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Electromyography Monitoring for Complete and Incomplete Transections of the Spinal Cord in Humans Who Received a Cell Therapy Combined with LASERPONCTURE® or LASERPONCTURE® Only: Methodology, Analysis, and Results

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1. Introduction

The most difficult thing to achieve in the case of a spinal cord injury (SCI) and/or spinal trauma is to objectively assess the progress and voluntary motor recovery. The exercise becomes even more hazardous when one sets as a preliminary rule that **each SCI or spinal trauma is unique and original both in its bone and spinal anatomical location, and in its consequences on the whole body.** Starting from here, we assume that there is no standard approach but an observation process to be adapted for each special case.
For example, two SCI individuals suffering from a complete transection of the spinal cord at anatomical level T5 will show totally different clinical pictures. They may be affected, or not, by spasticity – even flaccidity for some cases with a loss of mass muscle – or neurological pain. Each case is different and should have its own approach.
Before any examination can take place, a preliminary face-to-face interview to understand the injury and its manifestations is fundamental. Every single thing should be investigated during this interview whether it concerns the motor or sensory level, as well as the bowels and bladder functions, and sexual function. The information collected should be as thorough as possible. A psychological check-up should not be discarded either as it provides the SCI individual's input regarding his/her body image and relations s/he has with others.
Electromyography monitoring is a pioneering work published in the peer-review journal Cell Transplantation and presented in various scientific meetings.
Avicenna (980-1037), a Persian philosopher and physician commonly known as **Ibn Sīnā**, was credited with the following quotation "**the sick person cannot only be encompassed through his disease**".

2. Aim

The aim of this chapter is to highlight that a voluntary muscle activity below the SCI can be measured by electromyography monitoring.

Several groups were investigated:
Group A: incomplete spinal trauma with the following subgroups:
- Laserponcture® only
- Laserponcture® combined with ensheathing stem cells
- Laserponcture® combined with ensheathing autologous stem cells
- Laserponcture® combined with autologous hematopoietic cells
- Laserponcture® combined with a therapy based on multiple autologous stem cells

Group B: complete spinal trauma (complete transection of the spinal cord) with the following subgroups:
- Laserponcture® only
- Laserponcture® combined with ensheathing stem cells
- Laserponcture® combined with ensheathing autologous stem cells
- Laserponcture® combined with autologous hematopoietic cells
- Laserponcture® combined with a therapy based on multiple autologous stem cells

The *American Spinal Injury Association Classification of Spinal Cord Injury* defines a complete or incomplete SCI in its ASIA Impairment Scale as the following:
- A = Complete: no motor or sensory function is preserved in the sacral segments S4-S5;
- B = Incomplete: sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5;
- C = Incomplete: motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3;
- D = Incomplete: motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more;
- E = Normal: motor and sensory functions are normal.

3. Methods and material

Exclusion criteria:
- depression
- hyper spasticity

Inclusion criteria:
- complete or incomplete transection of the spinal cord treated by Laserponcture® only or Laserponcture® combined with a stem cell therapy
- cases with flaccidity post injury

Guidance and instructions for the patients were to voluntary contract the tested muscles (quadriceps, abdominal muscles, etc.) on demand. The sessions were also recorded on video.
The cases studied were selected according to the severity of the injury on MRI.
For each recording, a zeroing was performed to erase the parameters of the previous test with the aim of monitoring a change in the spasticity appearing during the examination.

Commentary

During the recordings, the following observations can be made:
a. a low curve when the individual is at rest predicts an increased response to the voluntary act during the next test

b. spasticity sometimes appears; it suggests muscle fatigue and requires to stop the test
More than 150 cases underwent the tests.
The PROCOMP5™ equipment with softwares BIOGRAPH INFINITI 5® and REHAB SUITE™ especially adapted to SCIs; the sensors MYOSCAN-PRO™ EMG (SA9401M-50) to record muscle activity, and FLEX/PRO™-SA9309M to record skin conductance were fixed on the skin. The unit of measurement is the µVolt.

