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An Animal Model for the Study of Compressive (Constrictive) Cervical Radiculopathy

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ABSTRACT

Purpose: The purpose of this study was to investigate the basis for the clinical and anatomical findings associated with C7 cervical radiculopathy in an animal model. In the diabetic population cervical radiculopathy is particularly more severe and symptomatic, especially C7.

Materials and Methods: A total of 60 Sprague-Dawley rats were randomly divided into six groups of 10 each. In each group, the nerve roots of C4, C5, C6, C7 and cervical plexus were exposed under the operating microscope with general anesthesia with pentobarbital and ketamine. Group 1 served as the sham operation group. In groups II-VI, different cervical roots were exposed and ligated by using 9.0 nylon at the point where they emerged from the foramina. In Group II C5, C6, and C7 were exposed and ligated, in Group III C4 was litigated, in Group IV C5 was ligated, in Group V C6 was ligated, and in Group VI C7 was ligated.

Results: After six weeks of ligation Groups III, IV and V improved and the allodynia completely resolved. In Groups II and VI improvement was noted but never recovered to the level of the other groups. Allodynia and hypoesthesia persisted throughout the study period.

Conclusion: Ligation of cervical roots independently or in combination can produce syndromes that resemble human CRPS I and II (International Association for Study of Pain Criteria), but the changes are more pronounced and persistent with C7 involved primarily or in combination with other roots

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Introduction

In a review by Mansfield et al., cervical radiculopathy was found to have an incidence in the general population ranging from 0.832 to 1.79 per 1,000 person years and prevalence ranging from 1.21 to 5.8 per 1,000. Based on experience and case reports, in the diabetic population cervical radiculopathy is particularly more severe and symptomatic, especially C7 where it can even mimic angina or CRPS [1-3]. Diabetic or infectious (i.e. herpes zoster) neuropathic changes in the cervical roots coupled with narrowing of the foramina may create the proper environment for neuropathic pain, along with sensory and motor abnormalities due to compression. Additionally, it may occur as a complication from contralateral C7 transfer for brachial plexus reconstruction [4].

This finding prompted us to investigate the basis for the clinical and anatomical findings associated with C7 cervical radiculopathy in an animal model. Findings include pain, weakness, and sensory disturbances when C7 is compressed or irritated as seen clinically in multi-level radiculopathies that include C7.

Interestingly we found in our animal model of the rat that C7 compression alone produced the most severe symptoms (especially pain). We postulate that this may be due to the contribution to the roots of C7 to the musculocutaneous, radial and ulnar nerves. None of the other roots alone produce C7-like symptoms. Severe pain symptoms also occurred when C7 compression was combined with compression of other roots.

Materials and Methods

This study was approved by the local animal use committee to meet international animal laboratory use and care standards A total of 60 Sprague-Dawley rats weighing between 200 and 230 grams were used. The rats were randomly divided into six groups. Group I consisted of 10 rats; this was the sham operation group. The nerve roots of C4, C5, C6, C7 and cervical plexus were exposed under the operating microscope with general anesthesia with pentobarbital and ketamine. Group II included ten rats. The same procedure was performed as on Group 1 but the roots of C5, C6, and C7 were exposed and ligated by using 9.0 nylon at the point where they emerged from the foramina. Group III included 10 rats, the same procedure was performed as on Group I but only C4 was litigated. Group IV included ten rats, the same procedure was performed as on Group I but only C5 was ligated. Group V included ten rats the same procedure was performed as on Group

I but only C6 was ligated. Group VI included 10 rats and the same procedure was performed as on Group I but only C7 was ligated. The animals were observed during a four-month period and euthanized at four months. During the period of observation, the rats were videotaped performing the walking track. Sudo-motor disturbances were also recorded by visual inspection. X rays were obtained to document osteopenia and longitudinal growth.

Results

Group I showed normal behavior and no pain or mechanical allodynia. Group II to group VI invariably showed signs of allodynia and avoided touching any objects on the floor. After two weeks the allodynia had gradually diminished but in Group II and Group VI allodynia remained unchanged and the animals refused to be touched, move, or to eat or drink for the entire period of observation. After six weeks of ligation groups III, IV and V improved and the allodynia completely resolved. In groups II and VI improvement was noted but never recovered to the level of the other groups. Allodynia and hypoesthesia persisted throughout the study period. The walking track similarly showed an improvement in all groups except groups II and VI.

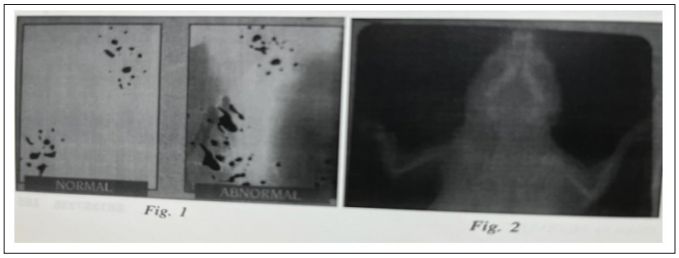

Figure 1: Walking Track

Figure 2: Diffuse Osteopenia and Delayed Growth

X-rays revealed diffuse osteopenia in all groups and all rats showed delayed growth at two months. By the fourth month the animals had become underweight. At four months the forearm of the animals was 10mm shorter compared to the normal contralateral side.

