

Potential Organ Donor Recovered From Severe Brain Injury Spontaneously and CNS Functions Improved Through Coordination Dynamics Therapy

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Received December 27, 2019; Accepted January 10, 2020; Published February 12, 2020

ABSTRACT

The 17 year old young man Fovios suffered from a motor cycle accident, a very severe brain injury. The neck hit a street border stone. Brain and brain stem were injured and he was unconscious following the accident. It was intended to use his organs for transplantation. He was a potential organ donor. The parents denied that their son was used for organ donation. Unexpectedly, the patient Fovios recovered from coma 7 months after the accident spontaneously. When 16 years later coordination dynamics therapy (CDT) was administered to him, his CNS functions improved by approximately 20% through three sessions of CDT. He could exercise faster with improved coordination and the will power for walking and running needed movement patterns pace and trot gait were improved first. It seems therefore not a myth that if somebody agrees to donate organs, the hospital staff and neurorehabilitation will not work as hard to save the life of that person in very severe brain injury.

Keywords: Potential organ donor, Coordination dynamics therapy, Brain repair

INTRODUCTION

Most organ donation for organ transplantation is done in the setting of brain death. Brain death may result in legal death, but still with the heart beating and with mechanical ventilation, keeping all other vital organs alive and functional for a certain period of time. Given long enough, patients who do not fully die in the complete biological sense, but who are declared brain dead, will usually start to build up toxins and wastes in the body. In this way, the organs can eventually dysfunction due to coagulopathy, fluid or electrolyte and nutrient imbalances or even fail. Thus, the organs will usually only be sustainable and viable for acceptable use up until a certain length of time. This may depend on factors such as how well the patient is maintained, any comorbidities, the skill of the healthcare teams and the quality their facilities.

The decision of brain death is now a days safe. The author worked on brain-dead humans and recorded with the single-nerve fiber action potential recording method from brain-dead humans and patients the organization and reorganization of the human central nervous system (CNS) (**Figures 1 and 2**) [1,2]. With these recordings, he was able to develop the coordination dynamics therapy (CDT) to partly repair the human CNS [3-5]. When the brain death is diagnosed, mostly soon later the still remaining functional parts of the CNS, mainly spinal cord

and lower brain stem, also die and before the failure of the organs.

The problem with organ donation occurs before the brain death, namely due to inefficient repair treatment administered to the patient with a severely damaged brain. With inefficient treatment, the pathologic processes win slowly against the innate physiologic processes and the patient becomes brain dead. Through efficient and intensive CDT, the damaged brain can be repaired and the patient may not suffer brain death on the long term. In previous publications it was shown that the patient Manolis, who lost half of the brain in a car accident and drifted with conventional therapy in direction of brain death and recovered when intensive CDT was administered. Manolis recovered fully after 5 years from coma and re-learned to speak through 6 years of intensive CDT with 20 h therapy per week [6].

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Citation: Schalow G. (2020) Potential Organ Donor Recovered From Severe Brain Injury Spontaneously and CNS Functions Improved Through Coordination Dynamics Therapy. Int J Med Clin Imaging, 6(1): 95-109.

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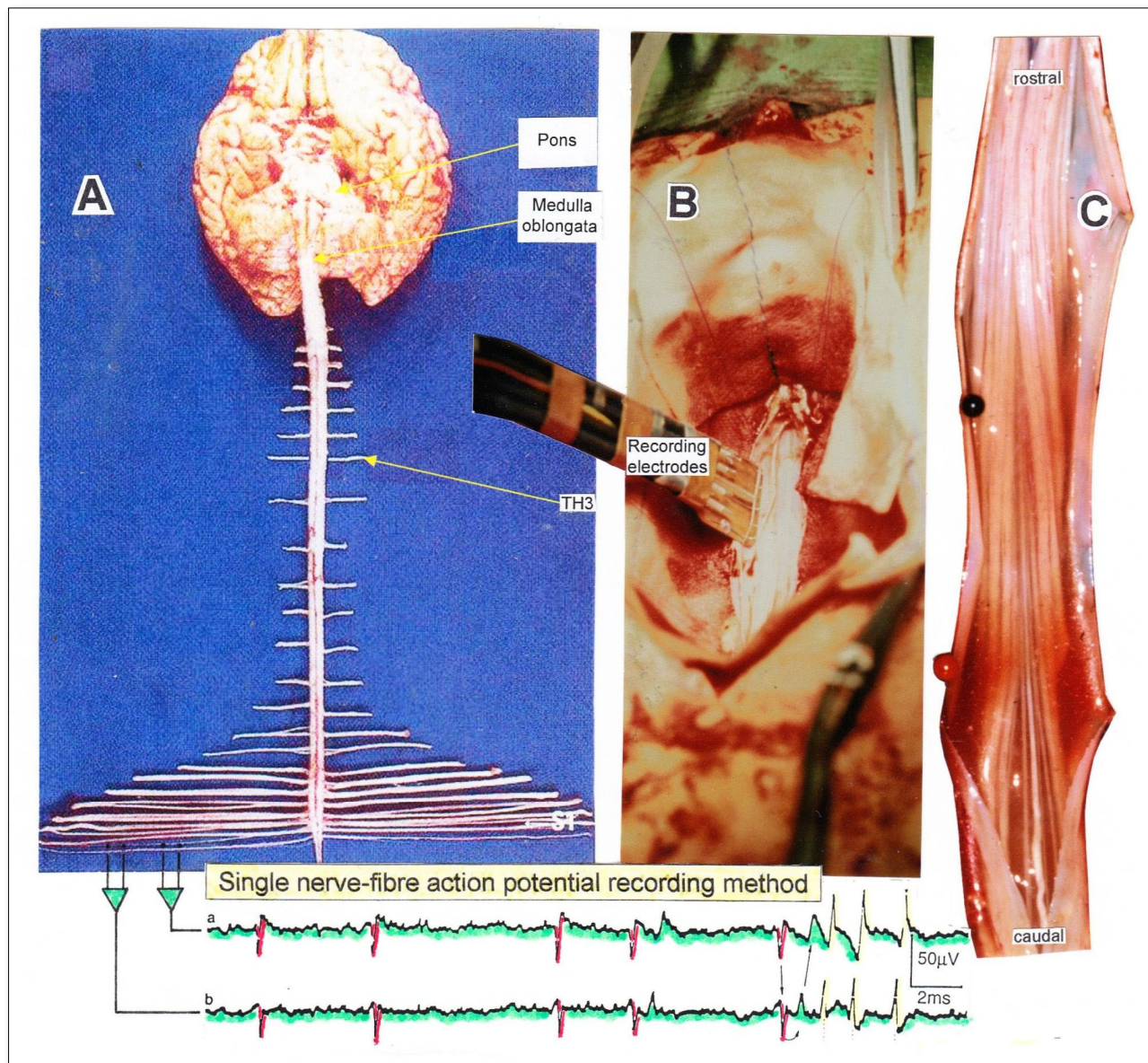


Figure 1. Layout of the recording of single-nerve fiber action potentials to measure the self-organization of neuronal networks of the human CNS under physiologic and pathophysiologic conditions. A radiologist would get nervous seeing a stretched brain (A) by recording with two pairs of wire electrodes (B) from sacral nerve roots (cauda equina, C) containing between 200 and 500 myelinated nerve fibers, records were obtained in which single-nerve fiber action potentials (APs) were identified from motoneuron axons (main AP phase downwards) and afferents (main AP phase upwards).

