Electromyography in nutritional osteomalacic myopathy

P. F. IRANI

From the Department of Neurology, J.J. Group of Hospitals, Byculla, Bombay 400008, India

SYNOPSIS Electromyographic studies in 15 women with nutritional osteomalacia and proximal muscle weakness showed brief duration motor unit action potentials of normal amplitude and increased proportion of polyphasic motor unit potentials in the majority of them. By employing quantitative methods of electromyography, more positive results were obtained, thus reducing the sampling data. The histology showed non-specific muscle fibre atrophy without degenerative changes and the clinical and electromyographic examinations together showed clear evidence of a myopathy, suggesting a reversible transient block of the muscle fibres. Contrary to a recent suggestion, the nature of muscular change in osteomalacia remains the same regardless of its cause being nutritional or otherwise.

Weakness, especially of the proximal pelvic muscles, has been well recorded in nutritional osteomalacia (Gough *et al.*, 1964; Felton and Stone, 1966; Singhal, 1966; Smith and Stern, 1967, 1969; Wadia and Swami, 1970) since Scott's vivid description of this in her extensive survey of osteomalacia in India (Scott, 1916). It has also been pointed out that osteomalacia from causes other than malnutrition may be associated with this weakness (Ekblom *et al.*, 1964; Prineas *et al.*, 1965; Chalmers *et al.*, 1967; Smith and Stern, 1967, 1969). It is generally accepted that this is a form of reversible 'biochemical myopathy' related in some ways to the calcium metabolism and vitamin D intake (Prineas *et al.*, 1965; Henson, 1966a,b; Smith and Stern, 1967, 1969). Electromyography has been occasionally used in the last decade to confirm the initial clinical impressions (Ekblom *et al.*, 1964; Prineas *et al.*, 1965; Singhal, 1966; Smith and Stern, 1969; Wadia and Swami, 1970; Stern *et al.*, 1973). A more systematic approach by quantitative electromyography was thought necessary and forms the basis of this report.

Coincidentally, Skaria *et al.* (1975) have recently given a detailed account of the use of similar methods in India.

METHODS

Fifteen patients who fulfilled the strict criteria of diagnosis and in whom electromyography was done form the basis of this report. All these patients had bone tenderness and proximal muscle weakness. In addition, elevated serum alkaline phosphatase, serum calcium, and phosphate levels, radiological and histological changes of osteomalacia, and a good therapeutic response to vitamin D were taken into consideration. The factor of undernutrition, especially for vitamin D, was established and no other cause of osteomalacia was evident.

Electromyographic examination was carried out with a 2-channel DISA (Model 14A21) electromyograph using concentric needle electrodes. In the first six cases routine electromyographic examination was done, but later it was felt that the quantitative method recommended by Buchthal (1957) would yield better results. Hence in the next nine cases the mean duration of the motor unit potentials (MUP), their amplitude, and the proportion of polyphasic motor unit potentials were calculated. Fifteen control patients selected randomly, having no deficiency disease or muscle weakness and matched for age,

from both sexes, were similarly examined to obtain control quantitative data. Motor nerve conduction velocity was measured in 10 patients mainly in the lateral popliteal nerve at a constant room temperature of 21°C.

RESULTS

All patients were females from the low socio-economic group. Nine of the 12 married women were multiparous and had been through prolonged periods of lactation. Their diet was poor, particularly lacking in milk, milk products, and vitamin D-containing foods. In addition to this, occupied as they were with rearing the family, they had little exposure to sunlight, and eight of them wore a 'burkha' when they went outdoors.

All patients presented with bone pains, mainly of the pelvis, of an average duration of 12 months. Regardless of the pain, they also showed demonstrable proximal pelvic girdle muscle weakness and a waddling gait. This was most obvious in two of them where the pain was mild. This was also strikingly brought out in

seven patients who had additional shoulder girdle weakness but with negligible pain. In eight patients the bone pains and proximal weakness appeared almost simultaneously, while in the other seven pains preceded the weakness by an average of eight months. The lower limb deep reflexes were normal in nine, brisk in three, sluggish in two, and in one the knee reflexes were brisk but ankle reflexes were absent.

Radiological changes typical of osteomalacia were seen in all except two patients (Table 1 and Fig. 1a,b). No radiological evidence of hyperparathyroidism was seen.

