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CONTRIBUTIONS OF THE POLYGRAPHY IN THE RESEARCH OF VASCULAR MODIFICATIONS IN SPINAL INJURIES

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INTRODUCTION

THE initial aim of this study is the research of an objective definition for peripheric vascular modifications in spinal injuries.

Utilisation of a recording combined of several parameters is the object of this, our first study. The final aim was to attain a choice of therapeutic actions tested by this technique, permitting an efficacious action.

METHODS AND EQUIPMENT

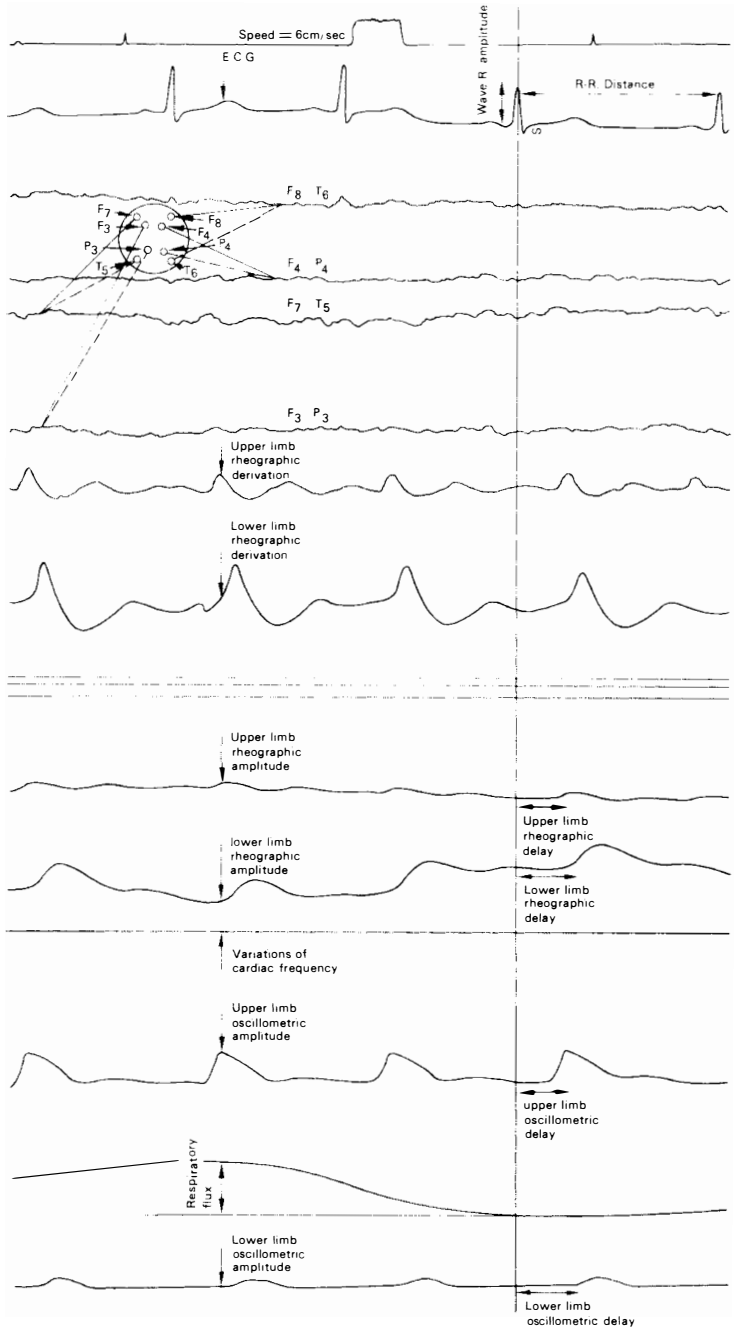
The basic material used was a recording and amplification unit with 16 channels offering a simultaneous study of the different parameters. However, after several trials only the following values were considered to be of real interest: skin temperature; pulse and the rheography and its derivatives. Each of these measures being simultaneously taken in the upper and lower limbs, one must add to these the respiratory flux, the cardiogram and four channels electroencephalogram (fig. 1).

After many adjustments concerning the equipment and the techniques of each of these measures the recordings and tests of 30 paraplegics and 15 able-bodied subjects of the same age group, taken for comparison, were considered. For each test we tried to determine the condition of the vasomotricity during rest and during a general stimulation of the circulation. During the first phase the subject is first left to rest for 15 minutes in decubitus position before the recording is taken. Immediately after this the subject is raised to the vertical position by means of the standing bed which carefully avoids all undesired movements. The measures are immediately registered after the first changing of position. The patient then returns to the vertical position for 15 minutes. After this the subject is returned to the horizontal position and a recording is immediately taken. This is repeated after another 15 minutes.