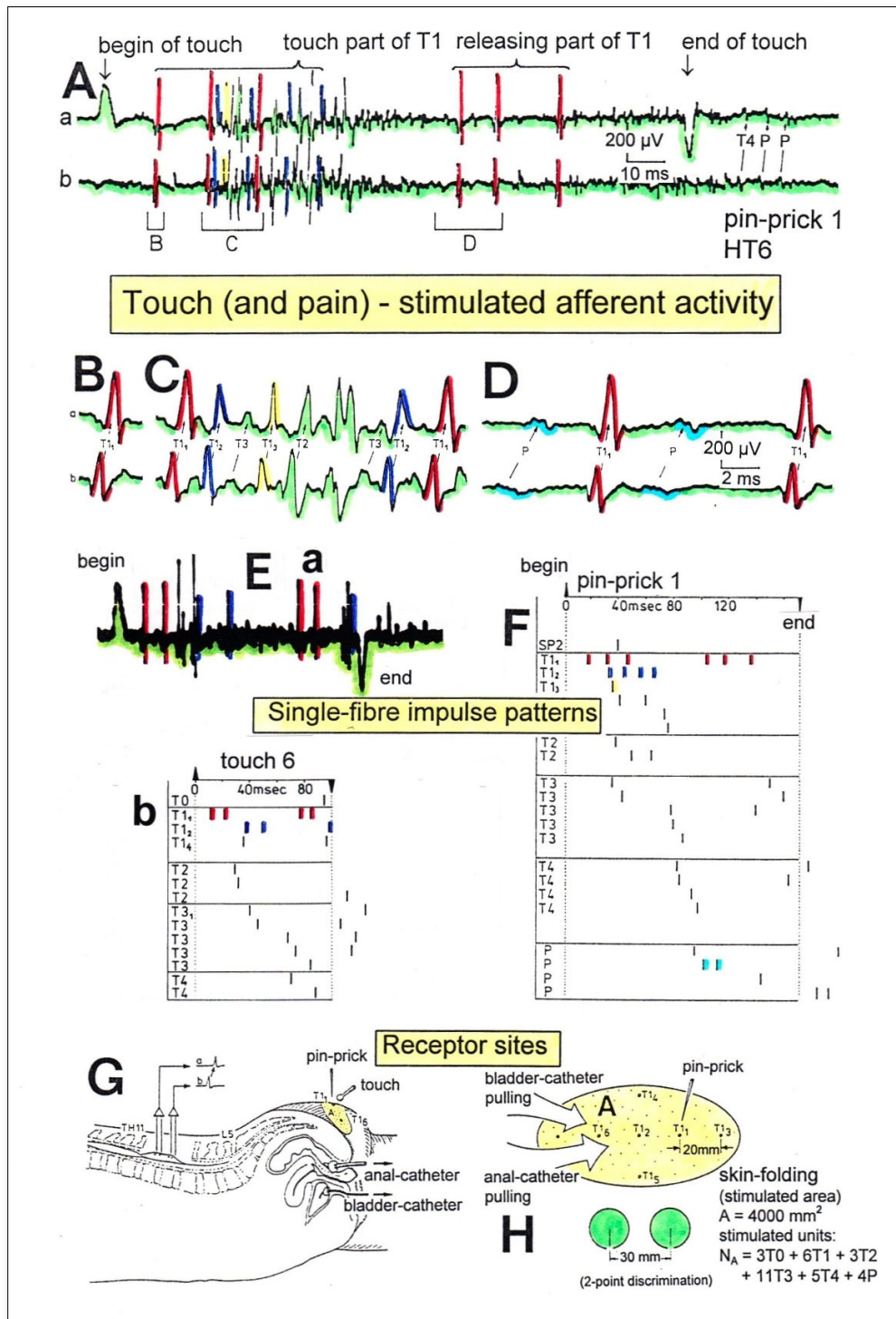


Figure 2. Touch (and pain)-stimulated afferent activity. Touch and pain activity, stimulated by pin-prick (A) and touch (Ea) of S5 or co dermatomes and recorded extra cellularly from a dorsal coccygeal root (brain-dead human HT6). T1, T2, T3, T4, P=mark action potentials (APs) from single touch and pain fibers. Subscripts 1, 2, 3 mark single fibers. A: Whole sweep following pin-prick 1 shown at a slow time base. The large upward artifact on trace ‘a’ marks electronically the beginning of the pin-prick. The large downward artifact on trace ‘a’ marks the end of the pin-prick. Note that 2 intervals of high activity of large APs occur, one after the beginning of the pin-prick with 1 AP in front, and a second before the end of the pin-prick; potentials with large amplitude are followed by potentials of small amplitude. Time intervals B, C and D are shown in a time-expanded form in Figures B, C and D.

B, C, D: Time expanded sweep pieces of A. Identified APs are indicated. Note that the APs from the T11 touch unit can be safely identified by the waveforms in B, C, D.

Eb, F: AP occurrence patterns of single touch and pain fibers following short touch 6 and pin-prick 1. No pain afferents are stimulated upon touch 6. Upon pin-prick 1, the single-fiber AP activity of the different touch and pain groups is identified by the AP waveforms on traces 'a' and 'b' and by the conduction times. The single touch afferents of the T1 group are marked with subscripts. One active secondary muscle spindle afferent fiber (SP2) could always be identified in F. Note that for pin-prick 1, touch and pain afferents are stimulated whereas for touch 6 only touch afferents.

G: Recording and stimulation arrangement for simultaneous recording of several single touch and pain units. A=area stimulated by skin folding, drawn in H in more detail. T11, T16 suggested touch points of the T11 and T16 units.

