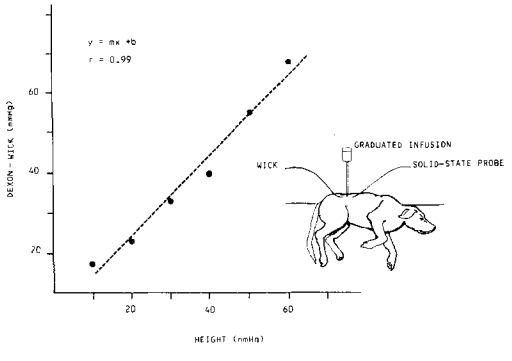

Figure 3. Scatter diagram. Six different heights of the infusion column are plotted against the corresponding pressure readings as measured with the Dexon-wick technique. The intracompartmental pressure as measured with the Dexon-wick correlated well with the height of the infusion column. Insert shows relative position of wick, infusion needle and solid-state pressure probe.

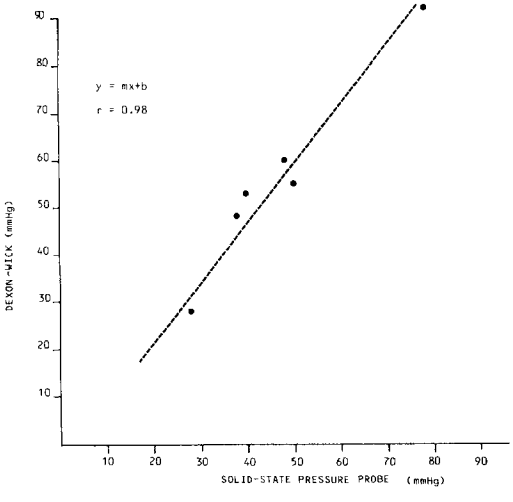

Figure 4. Scatter diagram. Simultaneous pressure measurements with the Dexon-wick and a solid-state pressure probe. Six different pressure readings as measured with the solid-state pressure probe are plotted against the corresponding readings as measured with the Dexon-wick technique. Intracompartmental pressure as measured with the wick correlated well with that of the solid-state pressure probe.

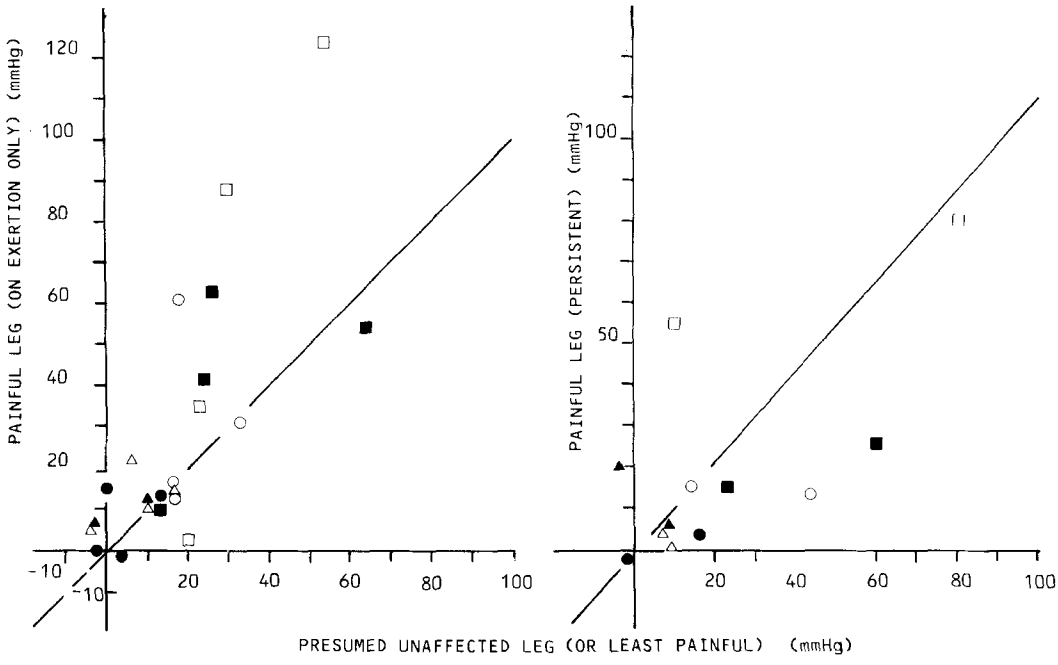

Figure 5. Scatter diagram of 34 paired Dexon-wick measurements in six patients. The pressure readings in the patient's presumed unaffected (or least painful) leg are plotted against the corresponding readings in the contralateral painful leg. Measurements in four athletic patients with pain on exertion (left) as compared to the same type of measurements in two patients with pain at rest as well (right).
● = resting pressure, △ = sitting, ○ = standing plantigrade, ■ = standing on the toes, □ = standing on the heels, ▲ = $\triangle P_6$ (see text).