The second test consists of increasing the ambient temperature of the room to a temperature of 32° in a delay of 10 to 15 minutes. This is followed by a cooling down of the ambient temperature to 17°, each time measures are taken immediately after and then 15 minutes after in exactly the same conditions.

The results obtained showed two comparisons: first, between the able-bodied subjects and the paraplegics and secondly, concerning the paraplegic himself, comparing the differences recorded above and below the level of spinal injury.

It must be stated that the study was based on an average, the individual results being added to and divided by the number of subjects tested. This implies that individually the results may be less significant. Our intention was to increase the number of spinal injury subjects tested, enabling us to have a sufficient number of recordings to make a separate valuation according to the level of the lesion.


Speed = 6cm/sec
E C G
Wave R amplitude
R-R Distance
F8 T6
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T6
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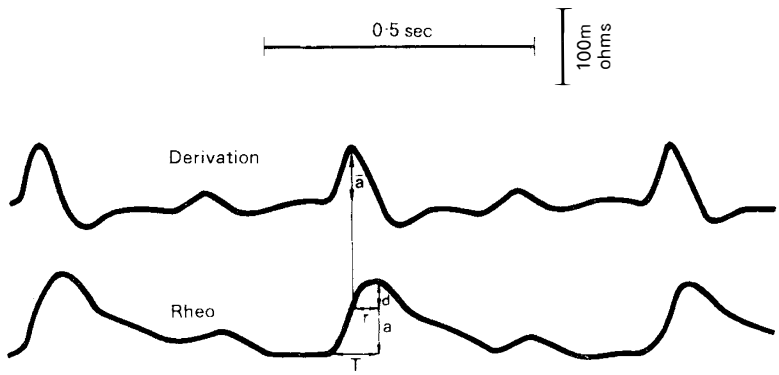
F7 T5
F3 P3
Upper limb rheographic derivation
Lower limb rheographic derivation
Upper limb rheographic amplitude
Upper limb rheographic delay
lower limb rheographic amplitude
Lower limb rheographic delay
Variations of cardiac frequency
Upper limb oscillometric amplitude
upper limb oscillometric delay
Respiratory flux
Lower limb oscillometric amplitude
Lower limb oscillometric delay

FIG. 1



$$IC = \frac{A}{A'.T} = \text{Indice of the conductivity}$$

$$C = \frac{a}{r.A'} = \text{Conductivity}$$

$$R = \frac{I.C.}{C} \times \frac{1}{T} = \text{Reserve}$$

FIG. 2

On the other hand it was clear that the rheography and its derivatives offer particular interest in the motor condition of the vascular system; a point of view insufficiently exploited by simple lecture. Therefore more attention was attached to this measure. We were able to approach our final aim thanks to the help of Jean Jacquy who perfected formulas for a detailed study of the rheogram and its derivatives for a quantitative research. In fact, the detailed measures, simultaneously of the two rheographic graphs and the rheographic derivatives gave the measure for the mark of conductivity $\left(IC = \frac{A}{A'.T.}\right)$ of the conductivity $\left(C = \frac{a}{t.A'}\right)$ and these two values give the reserve $\left(R = \frac{IC}{C} \cdot \frac{1}{T}\right)$ (fig. 2).

This reserve is of great importance for the present study, for it represents the actual possibility of the dilatation of the investigated vascular branch. The lower the value of the reserve the more important is the vascular dilatation. To bring the quality of this measure more with evidence a complementary test was established, this was submitted to four able-bodied subjects and four paraplegics with low thoracic lesions (fig. 3). This complementary test simply consisted of submitting to a quantative rheographic study the forearm and leg segments after garrot test. The value of the reserve being calculated before the test, then periodically after the opening of the garrot the vascular reaction was observed during its modifications.