TABLE 1
RADIOLOGICAL FEATURES

	<i>Patients (no.)</i>
Generalized demineralization	12
Pseudo-fractures (Looser zones)	10
Triradiate pelvis	5
Biconcave (cod-fish tail) vertebral bodies	5
Normal	2

(a)

(b)

FIG. 1 (a) Radiograph of the pelvis showing generalized demineralization, bilateral pseudo-fractures of the pubic rami, and Looser zones over the inner aspects of shafts of both femora. (b) Radiograph of the lumbar spine showing generalized demineralization and biconcave vertebral bodies.

SERUM BIOCHEMISTRY The serum alkaline phosphatase was elevated in 12 patients, and ranged from 86.4 to 909 KA units/l with a mean of 359.4 KA units/l. The serum calcium ranged from 1.95 to 3.23 mmol/l with a mean of 2.5 mmol/l and the serum inorganic phosphates ranged from 0.56 to 1.54 mmol/l with a mean of 0.97 mmol/l. Two patients (one with a serum calcium level of 3.23 mmol/l and the other with a serum inorganic phosphate level of 0.56 mmol/l) did not have any radiological or biochemical evidence of parathyroid disorder, their serum phosphate and calcium level being 0.87 mmol/l and 2.74 mmol/l respectively.

The product of calcium and phosphate levels (calculated in mg/dl) was lower than 27 in five patients and less than 30 in two more, these figures being at times considered significant for the diagnosis of osteomalacia (Howland, 1923; Chalmers *et al.*, 1967).

BONE HISTOLOGY A bone biopsy was obtained from the iliac crest in eight patients. In four the presence of irregular, abnormal seams of inadequate calcification frequently accompanied by frank osteoid tissue, and increased osteoblastic and fibrous activity supported the diagnosis of osteomalacia. In one, only recent calcification but no other changes of osteomalacia were seen. In a girl of 16 years, the biopsy specimen showed active rickets. In the remaining two, the bone was normal.

ELECTROMYOGRAPHY Electromyography was done in 48 muscles of both upper and lower limbs, 32 of which were proximal and the rest intermediate and distal. No abnormal features were seen in any of the intermediate and distal muscles.

The findings in the proximal muscles were as follows: on volition, in the six patients on whom routine qualitative electromyography was done, it was found that of the muscles examined eight were normal but six showed brief duration polyphasic motor unit potentials of normal amplitude. It was, therefore, felt that quantitation of these potentials would yield better results.

In 11 of the 18 muscles in the next nine patients thus examined the mean duration of the

motor unit action potentials was reduced by more than 20% of the controls.

Figure 2 shows quantitated data of patients and control subjects of the quadriceps and the deltoid muscles. In the controls, the mean duration of MUP in the quadriceps was 6.8 ms, while the patients showed a clear reduction. Similar changes were seen in the deltoid. The amplitude of MUP remained unremarkable, but the increase in polyphasic potentials was significant ($>12\%$).

Figure 3 illustrates the quantitative data of polyphasic motor unit potentials. In the quadriceps, the percentage of polyphasic potentials in the majority of the control subjects was from 0 to 4% with occasional increase to 10%. As opposed to this, in the osteomalacic patients the polyphasic potentials were more than 20% of the total MUP. Similar observations were made in the deltoid. The interference pattern was in the main full. It was found that quantitation gave positive results in 61% as against 43% by the earlier qualitative method.

FIG. 2 Mean duration of the motor unit potentials in the quadriceps and deltoid muscles of control subjects and patients.

FIG. 3 The percentage of polyphasic motor unit potentials in the quadriceps and deltoid of control subjects and patients.

There was no evidence of denervation as shown by the absence of spontaneous activity and normal motor conduction velocity in the lateral popliteal nerve (38 m/s to 60 m/s). Electromyography gave unequivocal evidence of primary muscle involvement in most of the clinically affected muscles.

MUSCLE HISTOLOGY Muscle was obtained for histological examination from nine patients, seven from the gluteus and two from the quadriceps. In six muscles (four glutei and two quadriceps) non-specific atrophy was found on light microscopy. In three of these, electron-microscopy was done and in all of them the atrophy was confirmed. Interestingly enough, in one of the three reported as normal on light microscopy non-specific atrophy was seen on electronmicroscopy.

THERAPY All patients showed some initial improvement while on hospital diet for only about two weeks. They were treated with weekly or fortnightly intramuscular injections of vitamin D₂ (600,000 units of calciferol). All of them (except one who went away before vitamin D could be administered) showed a marked regression in bone pains and bone tenderness within two to four weeks of treatment and the majority were free of pain at the end of eight to 10 weeks.

