PHENOL BLOCK IN THE MOTOR ENDPLATE ZONE CONTROLLED BY EMG-REGISTRATION

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I Abstract

In our institute,a rehabilitation center, injections with phenol in aqueous solution (5%) are often used to decreese uncontrolled activity in muscles of patients with upper motor neuron disfunction. It was felt desirable to improve the way of finding the appropriate places for injecting phenol. In this improved procedure we use the amplitude of the surface EMG signal after stimulation to find these appropriate points. There is also a special EMG set up developed to registrate and analyse the surface EMG (e.g. histogram, power density function) before and after the phenol block. The purpose of this EMG set up is to analyse the results of the phenol block and in general the course of certain neuromuscular disorders in a more quantitative way.

II Introduction

By means of injections with phenol in aqueous solution it is possible to block part of a nerve or nerve endings. The principle aim of such a block is to decrease uncontrolled activity. This can result in a better balance between agonists and antagonists and therefore specific movements can be performed again.
Many investigators reported on this subject e.g. Halpern (1966, 1977), Easton et al (1979) and Copp and Keenan (1972).
With respect to the method used basically, two different procedures are described viz: a) blocking of the nerve
b) blocking of the nerve endings (often called 'motor endplate block')
Halpern (1977) shows that the indication 'motor endplate block' is misleading, because histological examination shows that in fact nerve endings or groups of nerve endings are blocked on injecting phenol.
In our institute we use method b, mainly because of the following two reasons: 1. particular muscles can be blocked with a rather graded level.
2. afferent paths are hardly affected.
Since 1978 phenol blocks are carried out regularly on patients with an upper motor neuron disfunction. Recently we found it desirable to improve on two aspects of the procedure.
First, it proved sometimes rather difficult to find the appropriate places to inject phenol and therefore we looked for a tool in order to find these points more accurately.
Secondly it appeared to be difficult to give a quantitative description of the results.
In this paper we will describe our results with respect to the points just mentioned.

First it will be demontrated how EMG can be used as a tool for finding optimal places for phenol blocks. Secondly it will be shown how EMG can be used to evaluate results. With respect to this latter point it must be mentioned that a special EMG set up is developed in our clinic, especially for evaluating the course of certain disorders. In both cases EMG is

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measured by means of surface electrodes. With respect to 'EMG as a tool for finding an optimal place' one must realize that by means of surface EMG a more integrated view of the muscle functioning is obtained.
With reepect to the subject 'EMG measurements in order to evaluate results' the following remarks can be made:
In a rehabilitation center the use of surface electrodes leads to a better cooperation of the patient for obvious reasons.
Indeed in many cases patients fear needle EMG to such a degree that longterm investigations are hardly possible. We feel that the value of surface EMG is in fact underestimated. Especially in situations where the function of a total muscle is the primary aim of the investigation, surface EMG can be a more appropriate tool than needle EMG.
Finally, placing a surface electrode on a muscle is a relatively easy job that can be performed by a less qualified person.

III Methods

In this section the standard procedure of phenol blocking is described.
In figure 1 a photo of the EMG and stimulus apparatus is given.