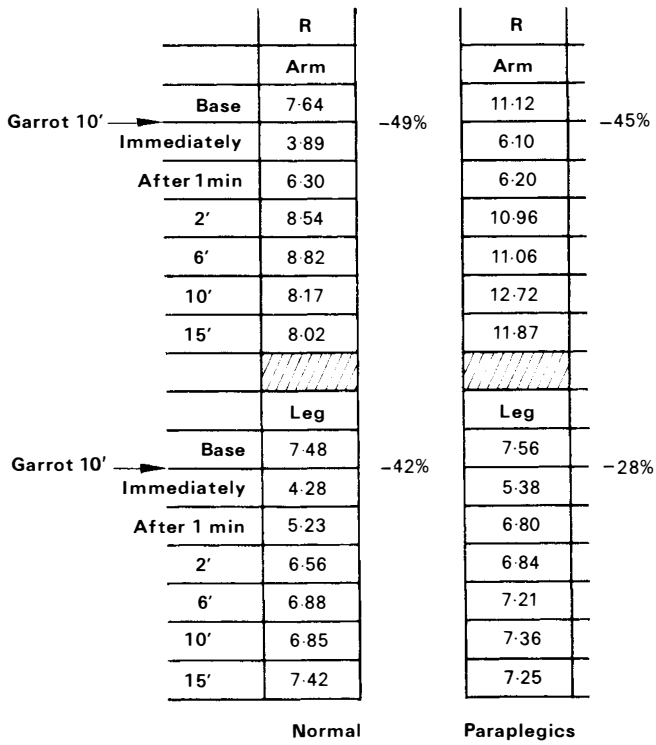


FIG. 3

RESULTS

1. **General Reactions.** *a.* Study of the respiratory flux (fig 4) measured by Fleish captor brings to evidence a large difference of variation of air flux between the group of paraplegics and the group of able-bodied subjects. It is especially during the test of verticalisation of the axe of the body that the modifications are manifested. They consist of an increase of the air flux in the group of able-bodied subjects, whilst the paraplegic group manifest a diminution.

b. The rhythm of the cardiac revolution by measure of the distance RR (fig. 5) shows no difference in the cardiac rhythm between the two groups tested.

c. The morphological study of the electrocardiogram by comparison between the two groups seemed to indicate that the spinal injuries involved less variations of the electrical axe of the heart during the modification of the position of the body axe. However, the technique utilised up till now seems inadequate and is actually under modification to enable a vecto-cardiogram to be obtained.

2. **Local Reactions.** *i.* The comparison of cutaneous temperatures between upper and lower limbs (fig. 6B) shows that the basic temperature, initial and permanent, is different between the upper and lower limbs of able-bodied subjects. This difference is not to be found with paraplegic subjects, a phenomenon which persists throughout the different experiences. In another connection it was noticed that

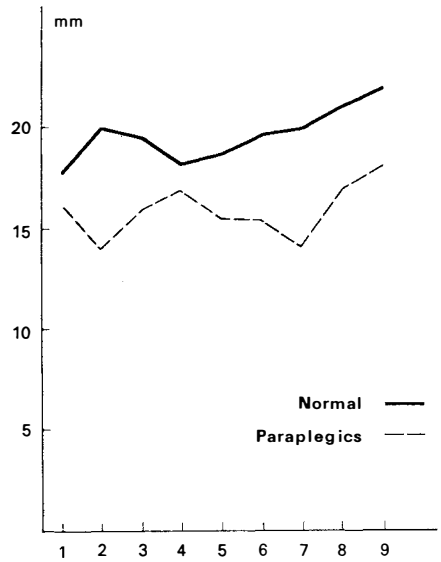


FIG. 4

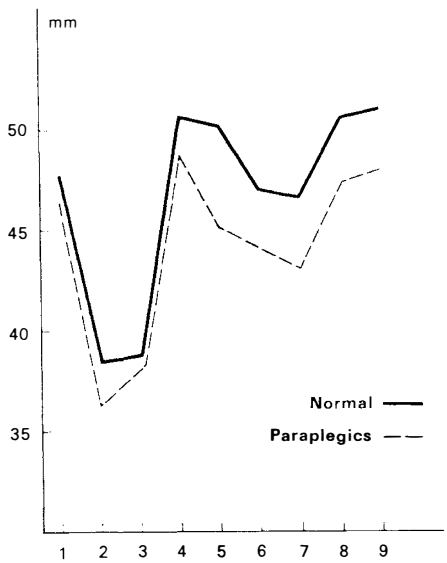
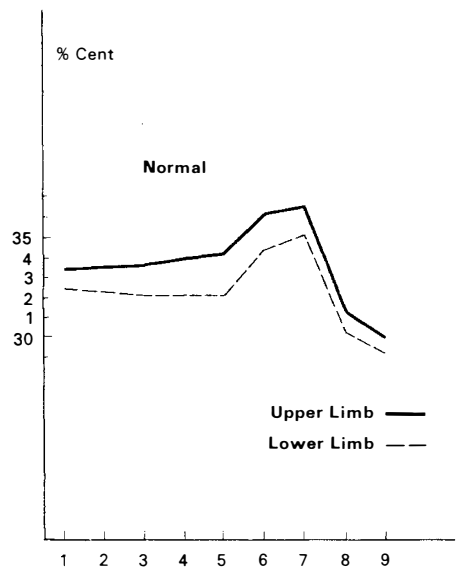
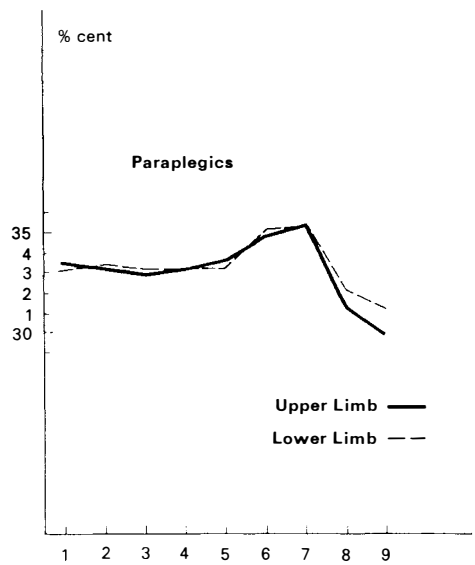