In summary, the walking track improved in all groups, except Groups II and VI. X-rays revealed osteopenia and delayed growth in all groups. By four months, Groups II and VI had become underweight. Notice similar physical appearance of both the fore paw of rat model and a patient with CRPS II.

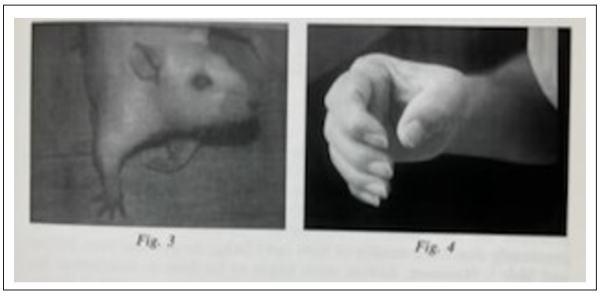

Figure 3: Rat Forepaw

Figure 4: Patient with CRPS

Note: Similarities between Rat Forepaw and Patient with CRPS

Analysis

Data were analyzed using Cochran Q test. This nonparametric approach was necessary given the all-or-none nature of the data, and because of the lack of confidence in either the similarity of variance among the groups, or whether the populations were normal.

Table 1 presents the frequencies, with results presented in Table 2. The results indicate that the differences between the clinical outcomes of Groups II and VI, compared to Groups I, III, IV, and V are significant at a probability level equal to or less than .0001.

Conclusion

Ligation of cervical roots independently or in combination can produce syndromes that resemble human CRPS I and II, but the changes are more pronounced and persistent with C7 involved primarily or in combination with other roots. This model appears to be valid and practical for the study of neuropathic syndromes and different than previously described models [5-7]. Another previously described model uses cervical crush injury [8]. Our model is more aligned with constriction and compression frequently seen in foraminal stenosis and degenerative cervical disc disease. However, further work needs to be done to standardize the evaluation of this model as most parameters have been described for the hind paw of the rat, such as the hot-plate test and walking track.

We found there's merit to the symptom severity of C7 as previously noted in the literature after contralateral C7 transfer for brachial plexus reconstruction [4]. We postulate that the large numbers of motor, sensory and proprioceptive fibers in C7 may contribute to the clinical presentation when the entire root is transferred or damaged. Table 3 shows the large number of ventral and dorsal root fibers, and is reproduced from Lui et al. [9].

Table 1: Frequencies of Recovery Across Groups

	Recovery	No Recovery
Group I	10	
Group II		10
Group III	10	
Group IV	10	
Group V	10	
Group VI		10

Table 2: Test Statistics

N	10
Cochran's Q	50.000a
df	5
Asymp. Sig.	.000

Table 3: Number of Nerve Fibers

	Ventral Root	Dorsal Root
C5	7841 ± 1020	23 300 ± 2856
C6	7048 ± 1157	36 353 ± 7451
C7	8467 ± 1019	39 653 ± 8458
C8	5883 ± 1000	31 156 ± 8273

Because diabetic neuropathic changes in the cervical roots coupled with narrowing of the foramina may create the proper environment for neuropathic pain, along with sensory and motor abnormalities due to compression, future studies should include diabetic rats to further validate dysfunction related to C7 compression in painful neuropathic syndromes.

References

1. Chu EC (2022) Cervical radiculopathy as a hidden cause of angina: Cervicogenic angina. J Med Cases 13: 545-550.
2. Mashauri HL, Makunga FJ, Luhwago EC, Ndale E, Kilonzo KG (2024) Is it myocardial infarction? A case report of C7 cervical radiculopathy with cervical angina. SAGE Open Med Case Rep 12: 1-3.
3. Ozgur BM, Marshall L F (2003) Atypical presentation of C-7 radiculopathy. J Neurosurg 99: 169-171.
4. Yang G, Chang KW, Chung KC (2015) A Systematic Review of Outcomes of Contralateral C7 Transfer for the treatment of traumatic brachial plexus injury: Part 2. Donor-site morbidity. Plast Reconstr Surg 136: 480-489.
5. Ho Kim S, Mo Chung J (1992) An experimental model for peripheral neuropathy produced by segmental spinal nerve ligation in the rat. Pain 50: 355-363.
6. Bennett GJ, Xie YK (1988) A peripheral mononeuropathy in rat that produces disorders of pain sensation like those seen in man. Pain 33: 87-107.
7. Seltzer Z, Dubner R, Shir Y (1990) A novel behavioral model of neuropathic pain disorders produced in rats by partial sciatic nerve injury. Pain 43: 205-218.
8. Wu A, Lauschke JL, Morris R, & Waite PM (2009) Characterization of rat forepaw function in two models of cervical dorsal root injury. J Neurotrauma 26: 17-29.
9. Liu Y, Zhou X, Ma J, Ge Y, Cao X (2015) The diameters and number of nerve fibers in spinal nerve roots. J Spinal Cord Med 38: 532-537.

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