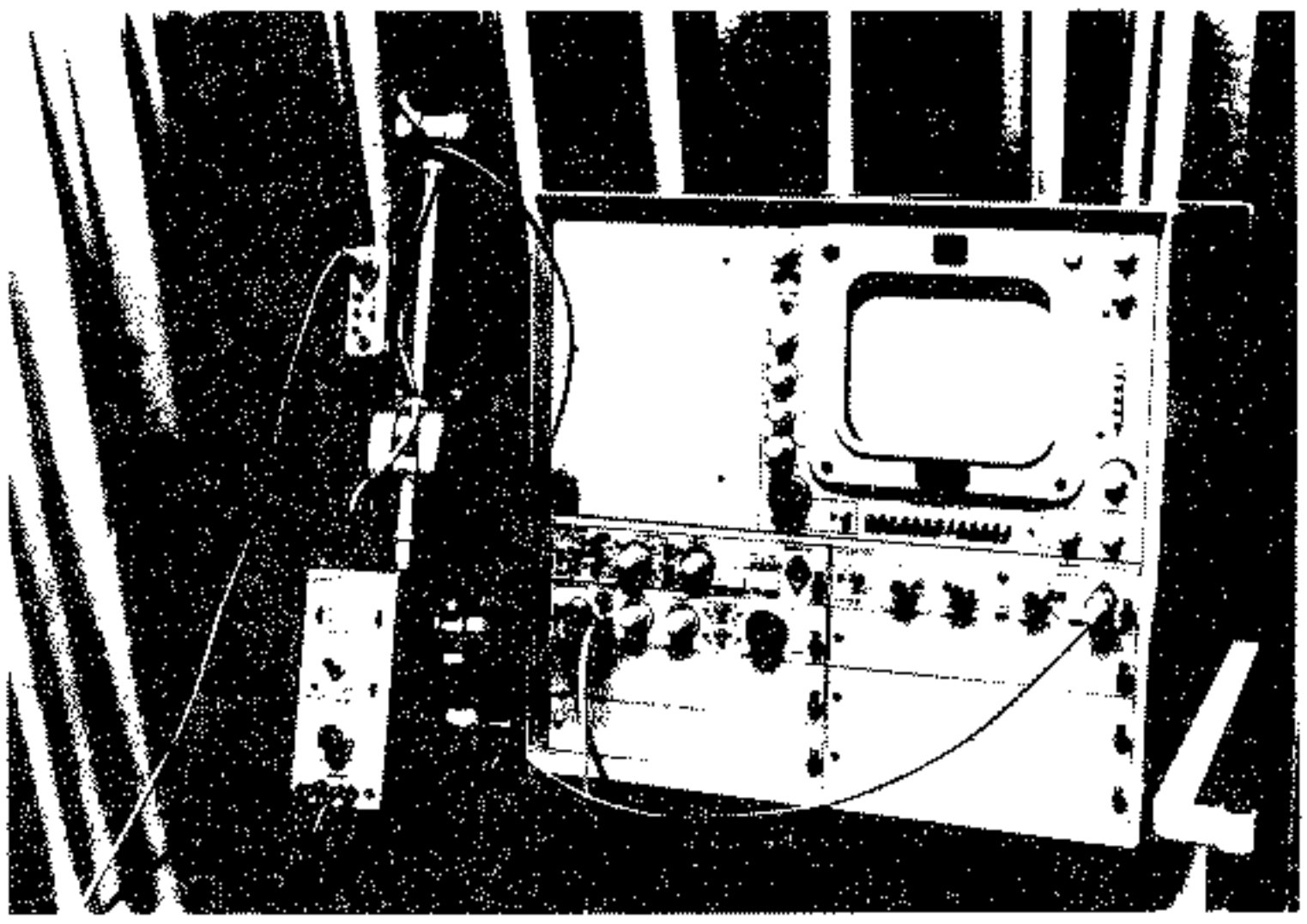

Fig.1: The EMG and stimulus apparatus used for the phenol blocking

We use an EMG amplifier together with a storage-unit, a stimulator and a screen (Medelec MS-6). The stimulator exists of a control unit for adjusting the stimulus rate and a control unit for adjusting the duration and the amplitude of the stimulus current. The storage unit serves to store the EMG-signal every time after a stimulus is given. The stored signal is presented on the screen until the next stimulus is given. Usually the first control unit is set to give a fixed rate (often 1 pulse every 2 seconds).
The procedure consists of two parts. First the motor endplate zone must be

localized by means of finding an optimal EMG-response on stimulation the surface of the muscle.
Hereafter the motor endplate zone must be searched within the muscle with the help of a stimulation needle electrode. This electrode also serves as the needle for injecting phenol. Figure 2 shows how the different electrodes are placed. In this case it is assumed that a gastrocnemius muscle has to be blocked.