FIG. 5



A



B

FIG. 6

the fluctuations of cutaneous temperatures during the different experiences were similar between the two groups. The variations are the same respecting the same proportions.

ii. The degree of the oscillometric delay of the lower limb compared with the forearm (fig. 7) shows a damping of the fluctuations of the circulatory delay in the spinal injury group. Seeming to indicate a more important passivity of the vascular

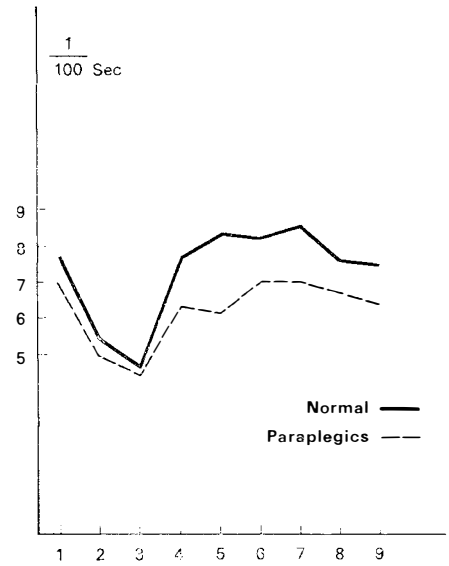


FIG. 7

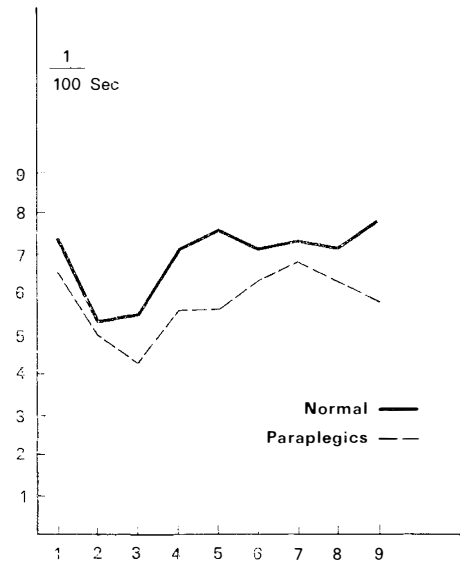


FIG. 8

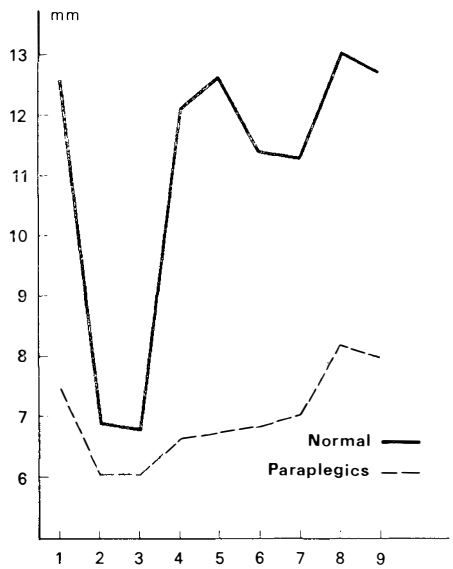


FIG. 9

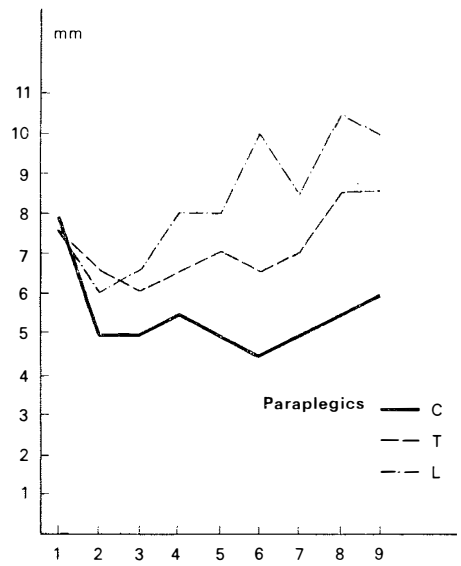


FIG. 10

network. The variations recorded during the thermic tests can be considered as following the same way, but concerning the paraplegic group it is a little less distinct than with the able-bodied.

iii. Comparitively the degree of the rheographic delay of the lower limb compared with the upper limb (fig. 8) shows a more marked delay in the reactions in the paraplegic group but a higher sensibility during the caloric experiments.

iv. The first morphological study of the rheogram concerned the amplitude of the rheographic wave (fig. 9).

The measures taken in the case of spinal lesions showed a feeble fluctuation of the rheographic amplitude and this for all the tests experimented. The only exception being the fluctuations observed during the cooling down of the ambient temperature. A more detailed study of the paraplegic group according to the level of the lesion seemed interesting (fig. 10). The subjects grouped according to their lesion level showed a similar evolution of the rheographic amplitude to the evolution recorded for the whole pathological group when the lesion level is cervico-dorsal. For the lumbar lesions, the variations were very similar to those recorded with the able-bodied group. It is to be remarked upon that there was an increasing passivity of the rheogram's amplitude according to the height of the lesion. These recordings seem to contribute to the fact that there is an absence of the regulation of the blood flow for the regions below the level of the lesion. This same measure of the rheographical measure taken for the upper limb gave no precise conclusions.

3. **Complementary Experiences.** The quantitative study of the rheogram opens new perspectives. The first results are significant and if we limit ourselves to the variations of the reserve, it is possible to draw partial conclusions. The variations of this value following the garrot test show identical variations at the arm level for both groups. Concerning the leg, this reserve indicates much smaller fluctuations with the paraplegics, seeming to indicate a slight modification of the vascular calibre and furthermore a lower possibility of adaption when there is spinal injury. The application of this quantitative rheography has most certainly marked a progress in our work therefore opening further fields for exploration.