The proximal muscle weakness improved at a slower pace depending upon the severity of the initial disability. Recovery was seen as early as two weeks and as late as 12 weeks. Electrophysiological re-examination was carried out in only three patients. In two of them, when re-examination was conducted at an interval of five weeks, there was considerable regression of the myopathy. The mean duration of the MUP had reached nearly normal values, while the percentage of polyphasic potentials had considerably reduced (Fig. 4a,b).

The clinical improvement in these patients had kept pace with the electrophysiological assessment. In the third patient in whom the deltoid muscle was not clinically weak, initial examination showed a short mean MUP duration of 3 ms, whilst after four months it had risen to 5 ms (Fig. 4a).

DISCUSSION

Clinically we were convinced that, even allowing for the pain, there was undoubted weakness of the muscles. This was clearly more evident in the two patients with pelvic girdle weakness and seven others with additional weakness of abduction of the shoulders without the limiting factor of pain. Moreover, during the stage of recovery the pains disappeared quickly, unmasking the muscular weakness. As all but one patient was ambulant, the question of disuse atrophy does not arise, especially as no localized wasting was seen.

The electromyographic evidence of myopathy was seen by our earlier qualitative and later quantitative methods of examination. The preponderance of brief duration motor unit potentials with or without strikingly increased

FIG. 4 (a) The tendency of the mean duration of the motor unit potential to return to normal limits after Vitamin D therapy. (b) The reduction in the percentage of polyphasic motor unit potentials after Vitamin D therapy.

percentage of polyphasic potentials was considered as evidence of primary muscular disease in our earlier cases; the reduction of the mean duration of motor unit potentials by more than 20% confirmed this with greater accuracy in the latter part of this study. The MUP amplitude was mostly unremarkable. There was also no evidence of denervation; the occasionally reduced interference pattern was considered to be due to lack of maximum effort on the part of the patient. At the same time, it was obvious with both methods of examination that electromyography may be normal even in a clinically affected muscle, although this was less so with quantitative analysis. Conversely, less frequently, electromyography showed changes suggestive of myopathy in a muscle without clinical weakness. A correlative analysis of the deltoid muscle shown in Table 2 illustrates these facts.

It appears in this series that, as expected, the quantitative method of examination was superior to the qualitative one, as 61% of the muscles examined by the former method

showed evidence of myopathy as against 43% by the latter. The rather small numbers involved in the examination preclude a statistical analysis, but a larger series by Skaria and others (1975) has shown that quantitation in electromyography reduces the sampling error and yields more positive results.

Previous authors (Ekblom *et al.*, 1964; Prineas *et al.*, 1965; Singhal, 1966; Smith and Stern, 1967, 1969; Rosin, 1970; Wadia and Swami, 1970; Stern *et al.*, 1973) have also found electromyographic evidence of primary muscle disease in osteomalacia of nutritional and other

TABLE 2
CLINICOELECTRICAL CORRELATION (DELTOID MUSCLE)

Clinical examination	EMG	Patients (no.)
Affected	Abnormal	5
Affected	Normal	2
Normal	Normal	1
Normal	Abnormal	2

aetiology (hyperparathyroidism; renal; post-gastrectomy; gluten sensitive enteropathy, etc.). Similarly, during the course of this study, seven patients having proximal muscle weakness of osteomalacia secondary to other aetiological factors (hyperparathyroidism, two; phenytoin induced, one; renal, four) were examined and four out of seven (57%) showed electromyographic evidence of primary muscle involvement.

Table 3 illustrates the variations in the results obtained by other authors which probably follow the different methods of examination adopted, the number of muscles sampled per patient, and the number of patients examined. As all these publications have made passing reference to electromyography, more details were not clearly available. Interestingly enough Smith and Stern (1967) in their earlier publication reported that routine electromyography showed myopathic potentials in 100% (five out of five) of their myopathic patients, but in a later larger series (Stern *et al.*, 1973) these results fell to 71% (15 out of 21). As is well known in all forms of myopathy (Kugelberg, 1949; Pinelli and Buchthal, 1953; Eaton and Lambert, 1957), the most common finding is a significant reduction in the mean duration of the MUP. This was observed as most important in our patients (66.6%). Skaria *et al.* (1975) in a recent controlled study from India using the quantitative method in five separate muscles also found

this evidence of myopathy as significant in 83.3% of their 30 patients, one of whom had no clinical weakness. However, unlike Skaria *et al.*, in our series the next most frequent abnormality was a significant increase in the proportion of polyphasic potentials; the amplitude was unhelpful. Whereas only a third of their patients showed abnormal findings in the deltoid, we had a higher percentage (70%) of positive results.