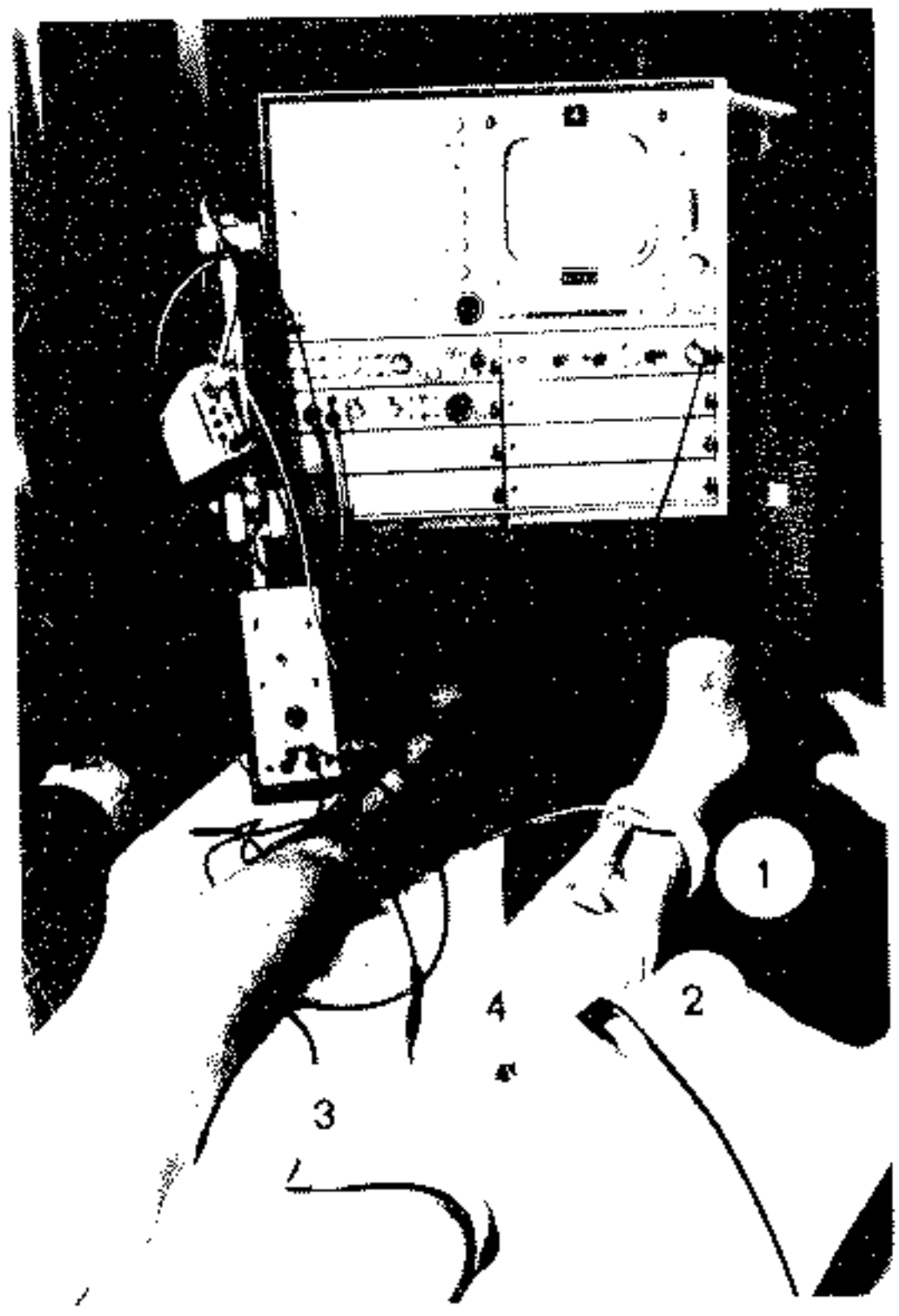

Fig.2: How the electrodes are placed for stimulation

A surface EMG electrode (2) is placed on the distal part of the muscle near the tendon. The grounding electrode (1, a saline-moistened band) is positioned more distally around the leg. The grounding electrode of the stimulator (3, a saline-moistened pad) is placed on the other side of the leg but now more proximally. In this way the stimulation current of the stimulator (4) will cause minimal artefacts on the EMG registration. In order to find a rough position of the motor endplate zone the stimulation electrode is placed on the belly of the muscle. Initially a pulse duration of 0,5 ms is used and the stimulation current is raised, from zero, until a muscular contraction can be observed. Now the stimulation electrode is shifted to a more lateral position in order to find an optimal place. This means a place where a maximal contraction is found. Through this point a line is drawn perpendicularly to the muscle fibers. Again the procedure is repeated but now the electrode is moved along this line. The point that shows an optimal response is marked.
The stimulation current is now lowered to a degree so that only a slight contraction can be observed and the EMG amplifier is turned on. Again small excursions are made with the surface stimulation electrode in order to find an optimal place but now the EMG response is used as an indication of the

muscular response. In this way a new point can be found, a point that is also marked.
If one is familiar with the place of the motor endplate zones of different muscles, the first part of the former procedure can be omitted.
If more muscles (or different parts of a muscle) have to be blocked, the procedure mentioned above is repeated in order to find a point for each muscle (or part of a muscle).

