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Asymmetry due to anomalous unilateral enlargement of olfactory bulb in Albino rat: A case report

Naushad Alam Dilkash, Sumayya and Aijaz Ahmed Khan

Department of Anatomy, JN Medical College, Aligarh Muslim University, Aligarh (UP) India

Abstract

Morphological asymmetry of olfactory bulbs (OBs) primarily based on quantitative estimate of different subcomponents of OBs of right and left side as well as sexual dimorphism is known. Here we report a unique case wherein an otherwise normal female adult albino rat had right-left gross anatomical asymmetry of OBs. Quantitative estimation of its olfactory glomerular subcomponent revealed that the means of glomerular diameter, cross-sectional area and number per 100 sq mm on the left side were 0.50 ±0.04 mm, 0.20 ± 0.03 sq mm, 496 ± 64 respectively as compared to 0.78 ± 0.07 mm, 0.48 ± 0.08 sq mm, and 213.16 ± 41.07 on the right side and the difference observed between two sides of these three comparable parameters were highly significant (p<0.001). Interestingly, all these parameters from apparently smaller looking OB closely matched with similar parameters from control and did not differ significantly. It is concluded that the asymmetry of OBs observed in the present case is due to an unprecedented enlargement of the glomerular subcomponent of the right OB and not due to hypoplasia of left OB warranting further study.

Key words: Albino rat, Anomalous, Olfactory bulb, Asymmetry, Glomerulus.

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Introduction

Olfactory epithelium, the main source of afferent input to the OB contains three types of cells namely basal cells, supporting cells and sensory neurons wherein basal cells are believed to be stem cells for both sensory neurons and the supporting cells [1]. Ultra structural study revealed that these neurons in adults lack intermediate filaments [2]. OB is the first site for the processing of olfactory information in the brain and signals from 1000 different types of odorant receptors are sorted out in 1800 glomeruli [3]. New neurons are added to the olfactory bulb throughout the lifetime of mammals. These new cells are born in the subventricular zone and migrate to the olfactory bulb via the rostral migratory stream wherein Prokr2 plays important role [4]. Diverse studies on olfactory system include its role in modulation of maternal behavior [5]**;** aging [6], and extraction of functional clusters of glomeruli [7]. Experimental studies include lateralized brain lesions on various behavioural responses [8, 9]; unilateral naris occlusion and cellular dynamics [10], bulbectomy-induced asymmetrical effects on hudding behaviour [11], role of phagocytic cells in the olfactory epithelium [12] and effects of lead on OBs [13]. Like cerebral right-left asymmetry reported in rat, mouse, rabbit and cat [14,15,16], olfactory asymmetry has been shown in the brain of rat [17, 18], cat [19], and olfactory hypoplasia in Prokr2 null mice [4]. In humans, MRI-based OB asymmetry has been linked to Schizophrenia [19]**,** and Parkinson's disease [20] and Septo-optic dysplasia [21]. Recently OB enlargement after rhinosinusitis treatment [23] and loss of grey matter in cortical brain area as a result of anosmia [24] have also been reported. However, literature on the gross anatomical asymmetry is almost non-existent. Here we report a unique case of an otherwise normal adult female albino rat with gross anatomical asymmetry between right and left sides of OBs which prompted us to work out whether the asymmetry of OBs is due to hypoplasia of smaller looking OB or else due to enlargement of apparently larger looking OB.

Material and Methods

Gross

With prior permission from the Institutional Animal Ethics Committee, during dissection of 10% buffered formalin-perfusion fixed adult female albino rat we noticed gross anatomical right-left asymmetry of OBs. Extra precaution was taken to dissect both OBs intact along with the whole brain. The brain thus obtained was photographed using digital camera [Olympus-SP-56OUZ].

Microscopic

Qualitative

OBs from both sides were processed together for paraffin embedding to avoid incorporation of extraneous factors which might affect the size of OBs at microscopic level. 10 µm-thick serial paraffin sections were cut using rotary microtome. Every 10^{th} section was stained with haematoxyline and eosin and light microscopic observations were recorded using trinocular light microscope [Olympus BX40, Japan] in sample photomicrographs. Similar procedure was used to record observations from an otherwise normal OB having no gross morphological asymmetry.