H: Drawing of the very approximate skin area stimulated by skin folding. T11-6 suggested focal T1 touch points. Two-point discrimination indicated for the sake of comparison. NA=number of stimulated units in the dorsal coccygeal root. Skin tractions evoked by anal and bladder-catheter pulling are indicated by the large open arrows. For the identification of the action potentials see **Figure 4**.

In this paper it is reported about a young man, who suffered a very severe brain injury in a motor cycle accident and it was intended to use his organs for transplantation. He was a potential organ donor. The parents denied that their son was used for organ donation. Unexpectedly, the patient Fovios recovered from coma 7 months after the accident spontaneously. When 16 years later CDT was administered to him, his CNS functioning improved substantially through three sessions of CDT. It seems therefore not a myth that if somebody agrees to donate organs, the hospital staff and neurorehabilitation will not work as hard to save the life of that person in severe brain/brain stem injury.

The author himself suffered a 'squamous cell carcinoma (epithelioma - a malign tumor) in the maxilla. The tumor (stage between 1 and 2) was removed and a neck dissection performed. Two lymph nodes with formation of metastases were removed and two stages of further lymph nodes and lymph vessels were removed for safety reasons. Radiation and chemotherapy were administered to the tumor area to reduce the risk of tumor recurrence from 30% to 15%. After one year, autograft transplantation from the leg to the maxilla (fibularis transplant) was successfully performed for the reconstruction of the maxilla. The author is now a 10 year cancer survivor and benefitted from transplantation [7]. Still the author has the opinion that one first has to fight for the survival of the patient with the severely damaged brain by all means. For the time being it is not sufficiently tried to save the life of the severely brain injured patients. Rehabilitation and universities are 30 years out-of-date with respect to human neurophysiology and human repair physiology [2,3]. Human neurophysiology and especially electrophysiology, and human repair physiology are not red at universities worldwide. The main difference

between a rat and a human is the functioning of the brain and its repair strategies. In rat the nerve fiber growing strategy is used for repair and in humans the learning strategy. CDT is a movement-based learning treatment to repair the human CNS.

In the Materials and Methods section, the scientific basis for CDT will be shortly introduced. In the Results, the repair of the very severely brain injured patient Fovios is measured by the coordination dynamics of the human CNS. In the Discussions, the brain/brain-stem repair of Fovios will be compared with those of another severely brain injured patient [6] and mainly brain stem injured patient [8].

MATERIALS AND METHODS

Coordination dynamics therapy mainly rests on human neurophysiology and human repair physiology [2,3]. Based on the new recording method of the human CNS, the single nerve fiber action potential recording method [1] (**Figures 1 and 2**), a classification scheme of human peripheral nerve fibers could be constructed [9]. In **Figures 3 and 4**, a peripheral nerve fiber is characterized by the conduction velocity and the nerve fiber diameter. Neural network organization at the single neuron level can now be recorded under physiologic and pathologic conditions and changes due to injury, malformation and degeneration measured. With every injury, malformation or degeneration, the phase and frequency coordination among neuron firings becomes impaired and has to be repaired, which can efficiently be achieved when exercising on the special CDT device.

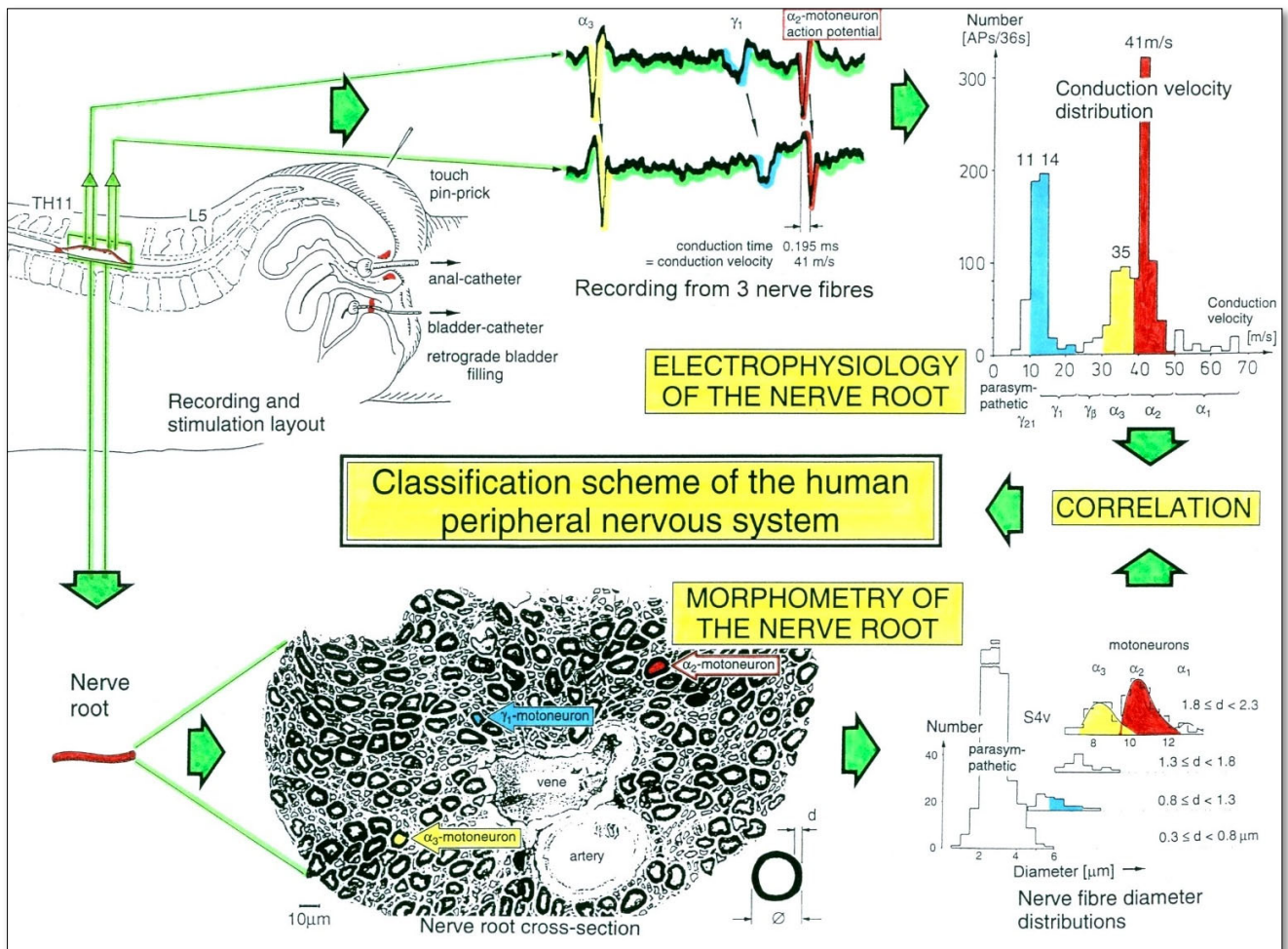


Figure 3. Development of a classification scheme for human peripheral nerve fibers. Conduction velocities (V) and nerve fiber diameters (\varnothing) of afferent and efferent nerve fiber groups in normal humans and in patients with a traumatic spinal cord injury for 0.5 to 6 years.