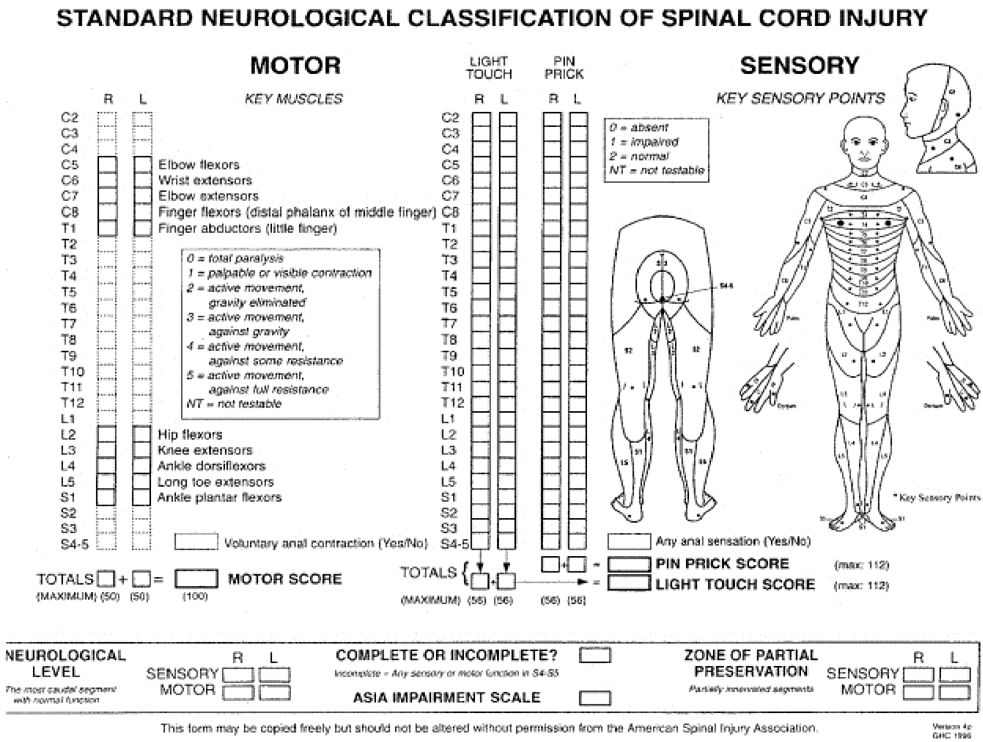

Fig. 1. Standard neurological classification of spinal cord injury.

4. Presentation of graphs and interpretation

4.1 Presentation of the graphs used

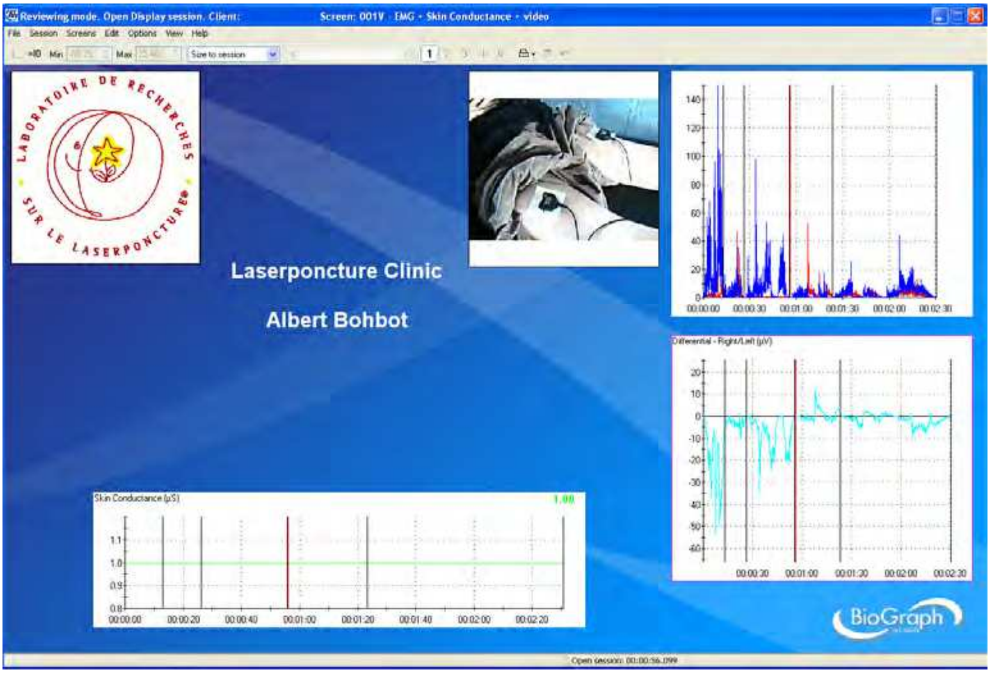

Fig. 2. Example of graphs used.
Graph A (top right): the red line represents the recorded activity of the right lower limb (RLL); the blue line represents the recorded activity of the left lower limb (LLL).
Graph B is obtained by arithmetic subtraction (bottom left): above 0: recorded activity of the RLL; below 0: recorded activity of the LLL.

