The oculomotor nuclear complex in humans
Microanatomy and clinical significance

R. Donzelli1, S. Marinkovic2, L. Brigante1, I. Nikodijevic2, F. Maiuri1 and O. de Divitiis3

Summary: This study has been performed to define better the anatomical structure of the oculomotor nuclear complex and its neuronal components. The oculomotor nuclear complex was examined in fixed and serially sectioned midbrains from 12 adult subjects free from neurological diseases. The complex included the somatic portion, (formed by multipolar motor neurons), and the parasympathetic portion, (formed by oval or fusiform preganglionic cells), on each side of the median raphe. The somatic portion consisted of the lateral somatic cell column and the caudal central nucleus. The somatic column measured from 0.2 x 0.1 mm to 3.4 x 1.4 mm (X = 2.4 x 1.2 mm) in transverse section. It was divided into the principal, intrafascicular and extrafascicular parts. The principal part was subdivided into the dorsal, intermediate and ventral portions. Isolated multipolar neurons were also found in the periaqueductal gray matter, the interstitial nucleus of Cajal, the Edinger-Westphal nucleus and the fibre bundles of the oculomotor nerve. These cells most likely represent the displaced motor neurons of the oculomotor nerve. The caudal central nucleus was 0.8 x 0.6 mm in size. The Edinger-Westphal nucleus consisted of the rostral, ventral and dorsal parts; the longest rostrocaudal diameter of this nucleus measured 7.1 mm. The anatomical data of our study are relevant clinically and allow explanation of the neurologic signs following complete or partial lesions of the oculomotor nuclear complex.

Key words: Oculomotor nuclear complex – Edinger Westphal nucleus – Oculomotor nerve – Ophthalmoplegia

The oculomotor nuclear complex has been examined more completely in animals than in man [6, 7, 9, 10, 13, 19, 25, 26, 28, 30]. This is especially true for its cytologic and cytoarchitectural cha-
racteristics, as well as for its neuronal connections. On the other hand the knowledge of lesions of this complex, as well as of the other portions of the oculomotor system, is very important in neurologic clinical practice [3, 4, 5, 17]. For these reasons we have decided to examine this complex in humans.

As already known, the oculomotor nuclear complex includes the somatic cell column and the Edinger-Westphal nucleus. The somatic column consists of two parts: the lateral column, which innervates some extraocular muscles, and the caudal central nucleus, whose fibers terminate in the levator palpebrae muscle [11, 25]. The Edinger-Westphal (EW) nucleus in the broader sense innervates the ciliary muscle and the sphincter pupillae [11]. The present study reports the results of the microscopic examination of 12 human midbrains and discusses the relationship of these anatomical data with the clinical signs of damage to the oculomotor nuclear complex.

Material and methods

We have examined 12 midbrains of adult subjects. All were free of neurological disease, as confirmed by the absence of neurological symptoms and signs during life and the lack of pathological changes at postmortem examination of the brain. The delay between death and fixation was 24 hours.

After perfusion with isotonic saline solution and 10% formaldehyde solution, the midbrains were fixed in the same solution for 10 days. The midbrains were dehydrated and embedded in paraffin or celloidin, and then cut serially in transverse (10 specimens) and parasagittal planes (2 specimens). Every ninth and tenth sections were stained with thionin fast blue and/or cresyl violet. The thickness of the sections was 10 mm. The sections were examined under magnifying glass and microscope.

Measurements were made using an ocular micrometre, after calibration of the microscope objectives by means of a scale with 1 mm divisions. As pointed out by many authors [1, 16, 23] swelling or shrinkage of the brain tissue occur during fixation and dehydration. The percentages range from 13% of reduction in volume to 25% of increase in volume of the brain tissue fixed in 10% formaldehyde solution.

In spite of this, many authors [8, 18] do not make allowance for swelling or shrinkage. We also failed to take into account the corrective factor for shrinkage, which was estimated to be 6% on average in our study.

Finally, mean value (X) and standard deviation (SD) were calculated from our data.

Results

As already mentioned, the oculomotor nuclear complex includes the somatic cell column, which is divided into the lateral column and the caudal central nucleus, as well as the parasympathetic Edinger-Westphal nucleus. All these portions will be presented separately.

The lateral cell column

There are two such columns, the right and the left, which converge ventrally, toward the midline (Fig. 1).

At caudal level, the somatic column is in contact with the medial longitudinal fasciculus (MLF). In addition, it is surrounded by the rostral linear nucleus, the dorsal part of the A10 dopaminergic group of neurons, the mesencephalic nucleus of the trigeminal nerve, (some neurons of which are occasionally located in the column itself, the dorsal tegmental nucleus), and by the caudal central nucleus.

At rostral level, the somatic column has a similar relationship; however, at this level, the dorsal tegmental nucleus and the caudal central nucleus are replaced by the neurons of the periaqueductal gray matter and the Edinger-Westphal nucleus.

The sizes of the somatic column are different in transverse and parasagittal sections. In transverse sections the column is from 0.2 x 0.1 mm to 3.4 x 1.4 mm in size (X = 2.4 x 1.2 mm; SD1 = 0.8; SD2 = 0.36). In the parasagittal sections, the maximal rostrocaudal length of the column is 6.1 mm, and the maximal dorsoventral diameter is 2.5 mm.

According to its relationship to the MLF, we concluded that the lateral somatic column can be divided into three parts: the principal, intrafascicular and extrafascicular (Fig. 1).