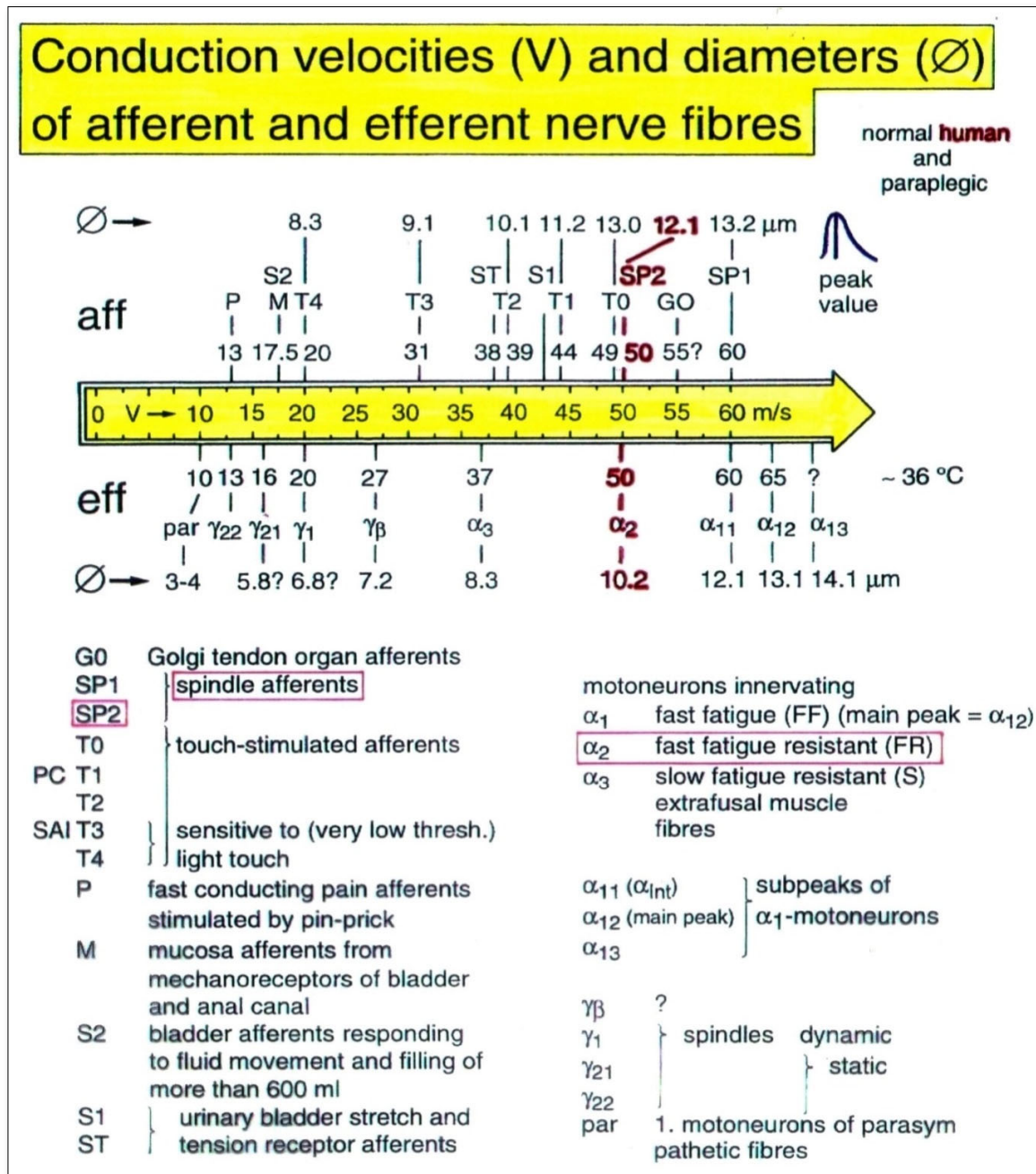


Figure 4. Classification scheme for human peripheral nerve fibers. Conduction velocities (V) and nerve fiber diameters (\emptyset) of afferent and efferent nerve fiber groups in normal humans and in patients with a traumatic spinal cord lesion for 0.5 to 6 years. The splitting of the α_1 -motoneurons into the 3 subgroups, α_{11} , α_{12} , α_{13} has not yet been confirmed. This is the only existing classification scheme for human nerve fibers.

With the new recording method, the “single-nerve fiber action potential recording”, the phase and frequency coordination could be measured invasively and with the single-motor unit “surface electromyography” (sEMG) non-invasively. With both electrophysiological recording methods progress in CNS functioning and repair was

achieved. The oscillatory firing of motoneurons/motor units for example could be measured (Figure 5). With the sEMG, even the phase and frequency coordination among motor unit firing (Figure 6) could be recorded during the development of motor programs [3].

