CONTINUITY OF THE BULBAR LOCOMOTOR STRIP
IS NOT ESSENTIAL FOR WALKING

N. N. Budakova and M. L. Shik

Bilateral destruction of the medulla, interrupting both "locomotor strips," was carried out on mesencephalic cats. After the operation walking could still be induced by stimulation of the more rostral (and also caudal) portion of the strip, although in some experiments the threshold of walking was raised. The connection of the "locomotor strip" with other structures of the brain stem and spinal cord is discussed on the basis of these findings.

KEY WORDS: medulla; locomotion; locomotor strip.

Electrical stimulation of a certain part of the brain stem induces the mesencephalic cat to walk on a treadmill. Points whose stimulation induces walking form the "locomotor strip" (LS), which stretches at a distance of 4 mm from the sagittal plane along the whole of the hindbrain – from the midbrain to the spinal cord [2, 5]. LS contains neurons giving synaptic responses to stimulation of adjacent portions of LS [3], although this does not rule out the presence of axons directly connecting the brain stem with the spinal cord in it. If this axonal component of LS plays a significant role, after interruption of LS stimulation of its more rostral portion ought not to induce locomotion. It is shown in the investigation described below that bilateral destruction of the bulbar LS does not abolish the locomotor effect of stimulation of its more rostral portion.

EXPERIMENTAL METHOD

Precollieular decerebration was performed on cats under ether anesthesia after tracheotomy and ligation of the carotid arteries. The ventral boundary of the incision passed between the mamillary bodies and the point where the third pair of cranial nerves emerges [1]. Part of the occipital bone and the tentorium cerebelli were removed. The cat's head was fixed and its body suspended so that the limbs touched the belt of the treadmill.

Stimulating electrodes (tungsten wire 20 μ in diameter, insulated with glass, outer diameter of electrode 40-100 μ) were introduced into the midbrain and medulla about 4 mm away from the sagittal plane. Monopolar stimulation was carried out with square pulses, of negative polarity, 0.2 msec in duration for the bulbar LS and 0.4 msec for the midbrain, with a frequency of 60 Hz. The electrode was moved in a dorsoventral direction until a point was found whose stimulation with a current of under 40 μA induced walking [2, 5, 3]. This point was then destroyed by passing a direct current through it, after which walking was again induced by stimulation of a locomotor point in the midbrain or in another part of the medulla. Next, in most experiments the symmetrical locomotor point was located in the medulla, it also was destroyed, and attempts were then made to induce walking by stimulation of the midbrain or other parts of LS. Altogether 22 experiments were carried out.

The location and size of the injuries were verified in photographs of sections cut on a freezing microtome. The Horsley-Clarke coordinates were taken from a stereotaxic atlas [4].

EXPERIMENTAL RESULTS

Neither unilateral nor bilateral destruction of the bulbar LS (P 11-13) prevented walking from being induced by stimulation of the locomotor point in the midbrain (P2) or of another point in LS, no matter whether it was situated rostrally (P 7-8) or caudally to the lesion (five experiments).
Fig. 1. Bilateral destruction of medulla at level P 11-13 following which walking was induced by stimulation of more rostral points of LS. 1, 2, 3) Frontal sections through medulla of three preparations; a, b, c) corresponding schemes. In top schemes a and b, coagulation tags indicate points whose stimulation induced walking after destruction of the medulla. 1) Corresponds to bottom schemes (a), 2) to bottom scheme (b), 3) to top scheme (c).

Foci of destruction of the medulla are indicated in Fig. 1 (three experiments). In one experiment (Fig. 1, 1) stimulation through the left electrode 16 mm from the surface of the cerebellum induced walking with all four limbs (25 μA), whereas at a distance of 16.5 mm from the surface walking was induced similarly but by a current of 35 μA. Stimulation through the right electrode 15.5 mm from the surface of the cerebellum induced dropping of the lower jaw and weak stepping movements with all four limbs (30 μA), at a depth of 16-17 mm it induced walking with all the limbs (20 μA), and at 17.5 mm walking changing into rapid spastic contraction of all the limbs (40-45 μA); with a smaller current no walking developed. After electrolytic destruction of all points whose stimulation induced walking (Fig. 1, 1a, the bottom three schemes) stimulation of the left LS 5 mm rostrally to the center of the left focus of destruction induced walking with all the limbs (25-30 μA; Fig. 1a, top scheme). The same effect was obtained in response to stimulation of a region 4 mm caudally to the focus of destruction (30 μA).

In two other experiments (Fig. 1) bilateral destruction was carried out at points stimulation of which by a current of 20-30 μA induced walking with all the limbs. Subsequent stimulation (35 μA) of a point located 4 mm rostrally to the left focus (Fig. 1, 2b) and stimulation (30 μA) 4 mm rostrally and caudally to the right focus (Fig. 1, 3c) induced walking by all the limbs. In both experiments walking could be induced after destruction by stimulation of the midbrain (25 μA in experiment 2, 100 μA in experiment 3).

Stimulation at levels P9-14 and in the midbrain (P2) continued to induce walking even after destruction in the caudal part of the medulla (P16-18, four experiments). The foci of destruction carried out on the left at a point whose stimulation (25 μA) induced walking with all four limbs, and on the right induced walking complicated by general spasticity (20-25 μA), are shown in Fig. 2a. Destruction on the right was more extensive. After destruction stimulation at level P11 on the left (25 μA) induced stepping movements with the forelimbs, whereas on the right as before it induced locomotion complicated by general spasticity (20-25 μA). Foci of destruction produced in the other experiment are shown in Fig. 2b (bottom schemes). After them, walking could also be induced by stimulation of the more rostral point (top scheme), although the threshold of walking was increased from 40 to 60 μA.