For the second part of the procedure a special needle is used. This needle serves both as a current stimulation electrode and as a needle to inject the phenol solution. The needle has a length of 5 centimeters and is coated with teflon. Only the top of the needle is not coated and therefore it serves as a stimulation electrode. Figure 3 shows the needle (1) that is connected to the stimulator (2) and to a syringe (3) filled with 5% sterile phenol solution in water.

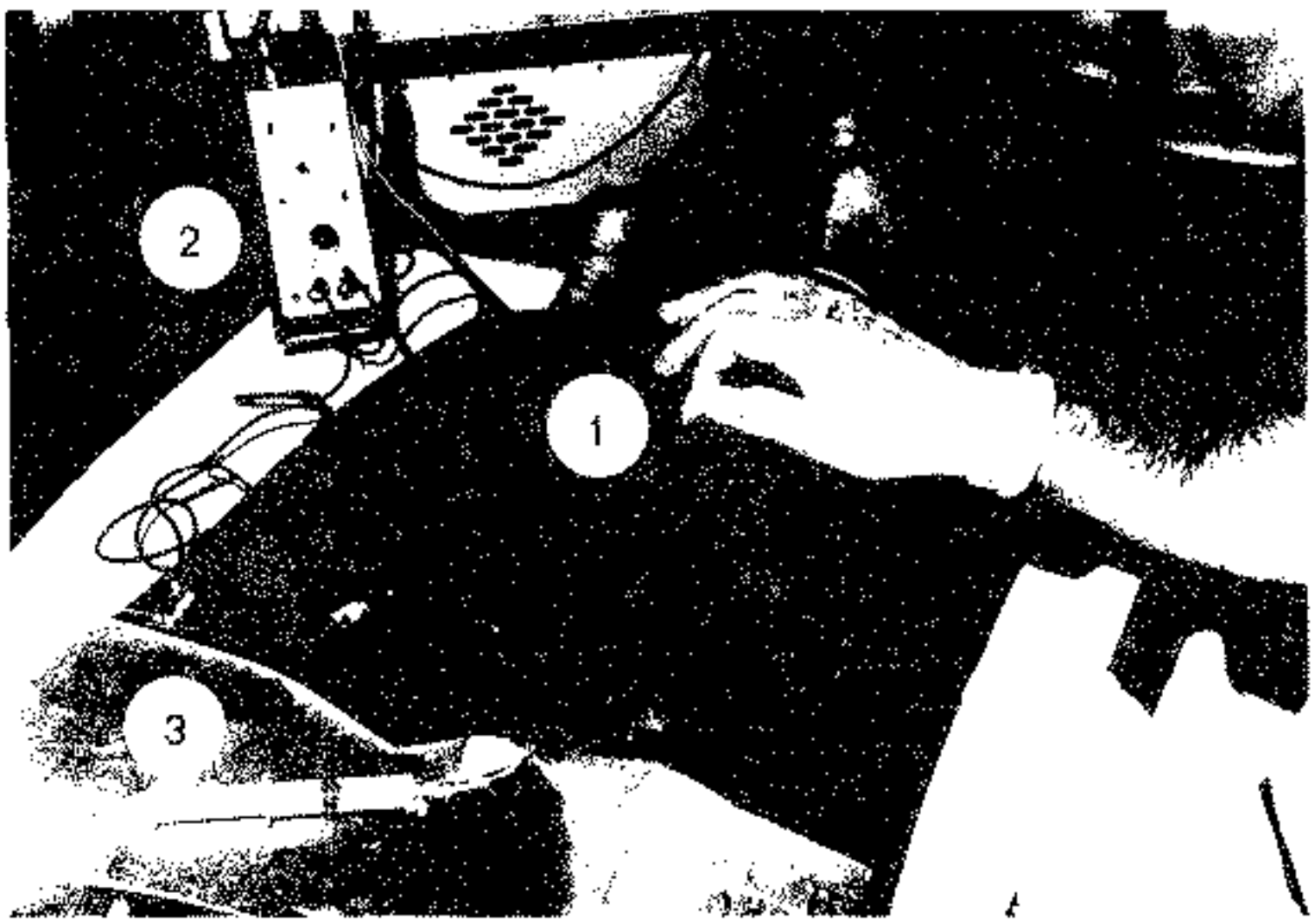

Fig.3: The special needle 1) connected to the stimulator and a syringe

Before inserting the needle the skin is anaesthesised.
First the needle is inserted just beneath the skin and the intensity of the stimulation current (puls length is 0,1 ms) is increased until a contraction is observed. Then the needle is inserted deeper. A starting point for the direction of insertion, is the structure of the motor endplate zone. This structure is studied extensively by Coërs and Woolf (1957).
If it is true that the endplates lie in a very small zone almost in the middle of the muscle fibers and therefore parallel to the tendon plates, the motor endplate zone will be related to the geometry of the tendons. Notice that the geometry of the motor endplate zone will differ from muscle to muscle and a special atlas of the muscles together with information about the motor endplate zones would be of great interest.
The needle is moved in order to find position with an optimal EMG response upon stimulation. If such a point is found, it is necessary to ascertain that the top of the needle is not in a blood vessel (no blood may be observed in the

transparent connection upon pulling the piston). Now a little amount of the phenol solution (0,2 - 0,3 cc) is injected. If the EMG-signal disappears immediately, the point is considered as an 'appropriate' point. Usually the EMG-signal recovers again. This effect is presumably caused by a displacement of the needle due to involuntary contractions. Again phenol is injected until the typical EMG response is diminished.
Now the needle is moved in a new direction to find new points of optimal EMG responses. In practice one to four points are found and treated in this way. It is recommended to use maximally 3 - 4 cc of the phenol solution for each motor endplate zone and at the most 15 cc during the whole procedure.

IV Evaluation of the results

