Indian J Physiol Pharmacol 1992; 36(3) : 193-196

FUNCTIONAL RECOVERY FOLLOWING REPTILEAN (CALOTUS CALOTUS) SPINAL CORD TRANSECTION*

VINOD KUMAR SRIVASTAVA

Neurosurgical Unit,
Department of Surgery,
J. N. Medical College,
A.M.U., Aligarh - 202 002 (U.P.)

(Received on January 29, 1992)

Abstract: Various approaches to remedy the effects of spinal cord injury have been suggested from time to time. One of these is to study the regeneration following spinal cord transection in phylogenetic lower species in order to gain some information from this for its application in non-regenerating spinal cord injuries in higher species. In the present study the functional recovery following spinal cord transection in a reptile (Calotus calotus) was studied in 30 animals, and it was observed that functional recovery was quite marked by 4 weeks and more or less comple by 6 weeks.

Key words: spinal cord injury spinal cord transection calotus calotus

INTRODUCTION

Spinal cord injury has been a challenge to the clinicians. Windle (1) suggested that the problem of spinal cord injury could be better understood by studying spinal cord regeneration in the sub-mammalian species. The comparative data obtained from such a regeneration is likely to yield results that could be interpolated in the treatment of human patients with spinal cord injury.

A lot of work has been done on the effects of spinal cord transection in the fish (2) and the amphibians (3). In reptiles, the studies have been mainly restricted to regeneration of the tail. The present study on spinal cord transection in the garden lizard (Calotus calotus) was thus envisaged. Functional recovery following mid-dorsal transection of the spinal cord was clinically assessed in these animals. The basic differences in this reptilean model and a human patient with spinal cord injury have been highlighted.

METHODS

Thirty garden lizards (Calotus calotus) having an average weight of 51.43 gms were chosen for this study. The animal was anaesthetized by placing it in a jar containing anaesthetic ether for about 10 minutes. The time for anesthetizing the animal was standardized by trial and error. A laminectomy was performed in the mid-dorsal region and spinal cord transected completely.

The operating procedure : 2-3 cm long skin incision was placed in mid-line in the mid-dorsal region and skin flaps raised. The paraspinal muscles were retracted and a laminectomy at three vertebral levels was performed with a bone rongeur. The dura was opened under the operating microscope and the spinal cord transected with a triangular knife. Care was taken that the transection continued till the anterior bone limit of the vertebral canal was reached. The wound was closed. No post-operative antibiotics were given.

Since the animals refused to feed in captivity, they were forcefed with mosquitoes and other insects. They were given water with the help of a dropper. The animals were observed for tail rigidity, limb rigidity, changes in skin colour, ability to climb a vertical wire mesh and ability to walk and run. These data were analysed to evaluate functional recovery of the paralysed lower limbs in these animals.

*Work done at National Institute of Mental Health and Neurosciences, Bangalore – 560 029

RESULTS

At the time of spinal transection, 5 animals showed repeated jerking of both the lower limbs, 2 had twisting movement of the trunk and 16 showed no response (Table I).

TABLE I : Motor phenomena at the time of transection of the spinal cord.

Motor phenomena	*No. of animals*	*Percentage*
Jerking movement of limbs	5	16.67
Twisting movement of trunk	2	6.67
Tonic rigid tail	7	23.33
No motor response	16	53.33

Five animals died within 48 hours and another 6 died within 2 weeks. Nineteen animals survived beyond two weeks. The morphological changes noted in these animals have been tabulated in Table II.

The tail was flaccid in the beginning and could be moved easily with the help of a probe. By around the 7th day (6.7 days) the tail became rigid and straight, and could not be moved by the probe. By the end of the month, the rigidity gradually disappeared and the tail acquired its normal tone.

The limb rigidity followed the tail rigidity. By the middle of the second week (11.32 days), the hind limbs along with the tail became quite rigid. The hind part of the body of the animal moved enblock as it ran or walked. Even when the animal could climb a vertical mesh, the rigidity persisted and seemed to help the animal in gripping the wire mesh. By the end of the month, the rigidity disappeared. The colour of the skin became darker by around one week (8.35 days). The change in skin colour was noticed at the tail maximally and gradually progressed on to the rest of the paralysed part of the animal. By the end of the second week, the darker shade of the skin colour faded into normalcy. There appeared to be some correlation between the skin colour and the recovery of tone.

The skin colour became darker with increased tone and became normal as the tone returned to normal.

TABLE II : Morphological data from the transected animals.

S. No.	*Duration of survival (days)*	*Weight in grams*	*Tail rigidity (day)*	*Limb rigidity (day)*	*Change in skin colour (day)*
1	45	60	5	10	7
2	24 hr	53	-	-	-
3	13	47	7	10	10
4	60	67	6	12	11
5	30	55	7	12	7
6	30	50	7	11	8
7.	45	54	7	10	9
8	24 hr	45	-	-	-
9	48 hr	47	-	-	-
10	4	50	-	-	-
11	30	55	6	10	8
12	7	44	5	-	-
13	48 hr	45	-	-	-
14	6	48	-	-	-
15	45	55	7	12	10
16	38	60	7	10	10
17	3	55	-	-	-
18	47	56	8	12	10
19	11	50	7	-	7
20	25	54	7	12	7
21	22	45	7	12	7
22	5	48	-	-	-
23	25	55	7	12	9
24	62	56	7	13	8
25	8 hr	48	-	-	-
26	32	56	6	12	8
27	16	45	6	10	7
28	48	60	7	13	9
29	35	55	6	12	8
30	33	58	7	10	7

As the animals recovered from ether anaesthesia, they could drag the paralysed part of their body more or less immediately. While dragging, the paralysed part would wobble on either sides throughout the first week following the spinal transection. During the first week, their movements were sluggish. When the animals were put on a vertical wire mesh and the hind limbs were pulled away and left free, they made no attempts to hold the wire with their hind limbs. By the end of the second week (16.29 days), as the tone increased in the tail and the rest of the paralysed part, they could hold the wire in the mesh (Fig.1) with their hind limbs quite firmly. By the end of the month the tone returned to normal and the animal could walk or run normally (35.77 days). Thirteen animals survived one month and beyond and only two of them could survive for 2 months.