4.2 Different types of activity recordings

Examples of graphs and their interpretation

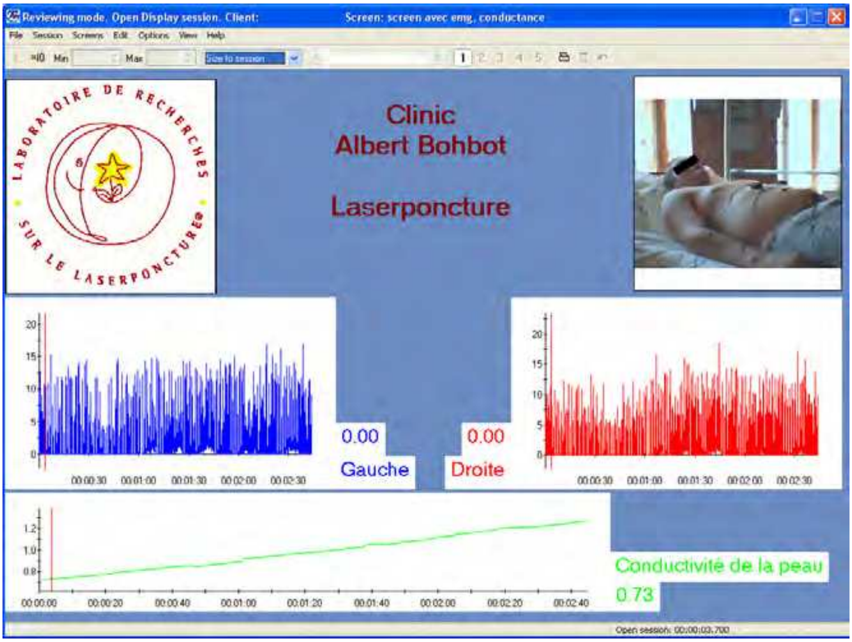

Fig. 3. Example of a muscle activity interference caused by spasticity.

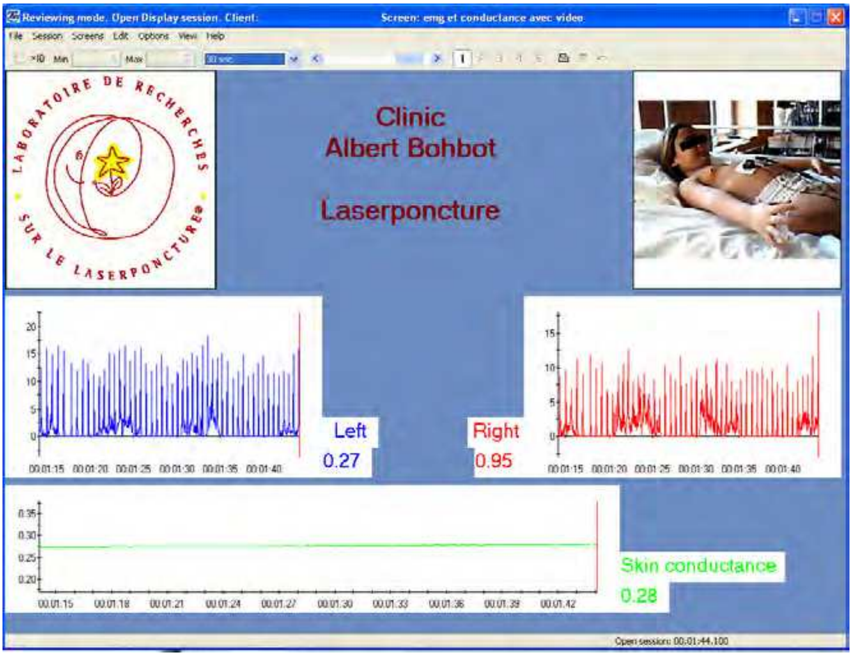

Fig. 4. Example of interference caused by the umbilical artery beatings (regular rising curve).

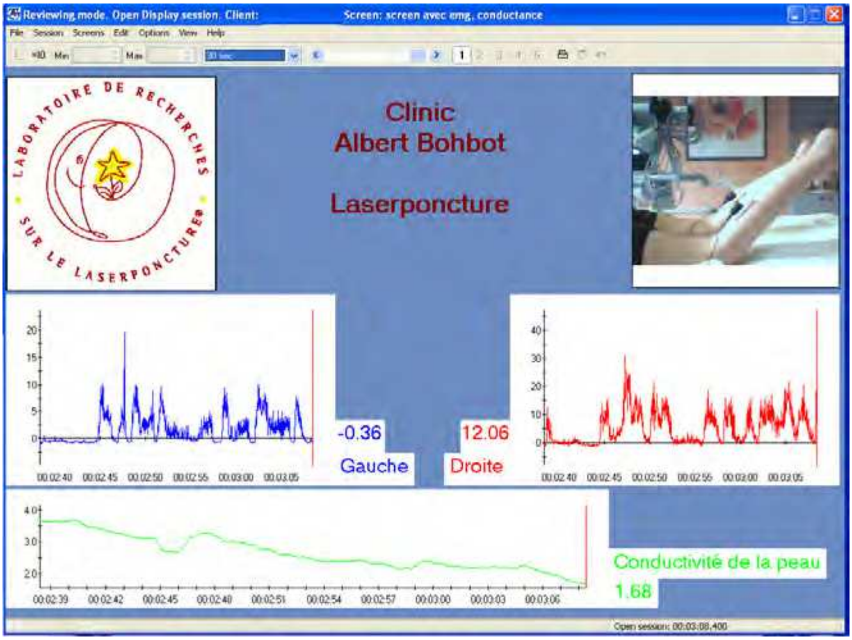

Fig. 5. Voluntary spontaneous muscle contraction (gastrocnemius muscles).