As mentioned before the aim of phenol blocks are to enable specific movements that were not possible before. Therefore the ability to perform these movements is a first indication of the result obtained.
The ability to move cannot be described in a quantitative way, only a subjective impression can be given.
In order to evaluate the results more quantitatively, a special EMG-unit is developed. This unit is rather new so no data can be given concerning longterm investigations. In this part only the way of investigating is explained.
Surface electrodes are placed on the muscles of interest. The patient is asked to exert a certain constant force. During this contraction EMG-activities of both agonist as well as antagonist are registrated.
In order to evaluate EMG, the outputs of the EMG-amplifiers are connected to analog-digital converters of a PDP 11 computer (12 bit AD, sample rate 1 kHz).
Usually surface EMG appears as a rather noisy signal and the amplitude is distributed according to a Gaussian distribution. Such a distribution is only determined by a mean and a standarddeviation. Since the mean value is always zero (amplifiers are 'AC-coupled') the standarddeviation (or the square:variance) is the only important parameter that describes the behaviour (e.g. 'the intensity') of the EMG with respect to the amplitudes in the EMG-signal. We found for the biceps/triceps that the quotient of the standarddeviation of the antagonist and the agonist activity, is an important parameter for describing spasticity (viz. a disbalance between agonist and antagonist).
This parameter is based upon the so called 'coefficient of reciprocal innervation'. (Visser, Zilvold, 1978)
Besides these parameters also the power density spectrum of the EMG is studied. (Fig.4)
This spectrum shows a number of interesting parameters e.g.:

- the first peak in the spectrum (Ff): the frequency at which this peak occurs is probably related to a mean firing rate of the active motor units. Usually this frequency is shifted to a higher value if contraction is increased, but in some cases (hemiplegia during the first 15 weeks after the stroke) we found however that this frequency is shifted to lower values.
- the frequency of maximal power density (Fm): this frequency is related to a mean duration of the motor unit action potential. Therefore it will shift to higher values if disorders concerning the muscle fibers are encountered. However it must be mentioned that also the distance between the skin and the muscle fibers influences the value of this parameter.

