INTRODUCTION

The corticobulbar projection, together with the corticospinal tract (CST), act in parallel with projections from the brainstem (such as the reticulospinal tract) to ensure direct or indirect control of movement on motoneurons in the spinal cord. In monkeys little is known about the projections coming from the motor cortex on the brainstem as well as on their influence. Previous studies suggested a role of the reticulospinal tract in the control of reaching movement and in the recovery after a lesion of the CST, spinal cord or cerebral cortex.

The aim of the present study was to anatomically analyze the corticobulbar projections coming from distinct motor cortical areas: the premotor cortex (PM), the supplementary motor area (SMA) and the primary motor cortex (M1) on the rostral formation of the brainstem, possibly influencing the reticulospinal neurons.

METHODS

The tracer biotinylated dextran amine (BDA) was injected unilaterally in either PM, SMA or M1 of seven intact macaque monkeys (Macaca fascicularis). The corticobulbar projections between striate and extrastriate cortex and BDA were then analyzed in 12 consecutive histological sections (50 μm thick), 250 micrometers apart. Axons and terminals, including boutons en passant, were then plotted using the software Neurolucida. An adjacent series of 12 sections was stained with Cresyl violet revealing Nissl bodies. On these sections we delineated the brainstem nuclei.

The Neurolucida software is connected to a light microscope (Olympus BX40). We used the objective 4X to trace the contours of the sections and the Pyramidal tract, the 10X to trace the axons and finally the 20X to plot the boutons en passant and terminals. For the series stained with Nissl we used the 1.25X objective to delineate the nuclei and to acquire pictures.

Both series of sections (BDA and Cresyl staining) were overlapped in order to match the zone of terminals and the nuclei delineated with Nissl staining.

RESULTS

A main result of the present study was that the corticobulbar projection was denser when originating from PM or SMA, as compared to M1. Animals injected in M1 showed a larger percentage of projections in the contralateral Gi and ipsilateral IRt and LRt. For Mk-93-80 the percentage of terminals in PnO and Gi for both the ipsilateral and contralateral sides to the injection. For Mk-93-80 the projection in IRt and LRt was mostly ipsilateral. Few projections were found in PnO+PnC. Mk-93-80 showed the largest percentage of terminals on both sides in both the Gi nucleus and the PrC + PrH nucleus (Figure 2).

Overall, the monkeys injected in non-primary motor cortex areas (PM, SMA) showed a statistically significant stronger corticobulbar projections on the ipsilateral side than on the contralateral one (except Mk-R13 (Figure 3)). This was the reverse in the monkeys subjected to M1 injections: predominance of corticobulbar contralateral projections (Figure 3).

A main result of the present study was that the corticobulbar projection was denser when originating from PM or SMA, as compared to M1 (Figure 3, Panel B).

CONCLUSION

A tendency to preferentially terminate ipsilaterally in the PMRF was found in monkeys injected in PM and SMA. On the contrary, the monkeys injected in M1 showed a tendency to preferentially terminate contralaterally in the PMRF. Moreover, the corticobulbar projection was less dense when originating from the primary motor cortex area as compared to PM or SMA.

In the future the same analysis will be performed on monkeys subjected to cortical lesion, to test if after a lesion of the primary motor cortex a reorganization of the corticobulbar projections coming from PM occurs, in line with the notion that PM contributes to the functional recovery from M1 lesion (Liu and Rouiller, 1999).