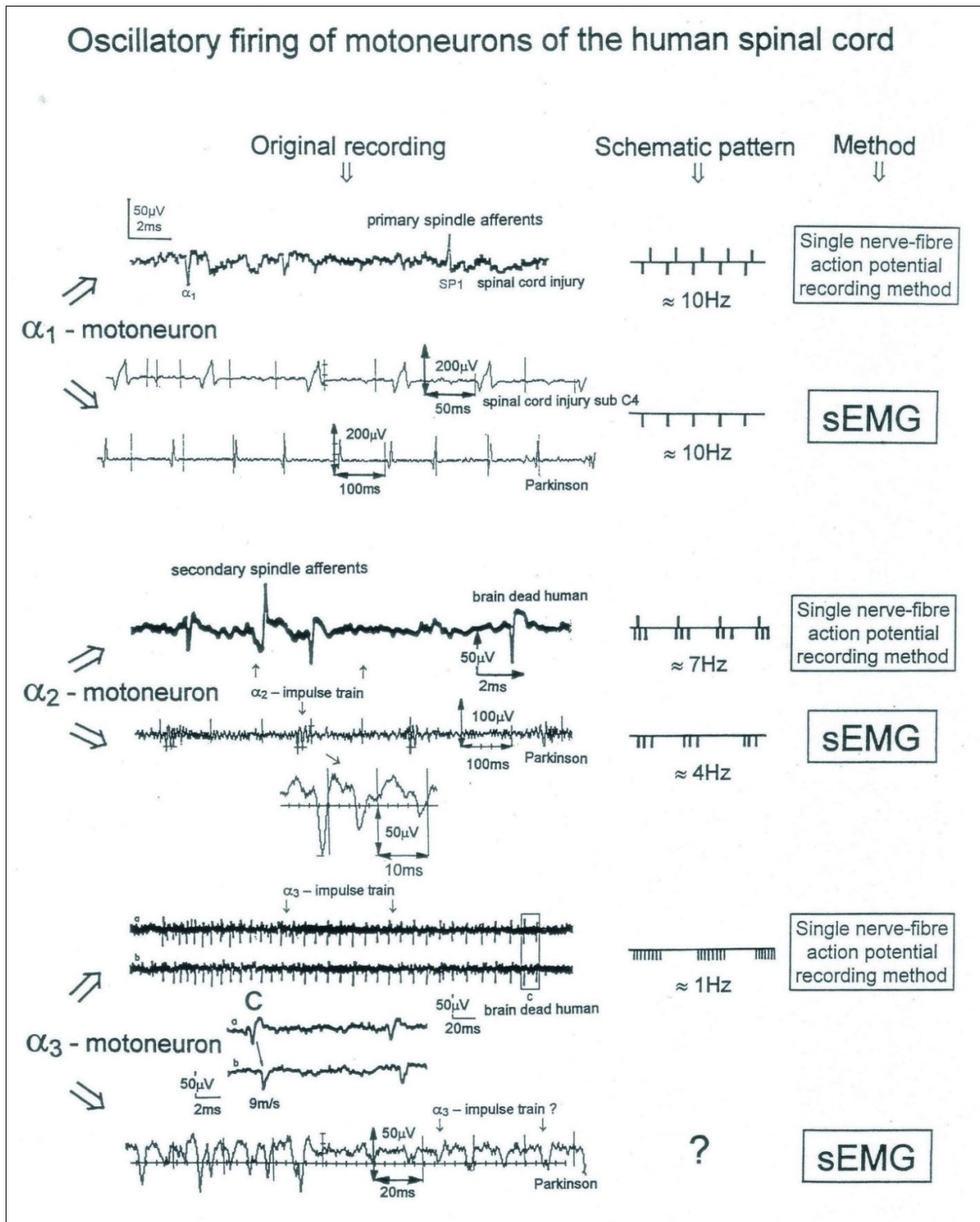


Figure 5. Oscillatory firing patterns of α_1 , α_2 and α_3 -motoneurons recorded from motoneuron axons with the single-nerve fiber action potential recording method and by surface electromyography (sEMG) from FF, FR, and S-type motor units. The left panel shows original recordings, the middle panel the schematic patterns; the recording methods are indicated on the right side. The recordings were taken from patients with spinal cord injury and Parkinson's disease and from brain-dead humans.

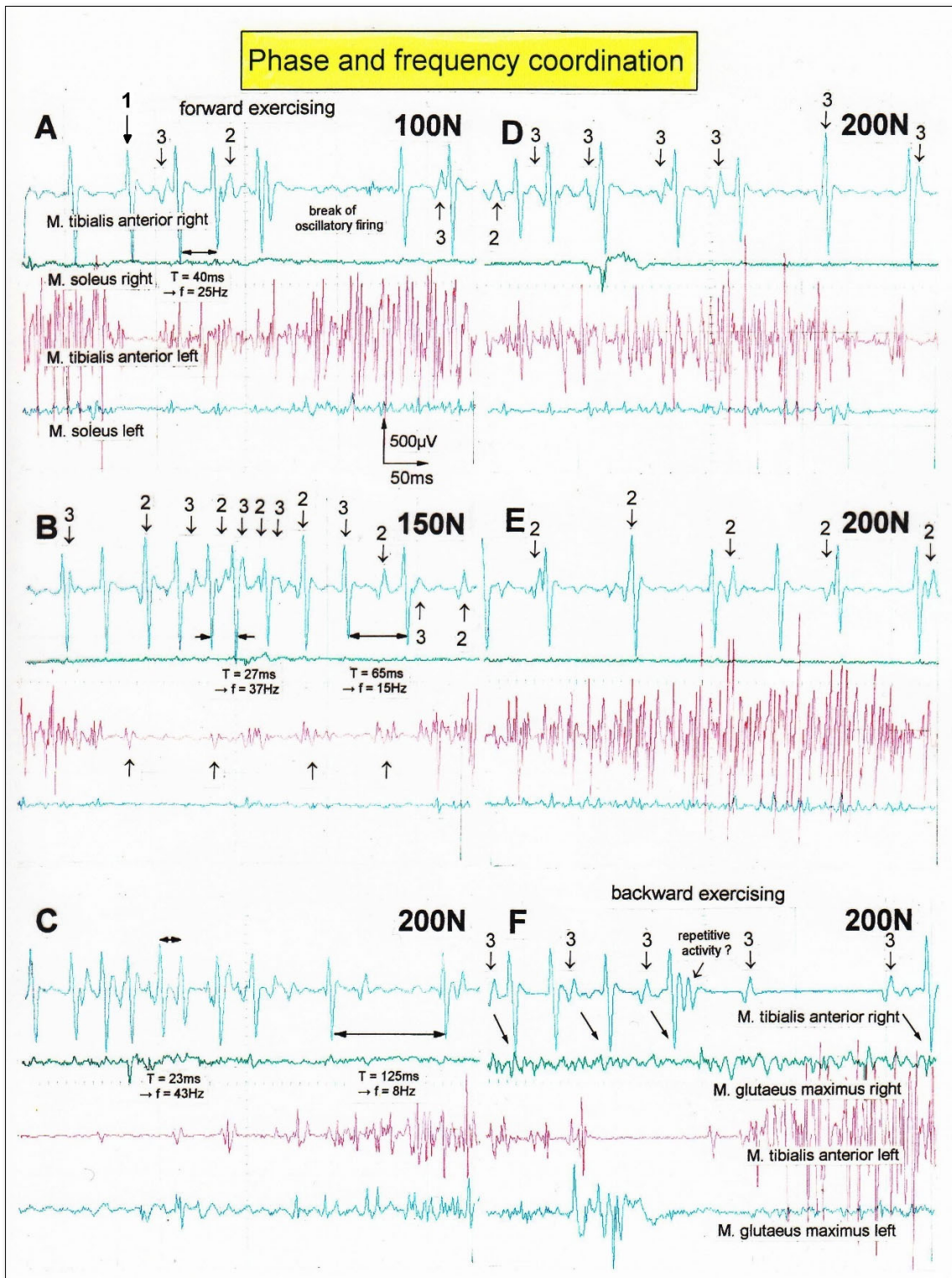


Figure 6. Recording of phase and frequency coordination between oscillatory firing motor units (1, 2, 3; FF-type) by sEMG during the generation of a motor program when exercising on the special coordination dynamics therapy device at loads increasing from 100 to 200N. Oscillation periods (T) and oscillation frequencies (f (Hz)) of oscillatory firing motor unit 1 are partly indicated. In F, some coordination's between motor unit '3' and '1' are marked.