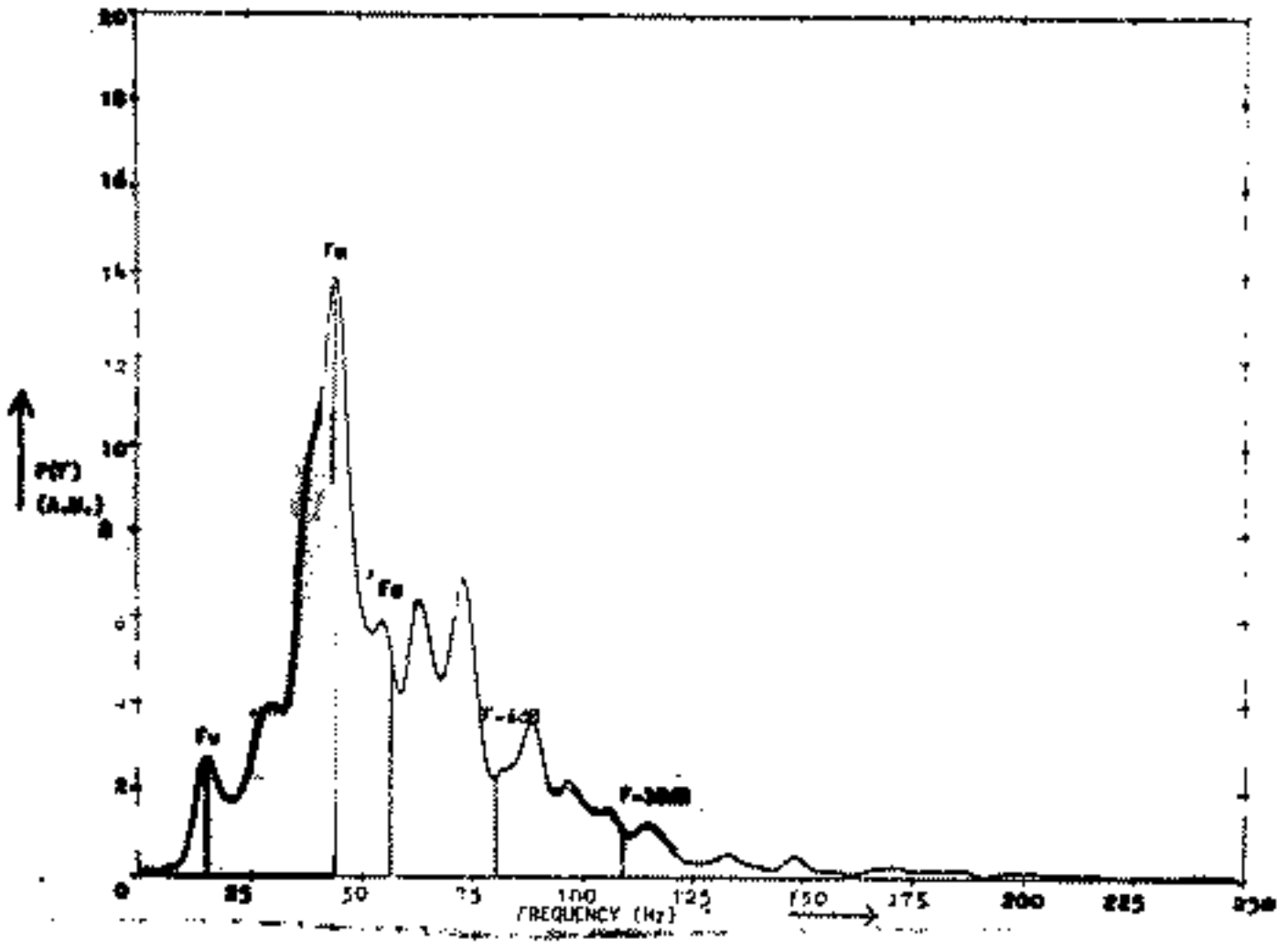

Fig.4: An example of a power density spectrum (biceps brachii, healthy person) in which the most important parameters are given

- the centre frequency (Fc): the median of this curve. This centre frequency shifts usually to a higher value if muscle fatigue occurs. The value of this parameter differs from muscle to muscle.
specific point like the 6db point, the 10db point and the relative power above 100HZ shift to higher values if disorders, concerning the mean number of muscle fibers of the active motor units, are encountered (e.g. dystrophy).