Like us, Skaria *et al.* (1975) and Smith and Stern (1967) have demonstrated the reversible nature of the myopathy by showing that as recovery of the muscular weakness occurs under treatment the electromyogram reverts to normal.

The absence of denervation pattern and the normal nerve conduction velocity led us to believe that there was no evidence of a lower motor involvement, a belief shared by others (Prineas *et al.*, 1965; Singhal, 1966; Smith and Stern, 1967, 1969; Rosin, 1970; Wadia and Swami, 1970; Interim Report, 1972). Skaria *et al.* (1975) alone have reported reduced nerve conduction velocity in almost all their patients, although they were careful to point out that this may be due to a separate subclinical peripheral neuropathy. This will require further substantiation because the coexistence of peripheral neuropathy with nutritional osteomalacia has not been generally observed by others by any method of examination.

Finally, Table 4 shows a comparison between the findings of electromyography and histology (light and electronmicroscopy) as seen in the corresponding muscles of the same patient, each examined by one of these methods. Histology showed either normal muscle or changes of non-specific atrophy of various degrees. Electromyography showed evidence of myopathy. It is well recognized in nutritional and non-nutritional osteomalacia and in other metabolic myopathies (Prineas *et al.*, 1965; Smith and Stern, 1967, 1969; Stern *et al.*, 1973) that histological changes as described here may go hand in hand with the electromyographic findings of myopathy. Buchthal (1970) explains this on the basis of a reversible transient block of the muscle fibres without actual destruction of the fibres and repair.

To date light microscopy and occasional reports of electronmicroscopy (Smith and Stern, 1969; Stern *et al.*, 1973) have shown no signifi-

TABLE 3
ELECTROMYOGRAPHIC ABNORMALITIES IN
OSTEOMALACIC MYOPATHY OF VARIED AETIOLOGY

Authors	Patients with EMG studies (no.)	No. with abnormal EMG	Incidence of abnormal EMG (%)
Ekbohm <i>et al.</i> (1964)	3	3	100
Prineas <i>et al.</i> (1965)	2	2	100
Singhal (1966)	5	2	40
Smith and Stern (1967)	5	5	100
Smith and Stern (1969)	8	7	87.5
Wadia and Swami (1970)	12	4	33
Rosin (1970)*	Unspecified	0	0
Stern <i>et al.</i> (1973)	21	15	71
Skaria <i>et al.</i> (1975)†	30	25	83.3
Present series	15	10	66.6

*Total number of patients and number with myopathy unspecified.

†One patient without clinical myopathy.

TABLE 4
EMG—HISTOLOGICAL CORRELATION

Muscle	(No.)	Myopathic EMG	Light microscopy		Electronmicroscopy	
			Normal	Non-specific atrophy	Normal	Non-specific atrophy
Gluteus maximus	3	3	1	2	—	3
Quadriceps	2	2	—	2	—	1

cant differentiating point in the myopathy of the osteomalacias of various aetiology. Dastur *et al.* (1975) maintain that on electronmicroscopy they found 'evidence of non-specific muscular atrophy in the nutritional group and degenerative changes which constitute a form of myopathy similar to those seen in muscular dystrophies in the group with a major added metabolic or endocrinal factor'. They contend that in nutritional osteomalacia no myopathy exists and the proximal muscle weakness is in the nature of an atrophy, a reflection of a combination of disuse and malnutrition of the musculature. It was felt that truly myopathic changes appear only when metabolic or endocrinal factors cause osteomalacia. This histological and pathogenetic distinction is contradictory to the clinical and electrophysiological findings. Disuse from pain contributes very little to the symptomatology and is, moreover, common to all osteomalacias. We strongly feel that, even though some of the clinical material used by Dastur *et al.* (1975) and here is the same, the nature of muscular change in osteomalacia of nutritional aetiology is no different from that due to other causes. Osteomalacia regardless of its aetiology is in fact a true reversible myopathy, as noted by others earlier.

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