For CNS repair, the phase and frequency coordination has to be repaired, which can efficiently be achieved when exercising on the special CDT device, where the different patterns between pace and trot gait are imposed by the device. Pace and trot gait are innate automatisms and humans use them for crawling, walking and running. But the device imposed intermediate coordination between pace and trot gait are very difficult for the CNS to generate and the whole complexity of neural network organization is needed to generate them. When the patient becomes able to generate these patterns and exercise rather smoothly on the device, his CNS has improved in its functioning and repair has been started. Animals like rats are most likely unable to generate this intermediate coordination between pace and trot gate because of the missing complexity of CNS neural networks. Exercising on a special CDT device is nearly always the first physiologic movement a severely brain-injured patient can perform. Important for repair through movement-based learning is the learning transfer to vegetative and higher mental functions [10]. In very severely brain-injured patients the improvement of the cognitive functions is very important to reach a meaningful life.

For repair through movement-based learning it is important to measure objectively the progress of repair. The quantification of CNS functioning can also be achieved when exercising on a certain special CDT device. The arrhythmicity of turning, the so-called coordination dynamics value, quantifies by one value the quality of integrative CNS functioning. Therefore, when exercising on a special CDT device, CNS functioning is improved and measured at the same time.

The theoretical background for measuring CNS functioning through movements is coming from the "System Theory of Patterns Formation" [11]. Through movement pattern change, the CNS functioning can be measured. The pattern change is achieved when the patient is exercising on the special CDT device and the coordination dynamics value is obtained from the arrhythmicity of exercising during the pattern change. The device is imposing the patterns to which the patient has to adapt to and to turn as smoothly as possible. When the CNS is functioning well, the patient can turn rather smoothly and the coordination dynamics value is small (good). When the patients CNS functions poorly, the patient can turn only with high arrhythmicity and the coordination dynamics value is high (bad) or the patient is not able to turn at all. In this case, the patients CNS can

just not generate the different movement patterns. In the patient of this case report, first the patient could not exercise at all. With the help of the author, he learnt unexpectedly quickly to exercise by himself. Then it became possible in the first therapy session to improve CNS functioning and to measure the progress with movement-based learning. It will be shown in the Results that the very severely brain-injured patient learnt first the important automatic patterns of human which are needed for walking and running and then also the complicated intermediate coordination between pace and trot gait started to improve. It is actually astonishing how quickly the patients CNS learned to functioning better, even though he was selected to be a potential organ donor!

RESULTS

Case report

General case

The 17 year old Fovios suffered in a motor cycle accident a very severe brain injury. The neck hit a street border stone. Brain and brain stem were injured and he was unconscious following the accident. Most likely he was ventilated. The parents were asked whether they agree that Fovois could be used as a potential organ donor. They refused. Unexpectedly the young man recovered from coma after 7 months spontaneously. The patient was continent. The remained continence was also unexpected, because in very severe brain injury also the continence is lost. But in a rather complete spinal cord injury also sometimes the continence is retained. Conventional physiotherapy was administered with little progress. A leg operation was performed 4 years after the accident. Fovios became able to move slowly in the upright position without support.

16 years later, at an age of 33, the father came with his son three times for consultation and treatment to the author. The patient needed for upright moving support (**Figure 7A**). Together with the author a highest speed of 3 m per 35 s was achieved (which is an extremely slow speed) when the author was holding both hands for support and balance (**Figure 7B**).

The right hand and arm were spastic (**Figure 7A**) like in stroke patients. When the author was holding both hands the spasticity in the right hand reduced (**Figure 7B**). Through exercising on a special CDT device for 30min to 60 min, the right-hand spasticity reduced strongly in the short-term memory as in stroke patients.



Figure 7. A: Patient Fovios with a severe brain injury during moving. B: This patient moving with support of the author at the highest speed of 3 m per 35 s.

When the right hand was fixed to the handle of the special CDT device, the patient learned unexpectedly quickly to exercise by himself. First the author supported the turning (**Figure 8**). Then the author included during the support coordinated instructive training by counting in coordination with the handle position “one-two-three” (**Figure 9**). After approximately 30 min of exercising the

CNS functioning had improved that much so that the patient became able to turn by himself. It became thus possible, besides the training for repair, to measure the improvement of CNS organization via the coordination dynamics in the three therapy sessions two to three days apart (**Figure 10**). The improvement of CNS functioning will now is analyzed.



Figure 8. The author is supporting the exercising on the special CDT device, because the patient is at the beginning of treatment unable to turn by himself. The right hand had to be fixed to the handle by a bandage.



Figure 9. The author is including during the supported exercising the instructions “1-2-3-...” in coordination with the turning movements to speed up the learning process. The speaking of the author is suggestive as can be seen from the expression of his face.



Figure 10. The patient became able to exercise by himself and the nervous system functioning could be measured.

Increase of the turning frequency as the first sign of CNS functioning improvement

In **Figure 11**, the improvement of CNS functioning is shown from the beginning of the first to the third therapy session. When the patient became able in the first therapy session to turn by himself, he could turn only slowly (**Figure 11A**, 0.339 Hz). Then he became able to turn faster (**Figure 11B**, 0.464 Hz). During the second therapy session he could turn further faster (**Figure 11C**, 0.529 Hz) and during the third session still faster (**Figure 11D**, 0.679Hz). The increase of the turning frequency is one indication of improvement of CNS functioning. It increased by 50%. The inner frequency of turning of the author is in the range of 1.5 Hz.