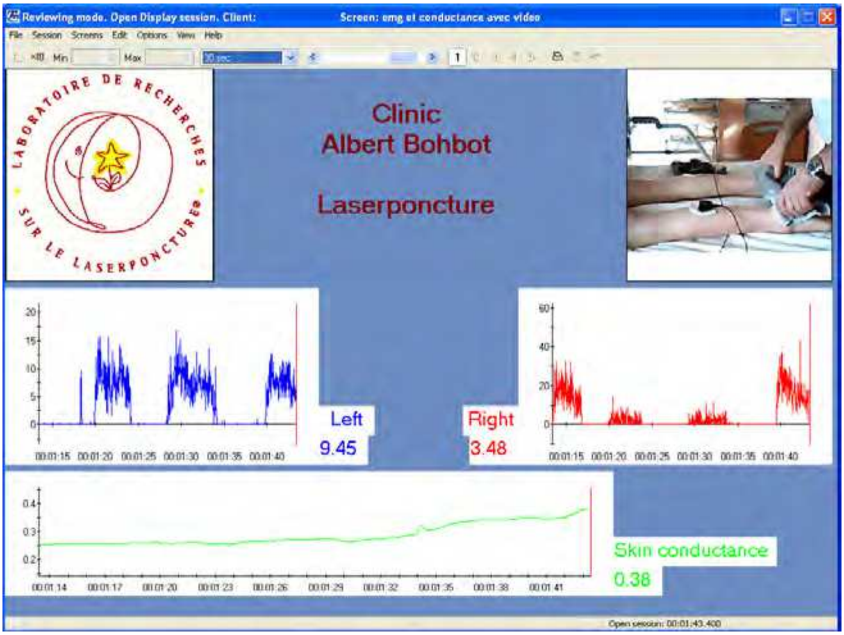

Fig. 6. Voluntary muscle contraction against resistance (gastrocnemius muscles; the operator's hand has no direct contact on the patient skin).

5. Positioning of captors

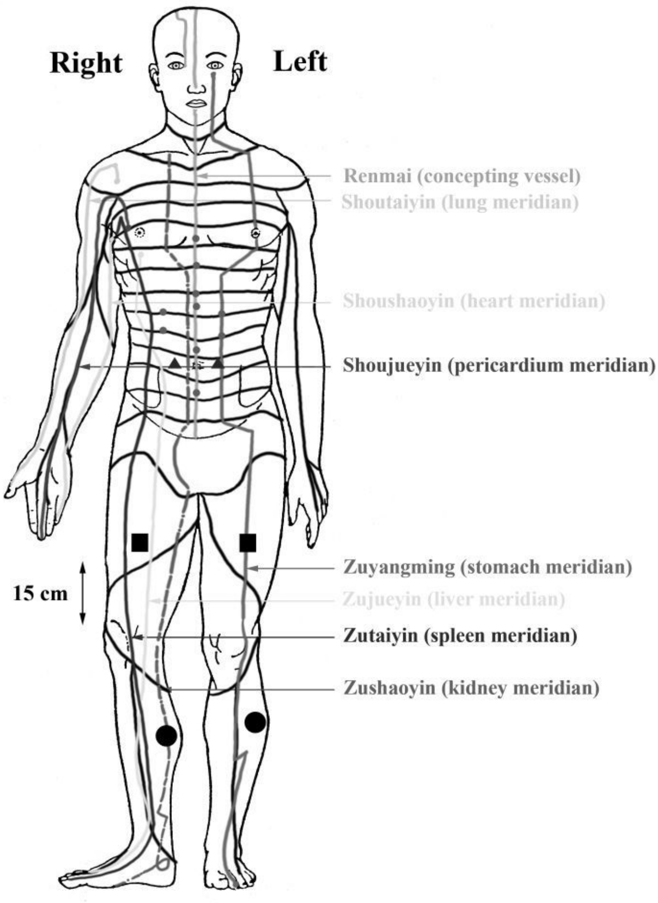

Fig. 7. Positioning of captors.

Front face
Squares: quadriceps
Triangles: abdominal muscles (upper, middle, and lower abdominal muscles)
Rounds: gastrocnemius
Other muscles can also be tested.

6. Case study

6.1 Quadriplegia with a complete SCI transection and Laserponcture® only

No MRI available for this case.

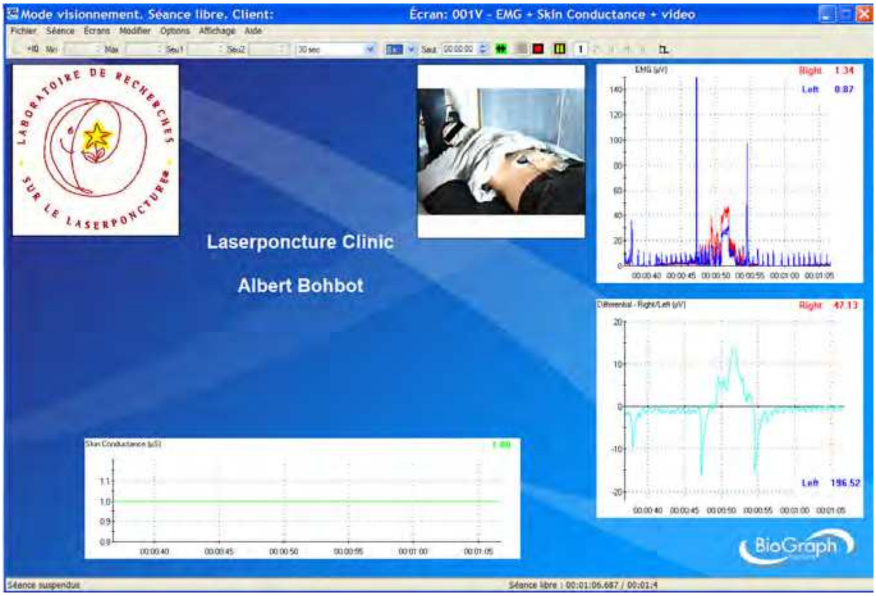

Fig. 8. Electromyography monitoring on April 1st, 2010 (upper abdominal muscles).