Quantitative

In the present study attention was focused on the glomerular layer because in addition to its functional significance in processing of olfactory signals [3], this layer is superficial, well circumscribed and consists of multiple units which can be delineated and counted. From representative sections, all the glomeruli observed in the field were outline in a polygon with the help of Motic software (Fig-1C). With the help of area of the polygon and the number of glomeruli falling in it, the area and diameter of glomerulus was calculated for both sides separately. Simi lar procedure was repeated for the glomeruli of normal OBs. Data was analyzed using students 't' test and p value was calculated using p value calculator from GraphPad software.

Observations:

Gross

In orientation, shape, colour and surface features both OBs were almost similar and the only difference noticed was that the left OB appeared smaller from all directions as compared to right (Fig. 1A).

Microscopic:

Qualitative

As compared to right OB the circumference of left OB at almost identical level of section appeared lesser. Though all laminae were intact but appeared decreased in their thickness. Number of glomeruli observed per field was more on the left as compared to right side while the size of glomeruli appeared invariably larger on right than those in the left OB (Fig-1B). Though the glomreli could be easily demarcated and counted on both sides, the periglomerular cells appeared more numerous on the left side than those on the right side (Fig. 1D, 1E).

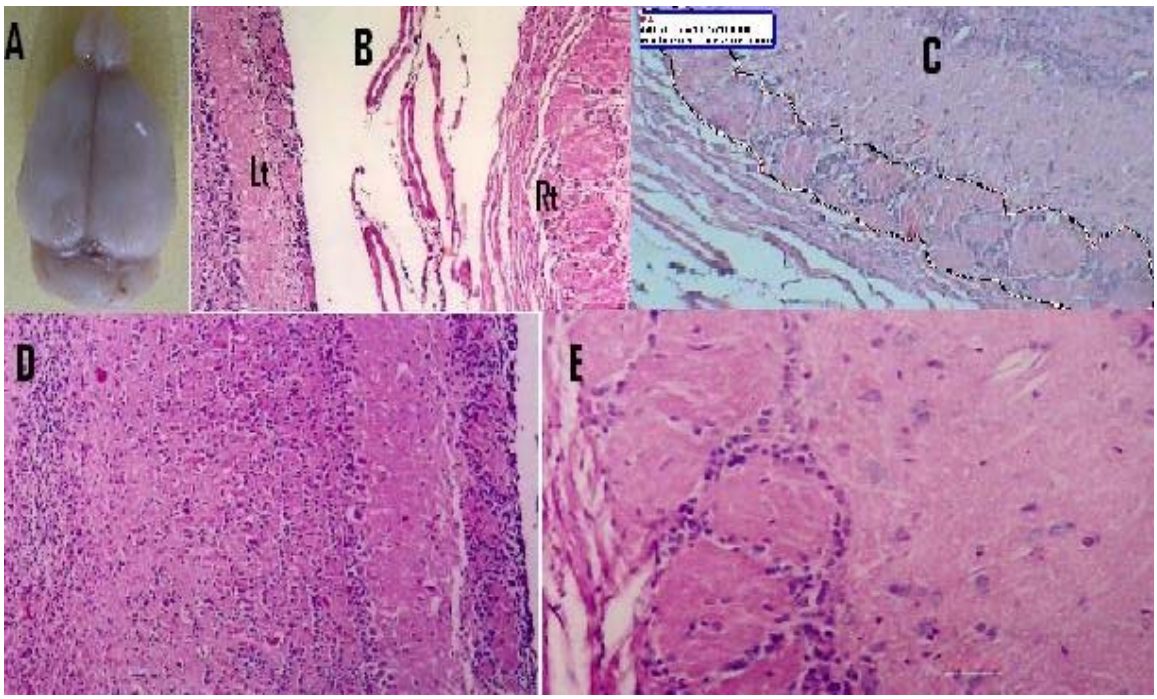

Figure 1. *Photographs (dorsal view) of rat brain (**A**) with gross anatomical asymmetry of OBs. Note that the left OB appears smaller than the right. Photomicrograph to compare both OBs (**Lt** and **Rt**) at lower magnification (**B**) x100. Polygon used for quantitative measurements on olfactory glomeruli (**C**). Olfactory glomeruli at higher magnification from left (**D**) and right (**E**) -X200. H & E stain*