Reduction of coordination dynamics values as the second sign of CNS functioning improvement

The coordination dynamics values also improved (reduced). They reduced from 57.845 (**Figure 11A**) to 57.530 (**Figure 11B**) in the first therapy session and further to 50.131 (**Figure 11C**) to 46.110 (**Figure 12D**) during the second and third therapy sessions. The improvement of CNS functioning, quantified by the coordination dynamics value, was by 20%. The decrease of the coordination dynamics values is a second measure for the improvement of CNS functioning. For comparison, the healthy and trained author has a coordination dynamics value of 2 in comparison to 46

which the patient reached. The authors CNS functioned at that time 23 times better.

The first selective enhancement of the pace and trot gait automatisms are a third sign of the CNS improvement

Interesting is further, how the different coordination patterns during exercising improved, which can be judged here by the frequency of turning. At the beginning of CNS repair, there was nearly no preference to a certain exercise pattern (Figure 11A). The patient got often nearly stuck. Then slowly the trot gait pattern (K)

improved (Figure 11B), because he could turn continuously with higher frequency around the trot gait pattern. During the second session, pace (P) and trot gait (K) movement patterns improved strongly. During the third therapy session, a rather continuous exercising became possible. The patient only seldom got stuck for certain exercise patterns. The frequency did not reduce transiently to zero (Figure 11). On the coordination dynamics trace of the healthy and trained author no priority of certain patterns can be seen. His CNS manages with all movement patterns well.

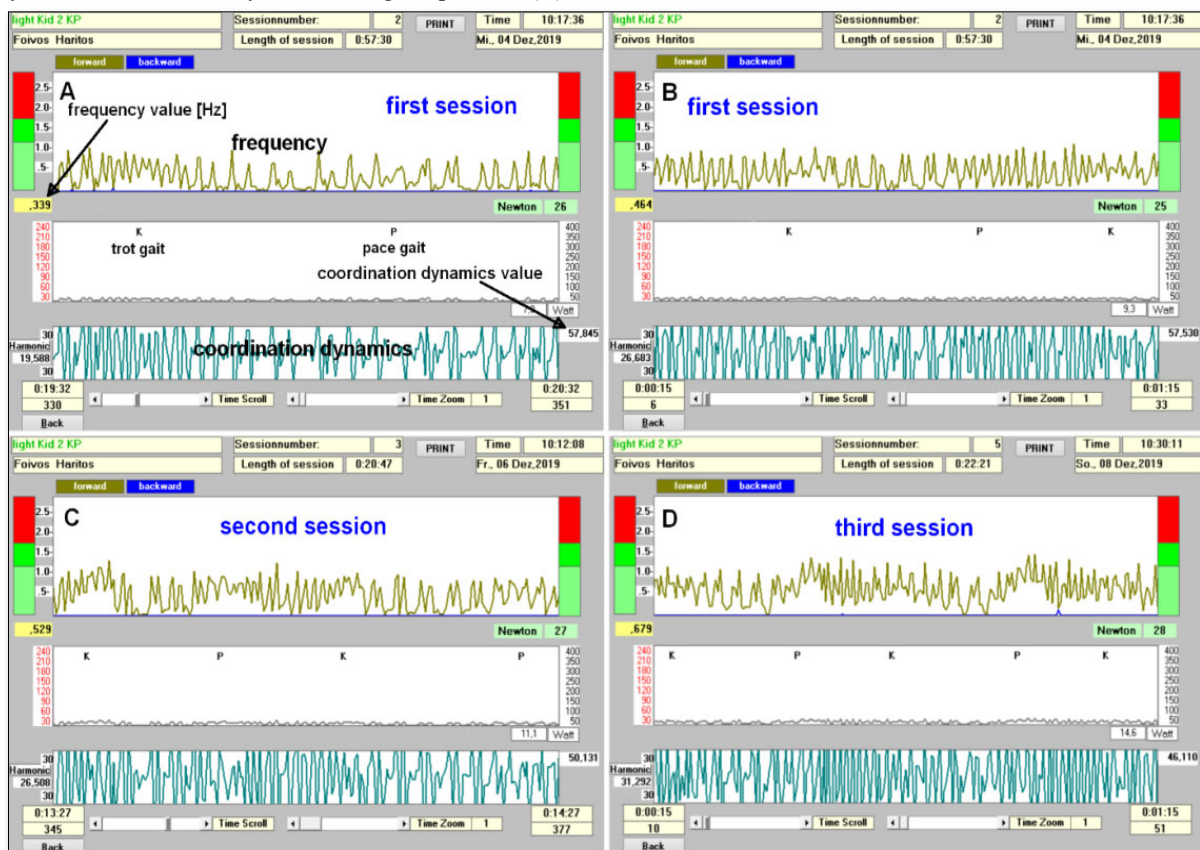


Figure 11. Coordination dynamics improvement of the patient Fovios with a very severe brain injury due to a motor cycle accident. P = pace gait, K = trot gait. The frequency and the coordination dynamics values are mean values of 1min exercising. The coordination dynamics trace gets out of range because of poor coordination between arm and leg movement and in turn because of strong impairment of the phase and frequency coordination among neuron firings.

In conclusion, during the repair through CDT, the CNS gave first priority to the repair of the automatism patterns pace and trot gait which humans need for crawling, walking and running. That means that during the repair of the CNS, the most important patterns for life are repaired first. The repair of the automatism patterns pace and trot gait is a third measure for the improvement of CNS functioning.

Necessity for an improvement of the breathing center functioning

During the third therapy session, Fovios got problems with the breathing. He could not sufficiently inhale to get sufficient oxygen supply for exercising and neural network repair. For sure he was not fit. Probably he had not trained fitness for years. During repair, power is needed for muscle activation and for neural network repair. The CNS neural networks have 'stress' to generate

the especially complicated patterns between pace and trot gait. During exercising for repair, the patients with severe brain injuries sweat because of muscle power generation and neural network repair. The CNS has difficulties to generate in the deep complexity of CNS organization the complicated patterns between pace and trot gait.

For repairing efficiently his CNS, priority has to be given first to the repair of the breathing center in the formation reticularis in the brain stem. For turning faster and longer may be oxygen has to be administered during the therapy sessions.

PROGNOSIS

Because of insufficient breathing, his speech was quietly. An improvement of the breathing center will improve his speech. Even though his higher mental functions are probably only little impaired, an urgent therapy is necessary, because he attempted already once to suicide. With an intensive efficient therapy like CDT, Fovios has a good prognosis to get rather fully back to life, because his CNS improved quickly in functioning.

DISCUSSION

To keep the level of CNS functioning

With several inefficient treatments Fovios could not keep during 16 years the level of CNS functioning. First, he

managed to move without a stick. Now at an age of 33 he needs a stick to slowly move. To keep the level of CNS functioning, he may have to train every day for 1 h.

