Gait analysis after neurorrhaphy in the brachial plexus

P. Reichert¹, Z. Kielbowicz², J. Kuryszko³, A. Bocheńska⁴

¹ Department of Traumatology, Clinic of Traumatology and Hand Surgery, Wroclaw Medical University, Borowska 213, 50-556, Wroclaw, Poland
² Department of Surgery, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, pl. Grunwaldzki 51, 50-366, Wroclaw, Poland
³ Department of Animal Physiology and Biostructure, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, Norwida 31, 50-373, Wroclaw, Poland
⁴ Department of Internal Medicine, Faculty of Veterinary Medicine, University of Warmia and Mazury in Olsztyn, M. Oczapowskiego 14, 10-719 Olsztyn, Poland

Abstract

The gait is a form of human and animal locomotion on land by using limbs. The study assessed functional recovery after end to side and side to side neurorrhaphy the ventral branches of the C5 and C6 spinal nerves to the C7 spinal nerve on the rabbit brachial plexus. Gait statistical analysis showed significant differences between the control group versus the end-to-side and side to side neurorrhaphy groups, in opposite to the comparison between the two experimentals groups. Gait analysis results corresponded with the histomorphometric results. The results indicate the potential use of gait analysis for the assessment of the recovery of nerve function.

Key words: gait analysis, spinal nerve, neurorrhaphy

Introduction

The results of attempts to repair peripheral nerves are still unsatisfactory (Dahlin 2008). The basic method of the treatment of the interruption of the nerve is direct suture (end to end). In cases of large gap we use the procedure of coaptation end-to-side (Viterbo et al. 1992, Lundborg et al. 1994). End-to-side neurorrhaphy has been dedicated as a way to increase the number of regenerating fibers by collateral sprouting from the donor nerves (Xiong et al. 2003, Kubek et al. 2004). The major question with using an uninjured donor nerve in end-to-side repairs is whether a sufficient number of fibers by collateral sprouting could be enticed to grow into the regenerating nerve without damaging the donor nerve (Kovacic et al. 2007). The main problem is the assessment of the effectiveness of each method. Previous studies are mainly based on histological and electromyographic studies. These results do not always correlate with the functional outcome. The purpose of this study is to present a new technique neurorrhaphy
side to side and the evaluation of the results was based on gait analysis.

The gait is a form of human and animal locomotion on land by using limbs. This is a series of cycling movements of the whole body. This analysis is one of the elements of a medical examination to assess the locomotion system. Gait analysis provides information about integration the skeletons, muscles, joints and nervous system. Gait analysis is also a useful test for the evaluation of the pain degree (Coulthard et al. 2002). It is an important tool in the assessment of the level of neurological disorders of the brain, spinal and peripheral nerve. Frequently gait analysis is performed by using advanced computer analysis techniques (McLaughlin 2001, Fanchon and Grandjean 2009). However, visual analysis of gait and footprint stride length assessment seems to be useful (Guillot et al. 2008). We believe that confirmation of the effectiveness of this method will complement the existing methods used in assessing neurorrhaphy.