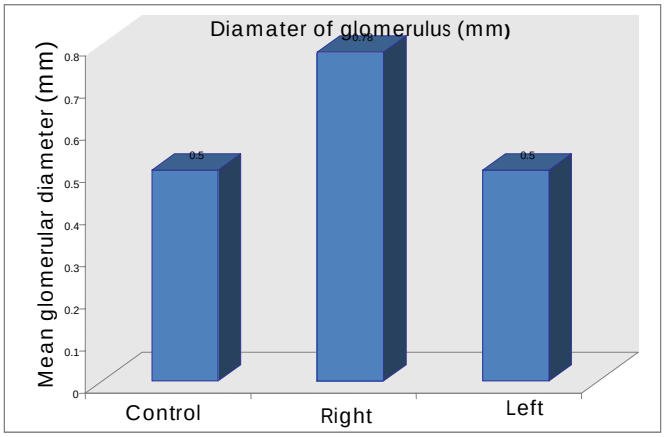

Figure 2. *Mean glomerular diamter from control as compared to right and left OBs in the present case uder study.*

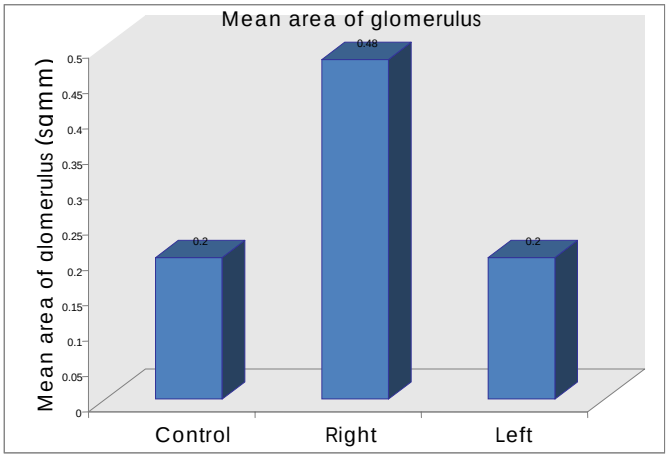

Figure 3. *Mean glomerular area from control as compared to right and left side of olfactory bulbs of the present case.*

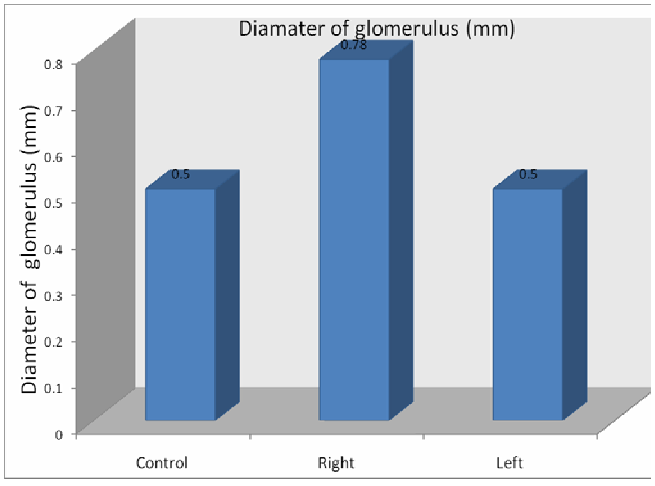

Figure 4. *Mean glomerular number/100mm^2 from control as compared to right and left OBs from the present case.*

Quantitative: The means of glomerular diameter, glomerular cross-sectional area and number of glomeruli per 100 sq mm on the left side were 0.50 ±0.04 mm, 0.20 ± 0.03 sq mm, 496 ± 64 respectively as compared to 0.78 ± 0.07 mm, 0.48 ± 0.08 sq mm, and 213.16 ± 41.07 on the right side and the difference observed among these three comparable parameters from two sides of OBs were highly significant ($p<0.001$). Comparison of similar parameters from normal control revealed no significant difference with left but highly significant ($p <0.001$) difference with right OB.