Comparison to very severe brain injury

In comparison to a severe brain injury as in the patient Manolis, Fovios with probably mainly a brain stem injury (a new MRI not available) is well up, because his higher mental functions are probably only little impaired and his brain stem injury can be repaired through CDT. Since the breathing is an automatism, the genetics will help for efficient repair as found out in animal experimentation. When the breathing center was damaged in a dog, it recovered spontaneously with 2 h [12,13].

Comparison to brain stem injury

When jumping on a trampoline, the eight-year-old Rafaela fell on the back and hit probably with the neck the metal support surrounding [5] in similarity to Fovios. As can be seen from her MRI, Rafaela had suffered an incomplete injury of the spinal cord extending from the thoracic segments Th1/2 rostral till to the medulla oblongata (**Figure 12B**). All the cervical spinal cord segments were damaged probably by pressure, caused by the edema and/or lack of blood supply caused by the pressure.

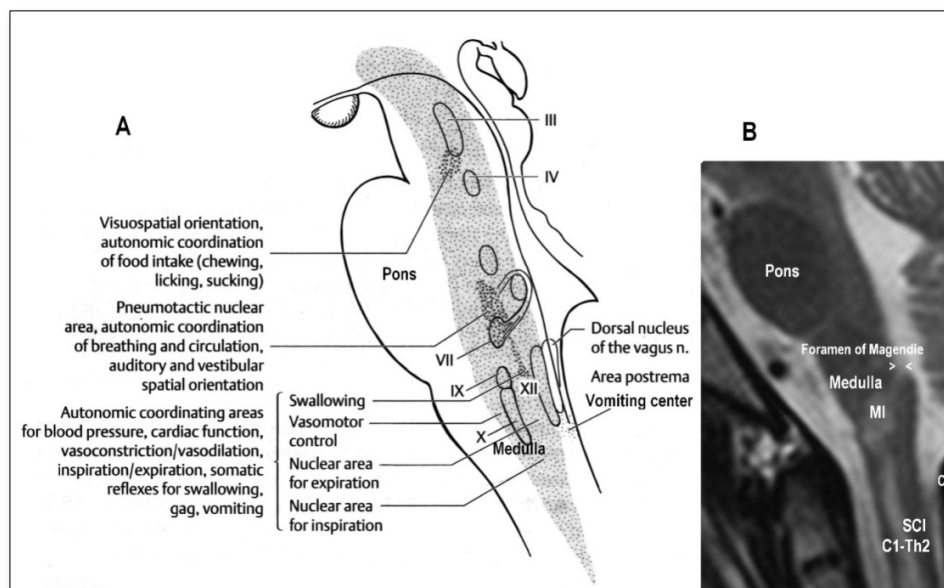


Figure 12. Injury of the medulla (MI) and the spinal cord (SCI, C1-Th2) of the eight year old patient Rafaela. By comparing the MRI (B) with an anatomical picture (A) and the clinical picture, it turned out that at least the nuclear area for inspiration/expiration, the nuclei of the vagus nerve (X), the phrenic nerves (C3-5) and the accessory nerve (XI, C2-4) were injured.

It seems that the injury included also a damage of the caudal part of the reticular formation and the nuclei of the vagus (X) and accessory nerve (XI). The caudal reticular formation is the nuclear area for inspiration and

expiration. This conclusion is supported by the clinics. Rafaela, being in the coma, had problems with breathing and was connected to a respirator. Five years later, Rafaela was operated because she had stones in the

kidneys and a big stone in the bladder, indicating that, most likely; also the vagus nerve/nucleus was damaged, because the vagus nerve regulates the secretion of the kidneys. From **(Figure 13A)** it can be seen that the shoulders of Rafaela are too much curved forwardly.

With intensive CDT for three months her breathing and her movement functions improved **(Figure 13)** [5]. She could stand up by herself from the sofa with a few trials **(Figure 13B and 13C)** and exercise on the sky-walker **(Figure 13D)**.



Figure 13. A: The patient Rafaela (with mother and sister) with an incomplete spinal cord injury extending from the thoracic Th1/2 segments rostrally to the medulla oblongata (including all cervical segments). Note the bending of the shoulder and the hanging of the arms, due to the injury. The expression of her face characterizes her psychological state. B, C: Through CDT, Rafaela succeeded to get up from the sofa by herself. D: She became able to perform sky-walking following three months of therapy.

When the coma regressed in Rafaela 10 days after the accident, she had no motor functions below the injury level. The physicians told the mother that Rafaela will stay like this for the rest of her life, but Rafaela recovered quite well. She is good at a normal school.

The injury of Fovios was much more severe because Rafaela was 10 days in the coma and Fovios 7 months, which seems to be the limit that a patient following severe brain injury can recover from coma spontaneously. The severely brain-injured patient Manolis recovered from permanent coma through 4 to 5 years of aggressive CDT. Interesting is that when the author studied medicine, after engineering and theoretical physics, he had the impression that after 4 to 5 years of learning medical facts the learning improved including memory.

PROGNOSIS

Even though the patient did not get better over 16 years, but got worse, he could be improved in three sessions with up to 1 h duration. An intensive CDT with 20 h therapy per week would improve most likely the right-hand function, improve breathing and would make him walk again. The problem is that after 16 years and trying

out many inefficient and ‘hocus-pocus’ treatments the patient and the relations do not believe in anything anymore and are worn out to fight again.

ORGAN DONATION

The demand for organs significantly surpasses the number of donors everywhere in the world. There are more potential recipients on organ donation waiting lists than organ donors. There is therefore strong interest to get more organ donors. Since further with a long-lasting movement-based learning therapy no money can be earned, but money can be earned with organ transplantation, there exists the possibility that not much efforts are taken to keep patients alive in cases of very severe brain injuries. Further, basic human neurophysiology and repair is not read at universities to inform medical students about new possibilities of brain repair. Physiotherapy of brain injuries is inefficient and at least 30 years out-of-date. When in Switzerland the physiotherapy education was upgraded from school to academy, only the names were upgraded, not the knowledge. During the change from school to academy there was no interest to integrate the knowledge of the author. That a potential organ donator even recovered

after 7 months from coma spontaneously is something like a horror scenario.

PRESS

The German parliament (Bundestag) decided at the 16.1.2020 for the "opt in" (only those who have given explicit consent are donors) and against the "opt out" (anyone who has not refused consent to donate is a donor (German: Widerspruchslösung)) probably on ethical grounds, but not on the basis of medical research at the edge. German TV at the same day showed a patient who benefited from a kidney transplantation; they did not show a patient who suffered a severe brain injury and was chosen for a potential organ donor.

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