TABLE III : Functional recovery in animals surviving beyond two weeks.

S.No.	*Can hold itself against a vertical wire mesh (day)*	*Can walk and run normally (day)*
1	15th	30
4	20th	30
5	16th	35
6	22nd	-
7	15th	35
11	20th	-
15	16th	35
16	15th	30
18	16th	40
19	-	-
20	15th	-
21	16th	-
23	15th	-
24	15th	45
26	16th	30
27	15th	-
28	15th	42
29	16th	30
30	14th	30

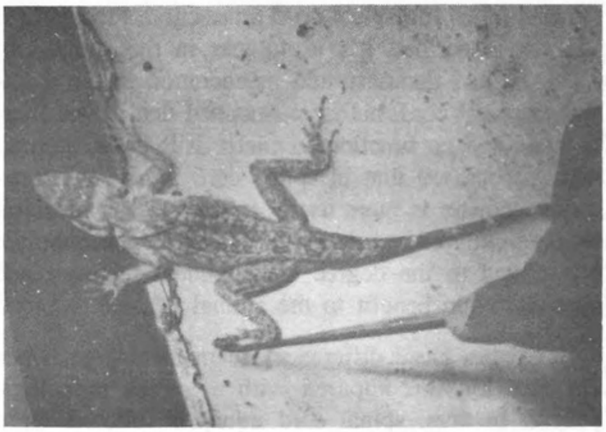

Fig. 1 : The animal could hold the wire in the vertical wire mesh with it's hind limbs quite firmly by the end of the second week (16.29th day).

DISCUSSION

Work on the reptilean spinal cord transection appears very meagre. Gegenbaur and Muler (3) demonstrated anatomical continuity in a regrown lizard's tail in the middle of the eighteenth century. The tail contained tissues composed of ependymal epithelium with some nerve fibres and neuroglia. Fraisse (3) in 1885 confirmed these findings in the lizard's tail. Similar studies were conducted by Marrotta (3) and Stefanelli (3) who demonstrated regeneration in the reptilean tail in Lacerta muralis. Zannone (3) and Thermes (3) also confirmed regeneration in the reptilean tail in gecko (Terantola mauritianica) and Lacerta muralis.

In the present study, the effects of mid-dorsal spinal cord transection were studied on 30 lizards (Calotus calotus). Functional recovery in these animals was analysed by studying two parameters, the ability to climb the vertical wire mesh on a window (16.29 days) and the ability to walk and run (35.77 days). It is clear from the results that the functional recovery was quite pronounced in the first few weeks and was more or less complete in eight weeks' time. It is difficult to comment, whether this functional recovery is the result of development of stepping reflexes or is due to true spinal cord regeneration. Shurrager et al (4) demonstrated the significance of stepping reflexes in the cats following spinal cord transection. Freeman (5) has also described it's usefulness in the spinal cat. Cajal (6) had demonstrated regeneration in the mammalian spinal cord, but he maintained that it was abortive and had no functional benefit. It is being increasingly recognised that in spinal cord injury, the functional recovery is more useful to the animal. Anatomical continuity or restoration of synaptic connection are not related to the degree of functional recovery and may add little benefit to the animal (1).

Certain basic differences seem to emerge, when the situation is compared with a human paraplegic patient. In man, spinal cord injury is followed by a period of spinal shock, which is followed by a spastic phase when the tone is markedly increased (7). Whereas in the lizard there appear to be three stages following transection; i.e. a stage of flaccid paralegia, followed by a stage of increased tone, which in turn is followed by a stage of normal tone, this third stage is missing in man. The reason for this is not clear. In the reptilean spinal cord, the vestibulospinal tract is either very small or not well developed. It is also doubtful, if the fibres originating from the telecephalon reach the spinal cord in the reptileans (8). It is difficult to ascertain the significance of these anatomical differences in reference to the present observations made in garden lizards.

In summary, a marked functional recovery, following spinal cord transection is observed in the garden lizard (Calotus calotus), which is so complete that the animal practically returns to normal activity by 6 weeks.

REFERENCES

1. Windle, W. Regeneration in the central nervous sytem. *Charles C Thomas, Springfield, Illinois,* 1955.
2. Bernstein JJ, Bernstein ME. Ultrastructure of normal regeneration and loss of regenerative capacity following teflon blockage in gold fish spinal cord. *Exp Neurol.* 1969; 24 : 538-557.
3. Clemente CD. Regeneration in the vertebrate central nervous system. *Int Rev Neurobiol.* 1964; 6 : 257-301.
4. Shurrager P, Dykman RA. Walking spinal carnivores. *J Comp Physiol Psychol* 1951; 44 : 252-262.
5. Freeman LW. Experimental observations upon axonal regeneration in the transected spinal cord of mammals. *Clinical Neurosurgery Vol 8* (The Williams and Wilkins Co., Baltimore). 1962: 294-316.
6. Raman Y, Cajal S. Regeneration and degeneration of nervous system. Translated by May, R.M. *(Oxford University Press, London),* 1928.
7. Guttmann L. Spinal shock and reflex behaviour in man. *Paraplegia.* 1970; 8: 100-110.
8. Kuhlenbeck H. The Central Nervous System of vertebrates: Spinal cord and Deuterencephalon. Vol 4, *S. Karger, Basel,* 1975.