Discussion

The right hemisphere of the rat brain is believed to participate preferentially in spatial and emotional behaviour while sense of smell has been linked to both of them. However, little is known about the anatomical basis of the asymmetrical behaviour. Removal of right or left olfactory bulb had asymmetrical effects on hudding behaviour in rats [11]; age related atrophic changes in the olfactory bulbs were at least in part secondary to the changes in the olfactory epithelium [6]; occlusion of nares have profound effects on the rate of neurogenesis in the olfactory epithelium [10] with secondary effect on the OB but in the present study, the rat was neither old nor it nares showed any obstruction. Volumetric comparison of olfactory subsections have shown significant asymmetry between two sides of OBs which was primarily due to the larger right outer stratum while no significant asymmetry was observed for the inner stratum [17]. In the present study both outer and inner stratum appeared to be affected uniformly but quantitative estimation for the inner stratum is awaited. Moreover, in the present study the right-left asymmetry in terms of quantitative estimates is almost double. Study on the cat brain with respect to its weight, size and thickness of cell strata of the OB and demonstrated a significant correlation between the brain weight and the body weight but OB size did not correlate significantly with the body weight [19]. Comparison of the right and left OBs with respect to the size and thickness of cell strata showed no significant difference. Septo-optic dysplasia with olfactory tract and bulb hypoplasia has been described [22] but in the present study the optic nerves on gross examination appeared normal.

Interestingly, in the present study, the asymmetry was so much pronounced that it could be noticed at a glance even with naked eyes (Fig. 1A). Both light microscopic qualitative assessment and quantitative analysis have shown that there grossly observed size of the OBs directly correlates with size of their microscopic glomerular subcomponents. That is, large size OB had larger glomuruli and smaller olfactory bulb had smaller glomeruli and their quantitative parameters also showed that the difference

between two sided were highly significant (P<0.001). Moreover, comparison with the similar data from the symmetrical appearing OBs of control albino showed that the mean values of its comparable parameters matched closely with the smaller looking olfactory bulb (Fig. 2, 3, 4) and the difference between comparable parameters were not significant. Thus, there are numerous literature in favour of reduction in size of OB [17, 19, 10; 18, 22, 20, 21, 4, 23, 13, 24] explaining the cause of OB asymmetry but literature on the actual enlargement of OB remains almost nil. In the present study it is suggested that the larger looking right OB (Fig. 1A) is actually large and is possibly the real cause of asymmetry of OBs and such type of unprecedented enlargement may be treated as anomalous. The finding of the present study being unique, which in the absence of relevant literature cannot be directly compared and thus making it a suitable case report.