6.2 Quadriplegia with a complete SCI transection and Laserponcture® combined with olfactory ensheathing cells

Fig. 9. MRI showing a C5-C6 complete SCI.

Fig. 10. Electromyography monitoring on March 17th, 2010 (upper abdominal muscles).

6.3 Quadriplegia with an incomplete SCI transection and Laserponcture® only

Fig. 11. MRI showing a C5-C6 incomplete SCI.

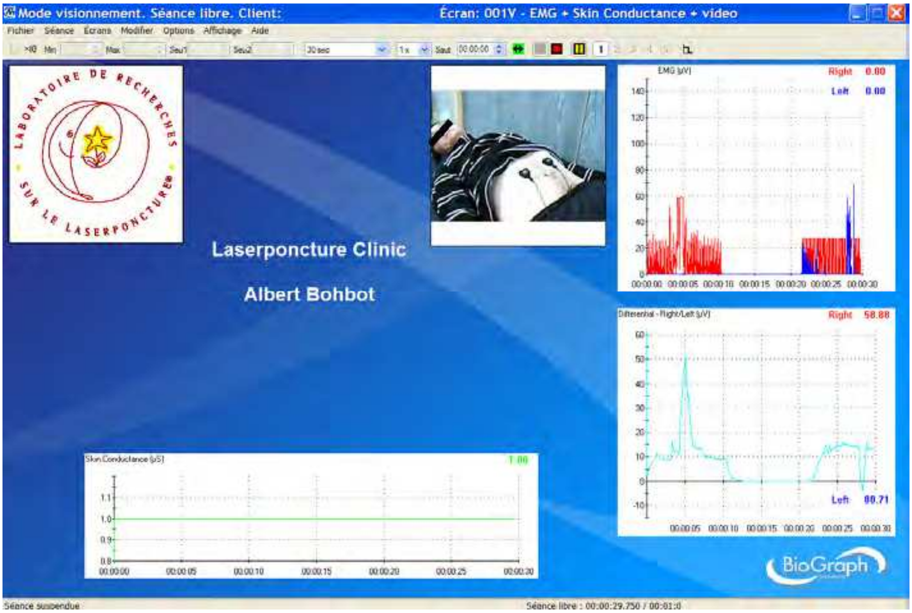

Fig. 12. Electromyography monitoring on January 12th, 2011 (upper abdominal muscles).

6.4 Quadriplegia with an incomplete SCI transection and Laserponcture® combined with cells (Nogo, Dr. Schwab's procedure)

Fig. 13. MRI showing a C6-C7 incomplete SCI.

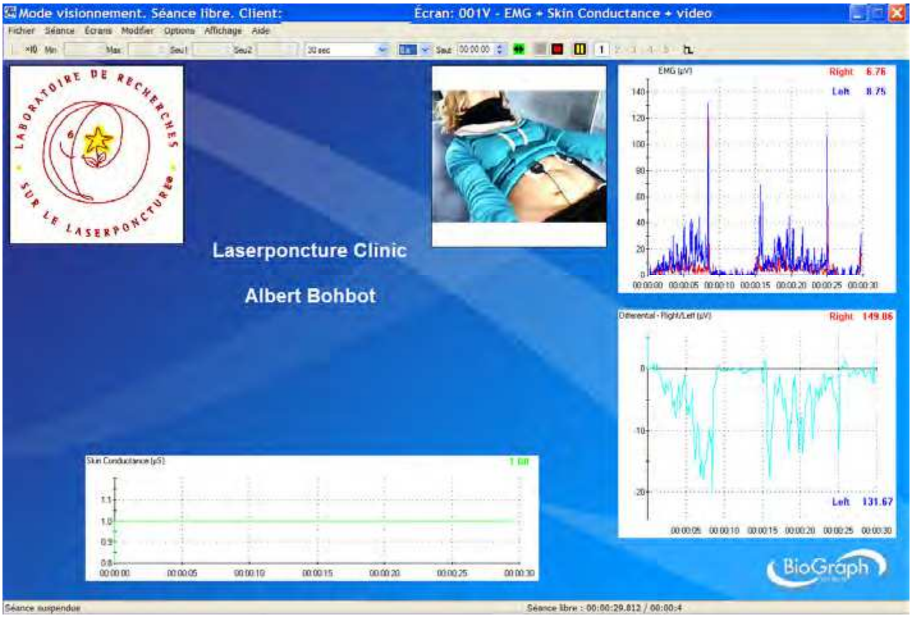

Fig. 14. Electromyography monitoring on February 28th, 2010 (upper abdominal muscles).

