THE RED NUCLEUS IN THE MICE, MONKEY AND MAN

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The histological features of the red nucleus in the mice, monkey and man have been studied. The dimensions of the red nucleus have been measured, the maximum diameter of its large cells, the cell density and the percentage of the large cells to the total cell population in the red nucleus at different levels of its extent have been calculated. The findings have been discussed in relation to the observations of the previous workers.

The red nucleus is a conspicuous reddish grey mass found in the ventromedial reticular area of the tegmental region of the mid-brain and is easily recognised in all mammalian forms.

Hatschek (1907) recognised magnocellular and parvocellular portions within the red nucleus and showed that the magnocellular part predominates in the lower mammals, whereas its parvocellular part becomes more conspicuous in the higher mammals. These conclusions were later confirmed by Friedmann (1912) and Ariens Kappers (1921). Winkler and Potter (1911 and 1914), however, described within the red nucleus, a magnocellular portion, and dorsilateral and ventrolateral small cell divisions; and their findings were corroborated by the observations in the Opossum. The nucleus is reported to extend further craniad in the cat than in the rabbit (Winkler & Potter, 1914; Magnus, 1924 ; Davenport & Ranson, 1930). Winkler & Potter (1914) recognised three divisions, while Davenport & Ranson (1930) maintained that it is only possible to distinguish a caudal compact part and a rostral reticular part both in the rabbit and the cat. These workers also identified the nucleus minimus of von Monakow (1909) and called attention to a small group of cells placed lateral to the cephalic part of the red nucleus within the reticular grey matter of this region, which they stated, might conceivably be regarded as a small celled component of the red nucleus in the cat and the rabbit. Rioch (1929) described a more compact caudal portion, having very large cells and a more loosely arranged cephalic portion with intermingled large and small cells in the dog. Although there is lack of general unanimity in the findings of the various workers, important contributions have been made to the knowledge of the red nucleus in man by Mingazzini (1928), Ramon Y, Cajal (1911), Foix and Nicolesco (1925), and Brodal and Gogstad (1954).

MATERIAL AND METHODS

The mouse and the monkey were selected for this study, since no work on the red nucleus in these laboratory animals has been reported so far. Under light ether anaesthesia the carotid arteries in these animals were cut, and the entire brain removed from the crainal cavity. Two specimens of the brain stem were obtained from the necropsy material of the bodies of persons who had died with no apparent evidence of damage to their brain stems. All the specimens were fixed in Heidenhain's "SUSA". The paraffin sections each 8-12 microns thick were cut serially and every tenth section was stained with haematoxylene and eosine. The antero-posterior and the transverse diameters of the red nucleus were measured, and the proportion of the large cells to the total cell population per unit area was obtained in the caudal, middle and rostral thirds of the nucleus in all the specimens. The diameter of the cells and the total cell density in the red nucleus were measured at the (i) lower pole (ii) midway between the middle and the lower pole (iii) at the midpart of the nucleus (iv) midway between the midpart and the upper pole, and (v) at the upper pole of the nucleus. For measuring the cell density a square was engraved with a diamond pencil on a haemocytometer cover glass cut to fit into the eye piece to form an ocular square measure. The area of the square so drawn was calibrated with the stage micrometer and found to be 0.08 sq. mm. or 8×10^4 sq. microns. This was placed on the eye piece and the cells within the field of this unit area were counted at a constant magnification in all the sections. The percentage of the large cells was calculated from the ratio of the large cells to the total number of cells in this unit area. No common criterion for the size of the large cells was adopted and only the obvious large cells in the animals were counted.

OBSERVATIONS

The red nucleus in the mice is situated close to the cerebral aqueduct and is discretely separated from the cellular elements of the substantia nigra at all the levels of the midbrain. In the monkey, the red nucleus is very extensive and is not as well circumscribed in the mouse. It is situated close to the cerebral aqueduct in the caudal portion of the midbrain, whereas in the middle and rostral thirds of the midbrain, the nucleus occupies a position midway between the cerebral aqueduct and the substantia nigra. The cells are usually round and widely separated. The red nucleus in man is situated near the cerebral aqueduct at all the levels of the midbrain. The nucleus is extensive and not very sharply defined. The cells are similar in appearance to those in the red nucleus in the monkey.

DIMENSIONS

The antero-posterior and transverse diameters of the red nucleus in the mice, monkey and man at different levels are given in Table 1.