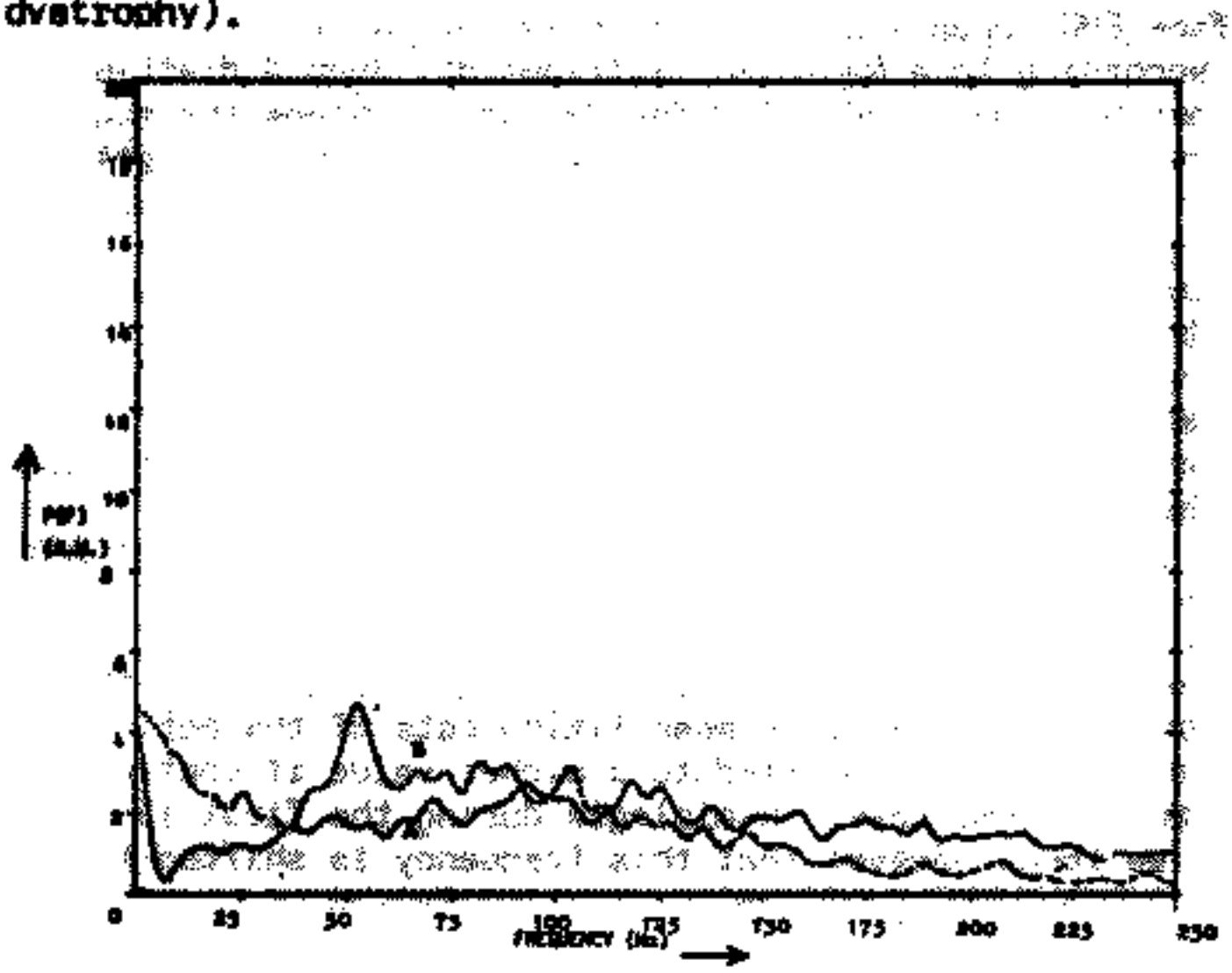

Fig. 5: An example of the power density function before (A) and after (B) the phenol blocking (wrist flexors, patient (HS) with vitum cordis congenitum). Shown are the average values of three power density functions.

Figure 5 shows an example of the power density spectrum before and after the phenol block. In this case the coefficient of reciprokal innervation changed from 1,15 to 0,71. Mark the change in the relative power above 100 Hz before and after the phenol block.

V Discussion

Although the procedures described in this paper are rather new (so no statistical data can be given) we found that:
- the use of surface EMG during the phenol block is a powerfull tool in finding places for injecting the phenol solution.
- the use of surface EMG before and after the phenol block can be of help for evaluating the result in a more quantitative way.

Another interesting point that is not evaluated yet, is the characteristic EMG-response as a result of a stimulus current. Sometimes biphasic responses are observed and othertimes rather monophasic responses are seen. Also spinal reflex responses are observed. It can be argued that the response will depend on the structure of the motor endplate zone (Griep, Boon and Stegeman, 1978) and the position of the needle with respect to this zone. Therefore it may be expected that the EMG-response contains information about the question if a certain position of the needle is appropriate for injecting phenol.

VI References

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