6.5 Paraplegia with a complete SCI transection and Laserponcture® only

Fig. 15. MRI showing a T12-L1 complete SCI.

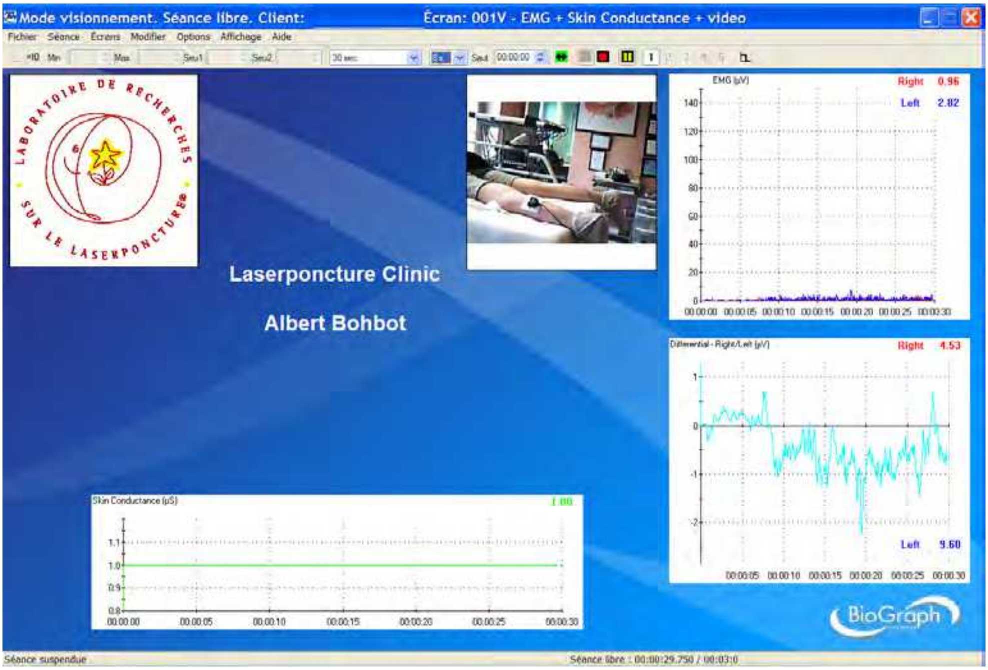

Fig. 16. Electromyography monitoring on February 9th, 2011, lateral gastrocnemius muscle.

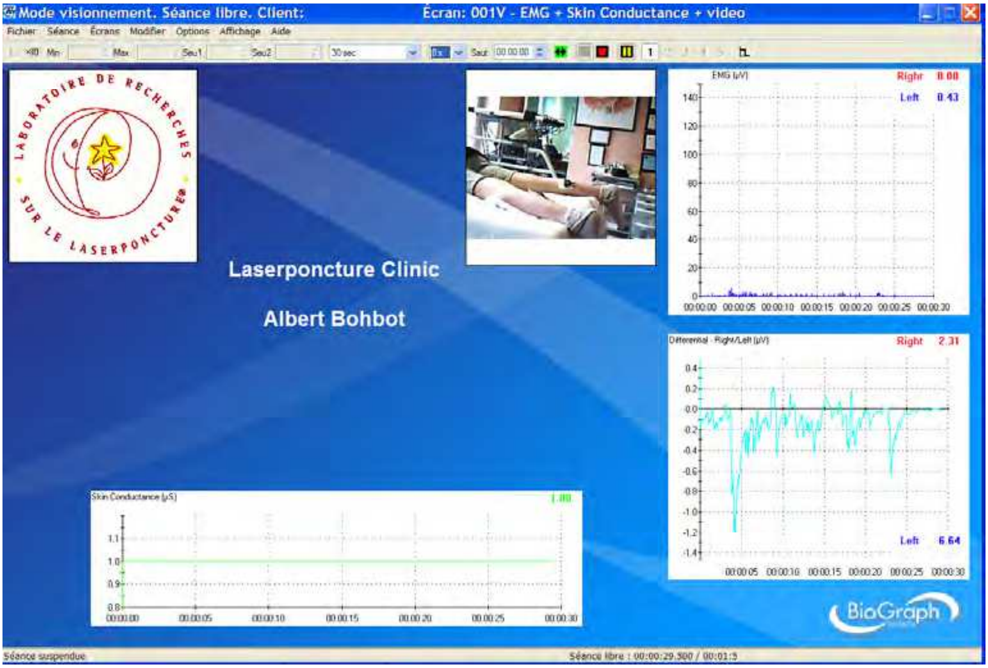

Fig. 17. Electromyography monitoring on February 9th, 2011, medial gastrocnemius muscle.