higher (Figure 5), whereas in the two patients aged 63 and 70 years with pain at rest and paresis of extensor muscles the pressure was mostly found to be lower in the more painful leg (Figure 5).

With our technique, the absolute pressure measurements in the painful legs of the four athletic patients were higher than those registered in the two older patients, whereas this was not so in the less painful legs (Figure 5).

The pressure increments, $\triangle P_6$, after 10 minutes walk in a corridor varied from −3 to +9 mmHg. No special trend was noted.

Table 2. Pain relief by fasciotomy in 40 legs (29 patients)

Type of pre-operative pain	Relief from pain: Complete	Partial	None or worse	No. of legs
Pain on exertion	17	3	5	25
Pain at rest, aggravated by walking	11	3	0	14
Pain only after walking	0	0	1	1
No. of legs	28 (70 %)	6 (15 %)	6 (15 %)	40 (100 %)

Pain relief by fasciotomy

Fasciotomy relieved leg pain both at rest and on exertion completely or partly in 34 (85 per cent) out of 40 legs operated on. Six legs (15 per cent) did not improve (Table 2). We have planned an open fasciotomy in one of these patients, who was bilaterally affected, because blind fasciotomy seemed to give complete relief from leg pain at rest and on exertion in one leg, but not, for some reason, in the other. If four patients (four legs) with an atypical history are excluded, fasciotomy relieved pain completely or partly in 33 (92 per cent) out of 36 legs. The relief from pain by fasciotomy was most dramatic in the 10 patients with pain at rest.

Fasciotomy relieved the paresis of extensor muscles in all patients except one, who — despite pain relief in the lower leg — had not regained function in her paralysed muscles 8 months after the operation. We had the impression that the distal part of the fascia contributed more than the proximal part to the maintenance of the painful syndrome.

Two patients experienced severe constant pain of unknown cause in the leg after the operation. One of these patients recovered spontaneously, the other was not relieved of her leg pain by the fasciotomy. No other postoperative complications were noted.

DISCUSSION

A patient with low back pain and pain and muscle paresis on exertion on the lower leg may present a difficult diagnostic problem. Affections of the central nervous system and vascular disease should be excluded before performing a minor operation like fasciotomy on the leg. On the other hand, it is essential to exclude a chronic lower leg compartment syndrome before embarking on a major operation such as laminectomia for a presumed lumbar spinal stenosis or a disc herniation.

Affections of the central nervous system were here ruled out by a thorough neurological clinical investigation in all patients. In addition, patients with severe neurological deficits were examined by functional myelography. Furthermore, a non-invasive screening test such as pulse volume recording made vascular disease unlikely in randomly selected patients.

In the chronic compartment syndrome neither oscillometry, electromyography and arteriography at rest and during pain nor phlebography before and after exertion seem to be of any diagnostic value (Reneman 1968). It might thus be assumed that a chronic compartment syndrome can only be diagnosed by excluding other causes. Since increased intracompartmental pressure is supposed to be the principal pathogenic factor in a compartment syndrome (Matsen 1975), intracompartmental pressure measurements seem to be a valuable diagnostic aid (Reneman 1968). However, the trend in our estimates of the intracompartmental pressure in the few patients tested suggests that the more severe and painful the syndrome, the lower the pressure registered. Nevertheless, most of the patients we operated on were relieved from pain by fasciotomy, which is thought to relieve the symptoms in both acute and chronic compartment syndromes (Reneman 1968, Matsen 1975). Furthermore, the greater the pain our patients experienced preoperatively, and thus the lower the pressure recorded, the more dramatic the relief from pain by fasciotomy. How can these apparently paradoxical observations be explained?