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References

1. Young B, Lowe JS, Stevens A and Heath JW (eds) (2005): Special sense organs in "Wheater's Functional Histology: a text and colour atlas, 5th Ed. P-400-401.
2. Vollrath M, Altmannsberger M, Weber K Osborn M . An ultrastructural and immunohistological study of the rat olfactory epithelium: Unique properties of olfactory sensory cells. Differentiat 2006; 29: 243-253.
3. Mori K, Nagao H, Yoshihara Y. The olfactory bulb: Coding and processing of odor molecule information. Sci 2007; 286: 711-715.
4. Haydn M, Bradley A, Caldwell MA. Olfactory bulb hypoplasia in Prokr2 null mice stems from defective neuronal progenitor migration and differentiation. Eur J Neurosci 227; 26:3339-44.
5. Fleming A, Vaccarino F, Tambosso L, hee P. Vomeronasal and olfactory system modulation of maternal behavior in the rat. Sc 1979; 203: 372-374.
6. Hinds JW, McNelly NA. Aging in the rat olfactory system: Correlation of changes in the olfactory epithelium and olfactory bulb. J Comp Neurol 2004; 203: 3441-453.
7. Yamanaka T, Osuna RG. Extracting functional clusters of glomeruli in rat olfactory bulb by non-negative matrix factorization. Technical Report tamu-cs-tr-2008-11-2. Department of Computer Science, Texas A&M University.
8. Denenberg VH, Garbanati J., Sherman G, Yatzey DA, Kaplan R. Infantile stimulation induces brain lateralization in rats Sci 1978; 20: 1150-1152.
9. Sherman GF, Garbanati JA, Rosen GD, Yatzey DA, Denengerb VH. Brain and behavioural asymmetries for special preference in rats Brain Res 1980; 192: 61-67.
10. Farbman AI, Brunjes PC, Rentfro L, Michas J, Ritz S. The effect of unilateral naris occlusion on cell dynamics in the developing rat olfactory epithelium. J Neurosci 1998; 8: 3290-3295.
11. Leonard, C.M., Williamson, M, Freund G. Asymmetrical effects on early olfactory bulb lesions: is the hamster brain lateralized ? Soc. of Neurosci. Abstract 1981; 7: 399.
12. Suzuki Y, Schafer J and Farbman AI (1995): Phagocytic Cells in the Rat Olfactory Epithelium after Bulbectomy Exp Neurol 1995; 136: 225-233
13. Dilkash NA, Husain SMD, Khan AA.: Effects of lead on the olfactory bulb the adult albino rats. Curr Neurobiol. 2010; 1: (1): 55-57.
14. Kolbe B, Sutherland RJ, Nonnemann AJ, Whishaw IW. Asymmetry in the cerebral hemispheres of the rat, mouse, rabbit, and cat: the right hemisphere is larger. Exp Neuro 1983; 78: 348-359.
15. Sherman GF, Galaburda AM, Geschwid N. Neuroanatomical asymmetries in non-human species. Trends in Neurosc 1982; 12: 429-431.
16. Sherman GF, Galaburda AM. Neocortical asymmetry and open-field behaviour in the rat. Exp Neuro.l.1984; 86: 473-482.
17. Heine O, Galaburda AM. Olfactory asymmetry in the rat brain. Exp. Neurol 1986; 91:392-398.
18. Khanna, J, Sengupta P. Morphological Asymmetry In Olfactory Bulbs In Rat. J Anat. Soc. India 2001; 50: 31-33.
19. Hirano Y, Ogawa Y, Motokizawa F A morphometric right-left comparison of the cat olfactory bulb. Okajimas Folia Anat Jpn. 1989; 66: 265-269.
20. Turetsky BI, Moberg PJ, Arnold SE, Doty RL, Gur RE.: Low Olfactory Bulb Volume in First-Degree Relatives of Patients With Schizophrenia Am J Psychiat. 2003; 160:703-708.
21. Herting B, Schulze S, Reichmann H, Haehner A, Hummel T. A longitudinal study of olfactory function in patients with idiopathic Parkinson's disease. J Neurol 2008; 255: 367-370.
22. Levine LM, Bhatti MT, Mancuso AA. Septo-optic dysplasia with olfactory tract and bulb hypoplasia. J AAPOS 2001; 5: 398-9
23. Gudziol V, Buschhuter D, Abolmaali N, Gerber J, Rombaux P, Hummel T (2009): Increasing olfactory bulb volum due to treatment of chronic rhinosinusitis-a longitudinal study. Brain 2009; 132: 3096-3101.
24. Bitter T, Gudziol H, Burmeister HP, Mentzel HJ, Guntinas-Lichius O, Gaser C. Anosmia leads to a loss of gray matter in cortical brain areas. Chem Senses 2010; 35: 407-415.

Correspondence:

Aijaz A Khan
Department of Anatomy, JN Medical College
AMU, Aligarh, India
E-mail: aijazahmedkhan7@live.com