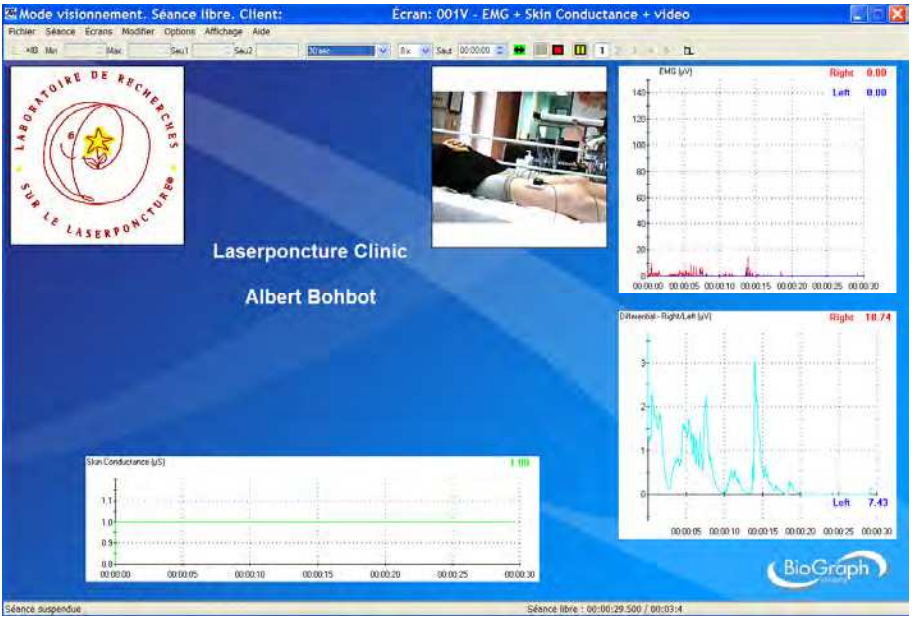

Fig. 18. Electromyography monitoring on February 9th, 2011, quadriceps.

6.6 Paraplegia with a complete SCI transection and Laserponcture® combined with olfactory ensheathing cells

Fig. 19. MRI showing a T10 complete SCI.

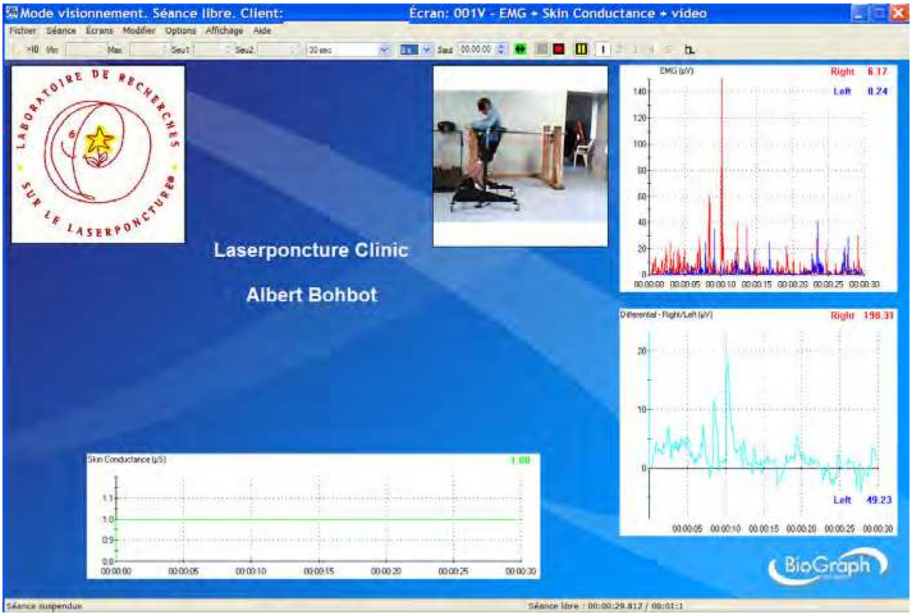

Fig. 20. Electromyography monitoring on November 22nd, 2010, quadriceps.

6.7 Paraplegia with an incomplete SCI transection and Laserponcture® only

Fig. 21. MRI showing a L1 incomplete SCI.