Materials and Methods

The experiments were approved by the II Local Ethics Committee for animal at the University of Life Sciences in Wroclaw. Thirty six New Zealand White rabbits were anesthetized and surgical procedure on the left brachial plexus (C5-ventral branches of spinal nerve C5, C6-ventral branches of spinal nerve C6, C7-ventral branches of spinal nerve C7) was performed. Premedication was performed with medetomidine (Cepetor) at a dose 150 μg/kg body weight, butorphanol (Torbugesic) at a dose of 0.2 mg/kg body weight and ketamine (Bioketan) at a dose of 35 mg/kg body weight. General anesthesia was performed with propofol, which was administered continuously at a dose of 0.1/mg/kg/min. The analgesic effect was supported by fentanyl at a dose of 2-3 mcg/kg. After the procedure, buprenorphine (Vetergesic) was used at a dose of 20 mcg/kg i.m. every eight hours. The animals were given meloxicam (Metacam) at 0.2 mg/kg body weight for two days after surgery. The same anesthesia protocol for all the rabbits was used. In 12 cases, end to side neurorrhaphy (C5, C6 to C7), in 12 cases, side to side neurorrhaphy (C5, C6 to C7), in 6 cases only cut (C5, C6) without suture were made. The control group consisted of 6 normal rabbits. C5 and C6 were arulsed incised after exiting the spinal canal. End-to-side repair was made by a 3-mm window on C7, and distal stump was sutured by 2 10-0 ethilon stitches by a 3-mm. Side-to-side repair was made by a 3-mm window on the right side of C5, C6, and distal stump was sutured by 2 10-0 ethilon stitches by a 3-mm window on the left side C7. Evaluation was performed 20 weeks after surgery. The assessment covered the position, posture and gait analysis. Neurological examination was performed including, proprioception, spinal reflexes and superficial and deep pain sensation. The six healthy rabbit not subjected to any medical procedures was the model for correct neurological response, body posture and position and gait traces. Inked-paw stride length was performed as described (Tillerson et al. 2002, Guillot et al. 2008). The front paws were inked and the rabbits were allowed to walk toward the paper without stimulation. Toe-to-toe measures were taken (the length of each forepaw step was measured) and averaged. The averaged length was calculated by summing the distance for each step and then dividing by the number of successful steps. The neurological examination was performed. Efficiency in the neurorrhaphy was made on the basis of histological analysis of the number of myelinated fibers and a factor of g-ratio (the ratio of the axon diameter to the diameter of the entire fiber).

Results

The comparison of material collected from C5, C6 1 cm after coaptation to material from C5, C6 on the same level in the control group reveals that the number of myelinated axons was markedly reduced accordingly compared to control group: in end to side-47%, in side to side group -36 %. G-ratio was respectively 0.6589 ± 0.08 in end to side neurorrhaphy group, 0.6318 ± 0.09 in side to side neurorrhaphy group compared to 0.6559 ± 0.08 in normal group.

Gait analysis results are shown in Table 1. Gait analysis statistical analysis (Student test) showed significant differences between control group versus end to side (t=0.00948, p<0.05) and side to side (t=0.00013, p<0.05) group, in opposite to the comparison between the two groups with neurorrhaphy (t=0.05779, p<0.05). These results corresponded with the results of histological studies.

Discussion

The number of myelinated axons observed in the experimental group is lower than that fund in others studies, compared with end-to-side coaptation, e.g. between the peroneal and tibial nerves, approximately 50-63% of the original number of axons are present in the recipient nerve (Liao et al. 2009). On the other hand, the G-ratio was similar. As reported (Chomiak and Hu 2009, Rushton 1951) the G-ratio in the central nerve system in rats is near 0.7, and in the periph-
Table 1. Evaluation at 20 weeks after surgery.

<table>
<thead>
<tr>
<th>Position and posture</th>
<th>Control group</th>
<th>Without neurorrhaphy</th>
<th>Side to side neurorrhaphy</th>
<th>End to side neurorrhaphy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>Invalid Limb after surgery dissuaded from the body axis by 45 degrees</td>
<td>Invalid Operated limb slightly dissuaded from the body axis</td>
<td>Invalid Operated limb slightly dissuaded from the body axis</td>
<td></td>
</tr>
</tbody>
</table>

| Gait                          | Correct | Walking in a circle, No active support on the affected limb | Invalid, The animal was able to move forward and get to the destination, noted a delay in the movement of the affected limb and extension of the support phase | Invalid but the animal was able to move forward and get to the destination, noted a delay in the movement of the affected limb and extension of the support phase |

| Neurological examination      | The withdrawal response, Deep and superficial and deep pain sensation also correct | No withdrawal response and deep pain sensation | The withdrawal response correct, Impaired superficial pain sensation deep pain sensation also correct | The withdrawal response correct Impaired superficial pain sensation deep pain sensation also correct |

| Averaged stride length        | 18.16 ± 1.47 cm | Non | 13.83 ± 1.85 cm | 15.41 ± 2.02 cm |

References


Lundborg G, Zhao Q, Kanje M, Daniels N, Kerns JM (1994) Can sensory and motor collateral sprouting be...