With the exception of a few case reports (see Reneman 1975), only one published clinical study could be found describing the *chronic* anterior compartment syndrome of the leg (Reneman 1968). Reneman's material seems to consist of 51 patients, 49 men and 2 women. Most of them were young male military personnel (median age 21 years). Reneman's patients were thus highly selected. None of his patients had constant pain at rest or any neurological deficits. The results of his pressure measurements, estimated by the

needle-manometer technique, indicate that the normal rise in intracompartmental pressure on exertion is significantly reduced with increasing age, and he found a significantly higher pressure in men as compared to women and in patients as compared to presumed normal persons in the same age group. Furthermore, the pressure increase Reneman found after a standardized muscle exertion normally fell to the resting value (about zero mmHg) within 6 minutes, whereas in patients the pressure fall was significantly slower within the same period of time. Reneman therefore claims that pressure measurements are a valuable diagnostic aid.

The wick technique is supposed to measure interstitial pressure, while the needle-manometer technique is supposed to measure total intramuscular pressure (Scholander et al. 1968, Reneman 1968, 1975).

The Dexon-wick technique seems to be a fairly useful and reliable method for estimating intracompartmental pressure (Mubarak et al. 1976). Our measurements in dogs support this contention (Figures 2–4). However, in the author's opinion these pressure measurements are only an estimate — or index — of intracompartmental pressure. Furthermore, we did not verify the actual position of the wicks in patients as we did in the animal experiments. The results of our measuring sessions suggest, however, that the wicks were located subfascially and not subcutaneously.

Our paired pressure measurements suggest that the more severe the syndrome, the lower the pressure (Figure 5). Since forceful muscular contractions are supposed to increase intracompartmental pressure (Reneman 1968), these observations may be explained by the fact that the more severe the syndrome in our patients, the less forceful the muscle contractions, owing to pain and paresis, and thus the lower the pressure. This contention is supported by eight paired intracompartmental Dexon-wick pressure recordings measured as outlined above in a 63-year-old man, who contracted unilateral painless drop foot of unknown cause. In the paralysed leg the maximum pressure registered was 2 mmHg, whereas in the other, presumedly normal, leg it was 50 mmHg (unpublished data).

In a young athletic patient with a typical history the diagnosis presented no problems and the indications for fasciotomy were based solely on the patient's failing ability to manage everyday activities including sport. Although a relatively high pressure was recorded (Figure 5), pressure measurements seem thus to be of little diagnostic value in such patients. In contrast, in a middle-aged or elderly person, with, for example, low back pain, leg pain at rest and paresis of the extensor muscles of the lower leg, the differential diagnosis may in many cases be very difficult. In the two patients tested with the Dexon-wick technique the pressure seemed to be lowest in the most painful leg. These observations may suggest that increased pressure within the whole medial muscle compartment of the lower leg was not a main pathogenic factor in these two patients. Thus, paradoxically, intracompartmental pressure measurements seem to be of least diagnostic aid when they are most needed. Furthermore, in selected patients neither electromyography of leg muscles nor nerve conduction velocity measurements in the deep fibular nerve were of any diagnostic aid.

Most of our patients were relieved of the pain by fasciotomy, often quite dramatically. Since fasciotomy is supposed to relieve pain, not only in compartment syndromes (Reneman 1968, Matsen 1975), but also in the anterior entrapment syndrome (Kuritz 1976), an anterior entrapment syndrome of the leg might also be considered.

The anterior entrapment syndrome of the lower leg is supposed to be caused by direct or indirect trauma causing entrapment of the deep fibular nerve where it passes deep to the extensor retinaculum (Kopell & Thompson 1976, Kuritz 1976). The initial symptoms and signs are supposed to be located in the part of the nerve distal to the entrapment, but later retrograde pain may occur. Furthermore

marked local secondary autonomic dysfunction may be encountered (Kopell & Thompson 1976, Kuritz 1976). Only 5 of the 51 patients investigated here reported trauma as the apparent precipitating cause of their leg pain, and the initial pain was usually located in the leg and not on the dorsum of the foot. Moreover, the more severe neurological deficits registered here were related to the proximal and not to the distal part of the deep fibular nerve. Thus, the painful leg syndrome — or syndromes — of our patients do not seem to fit either the description of the anterior entrapment syndrome as outlined by Kuritz (1976) or the chronic anterior leg compartment syndrome as outlined by Reneman (1968) and the aetiology and pathophysiology of the leg syndrome in our non-selected patients seem obscure.

Slight pressure on a previously sensitized nerve is supposed to cause pain by fibre interaction (Granit et al. 1944). These observations may suggest that slight pressure on — or within — the deep fibular nerve in the compartment may be a pathogenic factor in patients with a painful anterior lower leg syndrome.

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