Automatic analysis of EMG in the patients with low back pain

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There are many organs or tissues around the lumbar region which would produce low back pain. The first step to treat the patients with low back pain is to identify the tissues or organs which give rise to the pain. The analysis of the motor unit action potentials from the erector spinae and the gluteus maximus muscles could be of use in the objective evaluation of the low back pain.

The present paper describes the quantitative analysis of the motor unit action potentials from the erector spinae and the gluteus maximus muscles using computer, with the purpose of identifying the tissues giving rise to low back pain.

The subjects observed consisted of 84 patients with low back pain and 20 normal persons (104 subjects in total). Electromyograms were taken with concentric needle electrodes from the erector spinae and the gluteus maximus muscles during standing posture with slight forward bending. Three hundred consecutive discharges of each motor unit were recorded on the data recorder (TEAC R70 A), and all the motor units with amplitudes higher than 40 nV were then picked up and fed to the computer (Signal processor 7T07, Sanei). The motor unit discharge was finally displayed as functions of amplitude (peak to peak amplitude), durations and integral of the action potentials per unit of time in the form of histogram. Moreover, the variation of the intervals between the consecutive discharges was automatically measured and displayed as the interval diagram. In order to analyze the duration of the action potentials with bi-phasic or multi-phasic potentials, all negative deflections were converted to positive deflections and then integrated with a time constant of 1 sec. Then the computer began to measure the duration of these positive deflections which were larger than 40 nV.

In normal subjects, a peak in the amplitude histogram during the weak voluntary activation was seen at about 100 nV. In the duration histogram of the weak voluntary activation in normal persons, there was a peak at 2 msec with slopes ending at 8~10 msec. Thus the histogram consisted of a peak with steep slopes on both sides. During the mild voluntary activation of the muscles, the histograms showed less steep slopes, ending at 10~12 msec.

The intervals in normal persons fell within 128 msec during both weak and mild voluntary muscle activation. The integrate histogram in normal persons (Fig. 1, left) shows

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Normal pattern

Neurogenic pattern

one peak during the weak voluntary muscle activation, and the peak was shifted to the left during the mild voluntary muscle activation. The typical patterns in the patients with lumbar Intervertebral Disc Herniations (I.D.H.) are shown in Fig. 1 (right). In the cases with I.D.H., the existence of the prolapsed nucleus was confirmed by the surgery. The pain in these cases originated in the involved nerve roots, and the muscles which were innervated by these nerve manifested a neurogenic atrophic pattern in the EMG. Consequently, these cases were classified as neurogenic pain pattern. The amplitude and duration histograms in these cases showed multi-peak or non-peak with a delayed end-point. The discharge intervals exhibited large variations during both weak and mild voluntary muscle activation. The integrate histograms did not show any particular patterns according to the pathological changes. The decrease in the muscle power was suggested by large variations in the discharge intervals. Despite the decrease in the muscle power, the damaged muscles had to support the lumbar spine in standing. This was suggested by the existence of the action potentials of high and low amplitude and narrow and wide duration (Fig. 1, right). Some patients with acute low back pain fell under the category of the myo-fascial pain. These were the muscle spasm and tenderness over the muscles or the fascia of the lumbar region, but no neurological signs were detected. When the lumbar spine was moved, pain increased. The pain was completely relieved by infiltrating the muscles with 1% procaine. These cases were classified as the myogenic pain pattern. The results on these patients are shown in Fig. 2 (left). Small action potentials due to the muscle spasm were observed in
Myogenic pattern  
(M. gl. max.) (acute low back pain)  
weak contraction  
mild contraction  

Ligamentous pain  
weak contraction  
mild contraction  

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**Fig. 2** Histograms of muscle activities in Myogenic and Ligamentous pain pattern

the histograms of interval variations with high frequencies.

It is assumed that not the involved muscles, but the ligaments participated in supporting the lumbar posture.

The tenderness over the sacro-iliac or ilio-lumbar ligaments was demonstrated in some patients with acute low back pain, and the pain was relieved by infiltrating the ligaments with 1% procaine. The ligamentous pain pattern refers to the pain syndrome in which the pain originated in the ligaments or joints capsules of the lumbar region.

Action potentials with large & small amplitudes and long & short durations were observed in the histograms as shown in **Fig. 2** (right). The discharge intervals considerably varied during the weak activation whereas they remained fairly constant during mild activation (**Fig. 2**). It is suggested that the weakened ligamentous supports around the lumbar region were compensated for by the muscular supports. The patients with low back pain were classified into four patterns, according to the tissues giving rise to pain, that is, normal, neurogeni, myogenic, and ligamentous patterns.

Recently many papers have been published which deal with computer analysis of the motor unit action potentials. However, there are few literatures among them which throw some light on the pain mechanisms in the patients with low back pain. There is a possibility that the pain mechanisms in the patients with low back pain are clarified by means of quantitative analysis of the motor unit action potentials. The muscle, tendon, fascia,
bone, joint capsule and other mesodermal structures are the frequent sources of the pain syndromes. On the other hand, intervertebral disc, annulus, ligamentum flavum and interspinous ligaments are non-pain-sensitive tissues. Excessive strain and stress on these tissues and the muscle spasm following the deterioration of the supporting mechanisms in standing position may result in pain. The antigravitational muscles in these patients manifested the muscle spasm which was caused by the nerve irritation or reflex mechanism. In animal experiments, painful irritation of the lumbosacral joints and ligaments induces reflex spasms of the erector spinae and hamstring muscles. Continuous muscle spasm would produce local ischemia leading to some metabolic changes which, in turn, serve as a new source of noxious stimuli. According to the quantitative analysis of the motor unit action potentials of the erector spinae and the gluteus maximus muscles in the patients with low back pain, the pain mechanisms were classified into four patterns, as stated above.

The pain originating tissues were first inferred by means of obtaining clinical findings and then EMG analysis of these patients were carried out. Subsequently the results obtained through these two kinds of procedures were compared with each other, and the EMG pattern peculiar to the given pain originating tissue was therewith determined.

It is assumed in the case of the neurogenic pain pattern that it was the discharges from the muscle with neurogenic atrophy as well as muscle spasm that gave rise to the neurogenic pain pattern. This is also true of the pain in the case of the myogenic pain pattern.

The high frequency discharge in the diagram of interval variations in the case of the ligamentous pain pattern was observed during slight lumbar flexion position. This would suggest that the muscle supports have replaced the weakened ligamentous supports.

REFERENCES

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