TABLE I

Showing average diameters of red nucleus at different levels in millimetres

Animal	Caudal — Third A.P.	Caudal — Third Trans	Middle — Third A.P.	Middle — Third Trans	Rostral — Third A.P.	Rostral — Third Trans
Mice ...	0·3369	0·415	0·332	0·3203	0·3154	0 0332
Monkey ...	0·7911	0·8632	2·1181	0·6972	2·407	0·5744
Man ...	1·454	1·0473	2·6491	1·0059	2·7938	0·674

In the mice, the average diameters in the antero-posterior plane at the three levels, viz. caudal, middle and rostral third, are nearly equal while the average diameters in the transverse plane varies at these three levels, being maximum in the caudal third and minimum in the rostral third of the nucleus. In the monkey, the transverse diameter of the nucleus is greater than the antero-posterior diameter. The antero-posterior diameter is 3 to 4 times wider than the diameter in the middle and the rostral portions of the nucleus. In man, the transverse diameter decreases, while the anteroposterior diameters increase from the caudal to the rostral levels of the nucleus.

CELL SIZE

The average maximum diameters of the large cells (in microns) in the mice, monkey and man are given in Table II.

TABLE II

Animal	Levels Caudal to Rostral I	II	III	IV	V
Mice ...	12·0	13·0	17·6	13·4	12·6
Monkey ...	22·8	23·9	27·7	20·9	19·7
Man ...	21.6	23·5	28·1	24·3	22·4

It is observed that the cells having the largest diameter are situated in the middle third of the red nucleus in the mice, monkey and man. The diameter of the cells of larger type decreases towards either poles.

CELL POPULATION

The average cell density in the different animals is shown in Table III.

TABLE III

Animal	Caudal Third	Middle Third	Rostral Third
Mice ...	88	15	65·3
Monkey ...	15·5	22·6	13·0
Man ...	11·8	21·6	14·8

The cells are most densely packed in the middle third of the nucleus in the monkey and in man. In the mice the cells are densely packed in the caudal and rostral thirds, but become very sparse in the middle third.

LARGE CELL PROPORTION

The proportion of the large cells to the total cell-population per unit area expressed in percentage, in the caudal, middle and rostral thirds of the nucleus is given in Table IV.

TABLE IV

Animal	Caudal Third	Middle Third	Rostral Third
Mice ...	48	61.5	45
Monkey ...	50·6	35	46
Man ...	43	29	30

The percentage of the large cells is high in the middle third of the red nucleus in the mice. In the monkey the percentage of large cells is higher in the caudal and the rostral thirds of the nucleus, whereas in man the percentage is highest in the caudal part of the nucleus.

DISCUSSION

The caudal portions of the red nucleus in the mice, monkey and man are near the floor of the cerebral aqueduct. As the nucleus is traced craniad, it shifts more ventrally towards the substantia nigra in the monkey but in man the nucleus throughout its extent occupies a dorsal position, nearer to the cerebral aqueduct. In the mice, the red nucleus is situated near the aqueduct. Hatschek (1907), however, reported that in the mice, rabbit and dog, the red nucleus is ventrally

placed. In the mice, the average diameters (transverse and antero-posterior) are almost equal in all portions of the red nucleus but in the monkey and in man the transverse diameters show a decrease, while the antero-posterior diameters increase from the caudal to the rostral levels of the nucleus. Although in the mice, the cell diameters of all the cells are comparatively much smaller than the corresponding cells forming the red nucleus of the other species studied, the comparatively large cells are found throughout the major portion of the red nucleus in the mouse.

von Monakow (1895), Hatschek (1907) and Ariens Kappers (1921) have reported that in the apes the magnocellular portion of the red nucleus is very small, as compared to that in the lower mammals, and is almost on par with the red nucleus in man. But the cells which have been measured as large cells (magno-cells) in the monkey and in man are similar in size to the medium sized cells of the red nucleus in the cat (Jerath, 1961). If these cells are not grouped as "magnocells", the red nucleus in man and in the monkey may be regarded as lacking or having a rudimentary magnocellular component. Woolard (1927) showed that in the caudal portion of the red nucleus in man, large non-pigmented cells are scarcely seen.

In the mice, as compared with the monkey and man, the large cell count per unit area is the highest in the middle third of the red nucleus. The caudal portions of the red nucleus, however, in all the specimens studied have a higher large cell count as compared to their rostral portions. The paucity of the cells in the middle, with richness of cells in the caudal and the rostral thirds of the red nucleus in the mice, is difficult to explain. It is this portion of the red nucleus of the mice, where the largest number of large cells occur. The diameter of the large cells in the middle third is, on an average, 1.5 times more than the diameter of the large cells in the two poles.

The mesencephalon, in which the red nucleus and the substantia nigra differentiate from the general reticular formation at a later period is "the most conservative" region of the brain, undergoing least phylogenetic modification (Walter and Sayles, 1949). However, the size of the red nucleus in different animals, the relative poverty of the magnocellular component in the monkey and in man and the suggestive richness of connection of the parvo-cellular component would tend to indicate that the structure of the red nucleus is becoming more and more complex.

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