DISCUSSION

By this brief summary of our research we wanted to point out the difficulties met in establishing this systematic polygraphic study for the research of peripheric vascular disorders. The last report of the quantitative rheography is particularly rich in information and enables us to see clearly the orientation of our further studies. However, our first results obtained by polygraphic technique show a vascular passivity below the level of the lesion. This seems to have consequent effects in the blood circulation in general, but not on heart function. The heart rhythm and the ECG do not appear to be modified by spinal injury. The variation of the respiratory flux observed in the group of patients with spinal injury is most certainly associated with muscle deficiences which perturbs the ventilatory mechanics. Hence, there is no connection with the parameters which interest us. The cutaneous thermometry, especially the measure of the oscillometric delay and the rheographical delay, show even in the lesser reactions with the paraplegic group the existence of normal vascular passivity.

A direct observation of the rheogram gives facts too multiple and scattered to be able to be interpreted with satisfaction. The same cannot be said for the quantitative studies of the rheography and its derivatives according to the techniques perfected by Jean Jacquy. These offer many possibilities, of which the first is an approach to measure the degree of vasoplegie in the regions below the spinal injury. It seemed of interest to us to make known these first results and the possibilities resulting from them.

CONCLUSIONS

After having overcome the difficulties of the application of the polygraphy, we have gradually eliminated some of the given information finding particular interest. One can state that the cutaneous temperature, heart output and circulatory delay between the upper and lower limbs together according to the measures of the oscillometry and the apex of the rheogram; offer already an appreciable approach to the dynamic peripheric circulation. To this can now be added a validation of these measures which can be improved by a quantitative study of the rheography.

Results obtained confirmed our expectations and concerning paraplegics proved a passivity of the vascular network below the level of the lesion.

Also of marked interest was the use of the rheography as a means for measuring the pathological affects of this circulation dynamic, and the theraeutical possibilities.