FORELIMB MOVEMENTS IN CATS WITH COMPLETE OR PARTIAL BULBAR PYRAMID LESIONS

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Abstract. Adult cats were trained to use a forelimb to open a hinged door against resistance for a food reward. Normal cats performed the task with only toe or wrist motions. Cats with unilateral complete bulbar pyramid section showed persistent deficits in distal limb movements with toe fanning, wrist stiffness and pulling from elbow and shoulder. Partial medial or lateral pyramid lesions produced similar but less severe effects. These results suggest a significant role of the corticospinal system in distal limb movements and a lack of topographical localization of pyramid fibers related to these movements in cats.

Impairment of distal limb movements in cats after bulbar pyramid section has been noted in earlier studies (2, 4). In this paper, we present effects of complete and partial pyramid sections on movements using another simple method.

The adult cats were trained in a test chamber to use a forelimb to open a box with hinged doors against various resistances for food placed in a tray hanging on the inside of the door (Fig. 1). This food box (16.5 cm wide, 30 cm long and 18 cm high) had a hinged door (1.5 cm thick) at either end. The outer edge of each of these doors was cut at a 45° angle to provide a surface for the paw to grasp. At either end,
a sliding magnetic plate was mounted on top of the box and a metal plate was fastened to the exterior of the door and extending 2.5 cm above the upper border of the door. Changing the position of the magnetic plate could alter the resistance of door to be opened from 20 gm to 200 gm. During the testing, the cat was placed inside an open-topped test chamber (60 cm wide, 90 cm long and 60 cm high) and could be seen from the top or from the window (7.5×60 cm plexiglass) on each side. The food box was slid about 3 cm into an opening (25×15.4 cm) on the lower middle part of the front panel of the test chamber. The cat was presented with only one door which opened either to the cat's left or right depending on which end of the box was inserted into the test chamber. All cats were trained to use the left paw when the door opened left and the right paw when the door opened right. The formelimb movements in opening the door were observed.

All the pyramid lesions were made at the upper medulla through retropharyngeal approach with aseptic techniques in cats under intraperitoneal Nembutal anesthesia. At the termination of the experiments, the animals were perfused intravascularly with Saline followed by Formalin-Saline. The extent of the lesions was determined histologically.

We found that it took 10 to 25 days for cats to learn the task. Normal cats deliberately placed the paw, grabbed the door edge, then just flicked the toes to open the door when the resistance was 70 gm or less. For higher resistances, they grasped the door edge with toes, then flicked
the wrist rather than the toes. No gross elbow or shoulder movements were noted.

Three cats with unilateral complete pyramid section were tested again in 3 or 4 days after surgery. Deficits were observed only in the contralateral forelimb. The cat preferred to use the sound limb to open either side of the box. However, the contralateral impaired limb could be forced to perform the task. In approaching the door, the limb showed fanning (extension and abduction) of toes, stiffness of the wrist and failure to grab the door edge. The paw kept batting the door edge with motion mainly from the elbow and shoulder until the door was accidentally opened. The cat could never open the door when the resistance was above 20 gm. These deficits lasted for about 3 mo. Thereafter, the movements and the strength of the limb gradually improved. By 4 mo postoperatively, the animal could open the door with a resistance of 200 gm, although the distal limb movements were still impaired. The toes could grab the door edge only when the wrist was held stiff with pulling from shoulder still required to open the door. No further improvements were noted up to a maximum of 7 mo observation after pyramidotomy.

Partial lesions resulted in less severe impairment in performing the task. After sectioning the lateral one-half of the pyramid, the cat could open the door with a resistance up to 200 gm but with slight toe fanning, wrist stiffness and pulling from the shoulder. The movements improved considerably by the 6th day and were essentially normal by the 9th day postoperatively. After a lesion involving lateral three-fifth of the pyramid, it was unable to get the cat to use the contralateral forelimb for the task until the 5th day. At that time, normal movements and strength of the limb were observed. A lesion of medial three-fifth of the pyramid did not impair the forelimb movements when opening the door with resistance of 20 gm or less. The cat showed toe fanning and wrist stiffness initially in attempting to open the door with a higher resistance. However, the movements and strength of the limb appeared to be normal by 8th postoperative day. In the cat with a more extensive lesion involving the medial four-fifth of the pyramid and part of medial lemniscus, the toes could grab the door edge with a stiff wrist and pulled from the shoulder to open the door with a resistance up to 50 gm initially. By 12 days after surgery, the cat could open the door with a resistance up to 100 gm and showed return of wrist movements. By the 19th postoperative day, the movements and strength of the limb were essentially normal.

Thus, complete bulbar pyramid section in cats produces long-lasting deficits of distal limb movements, although these could probably be
restored through training as showed in the monkey (3). Partial lesions gave only transient impairment. Its recovery might have been mediated through the spared pyramid. That partial medial or lateral lesions resulted in similar deficits suggest a lack of topographical localization of pyramid fibers related to hand movements as noted in the muscle strength in monkeys (1).

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REFERENCES


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