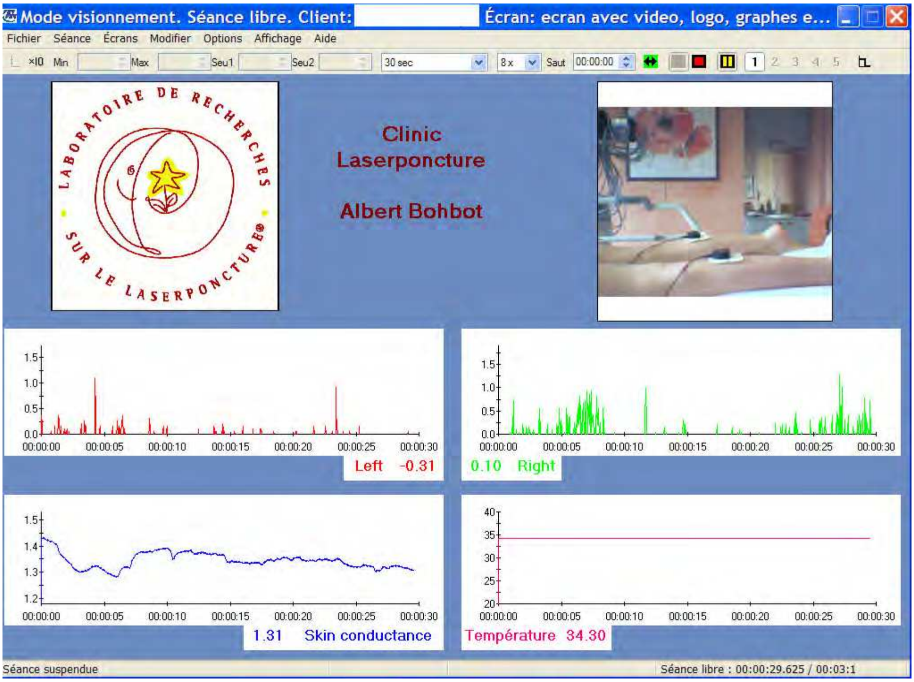

Fig. 22. Electromyography monitoring on February 26th, 2009, gastrocnemius muscles.

6.8 Paraplegia with an incomplete SCI transection and Laserponcture® combined with autologous hematopoietic cells

Fig. 23. MRI showing a T10-T11 incomplete SCI.

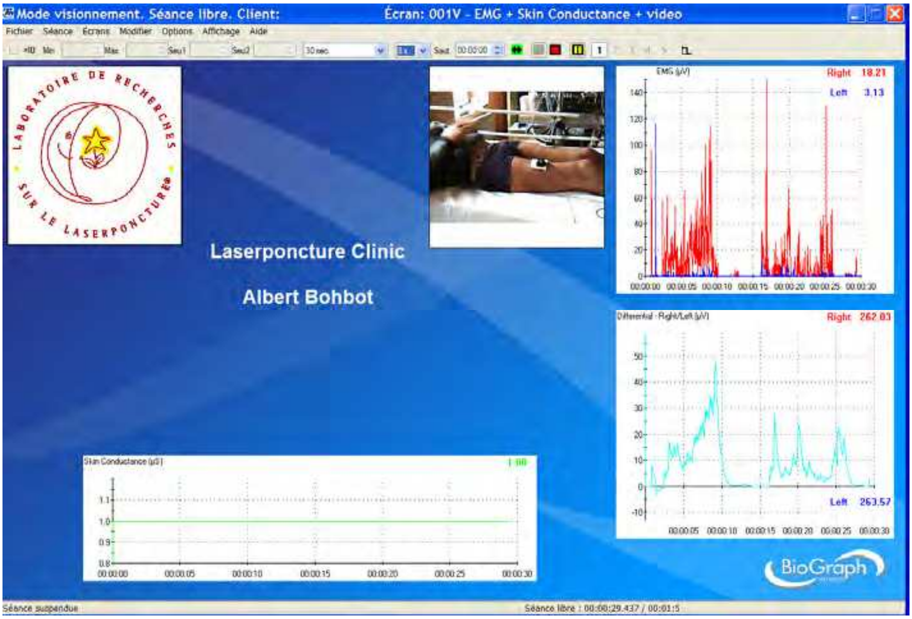

Fig. 24. Electromyography monitoring on January 26th, 2011, quadriceps.

7. Conclusion

This chapter underlines that it is important to track voluntary muscle activity below a SCI in order to possibly determine recoveries to come.

Electromyography monitoring suggests that there is muscle activity even though it may not be visible.

Despite a complete transection of the spinal cord, it also suggests that back-up networks develop to carry the brain orders through the body. It also shows that the information can be transmitted through other means, such as wavelengths, when there is a **complete anatomical transection** of the spinal axis, that is a tissue discontinuity preventing neurotransmitters to travel through synapses.

The information sent by the brain goes from an electrochemical state (neurotransmitters) to an electromagnetic state (wavelengths).

It also suggests that the brain deals with two languages of different nature, the electrochemical transmitter and the electromagnetic signal, which can relay each other.

8. Acknowledgement

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9. References

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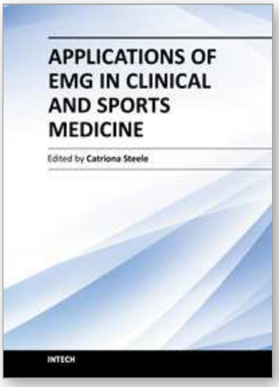

Applications of EMG in Clinical and Sports Medicine

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This second of two volumes on EMG (Electromyography) covers a wide range of clinical applications, as a complement to the methods discussed in volume 1. Topics range from gait and vibration analysis, through posture and falls prevention, to biofeedback in the treatment of neurologic swallowing impairment. The volume includes sections on back care, sports and performance medicine, gynecology/urology and orofacial function. Authors describe the procedures for their experimental studies with detailed and clear illustrations and references to the literature. The limitations of SEMG measures and methods for careful analysis are discussed. This broad compilation of articles discussing the use of EMG in both clinical and research applications demonstrates the utility of the method as a tool in a wide variety of disciplines and clinical fields.