Lesional location of lateral medullary infarction presenting hiccups (singultus)

M H Park, B J Kim, S B Koh, M K Park, K W Park, D H Lee

Background: Hiccups are an infrequent result of lateral medullary infarction. Their importance may be underestimated and they can cause distress, exhaustion, and aspiration. Hiccups in lateral medullary infarction remain poorly understood.

Objective: To evaluate the relation between the lesional loci of lateral medullary infarction and hiccups.

Methods: 51 patients with lateral medullary infarction were investigated by magnetic resonance imaging within three days of the onset of infarction. Seven of the 51 patients developed hiccup.

Results: All patients with hiccups had middle level lateral medullary lesions, including two with lower level lesions and four with upper level lesions. In the middle level lateral medullary lesions, dorsolateral lesions were most often involved. All patients with lateral medullary infarction presenting with hiccups also had vertigo, dizziness, nausea, vomiting, and dysphagia.

Conclusions: The observations suggest that middle level and dorsolateral lesion locations in lateral medullary infarction frequently induce hiccups.

Lateral medullary infarction (LMI) or Wallenberg’s syndrome is one of the best known vascular syndromes of the posterior circulation, along with events such as occlusion of the posterior inferior cerebellar artery or the vertebral artery. The usual symptoms of LMI include vertigo, dizziness, nystagmus, ataxia, nausea and vomiting, dysphagia, hoarseness, hiccups, impaired sensation over half the face, and the ipsilateral face, and Horner’s syndrome.

Among the symptoms, hiccups (medical term, singultus) can easily be overlooked, though among other effects they may cause aspiration pneumonia, respiratory depression, and oesophagitis. The aetiology of hiccups includes failure of the digestive organs, irritation of the diaphragm, ingestion of alcohol, excessive smoking, and any disease of the central nervous system that involves the brain stem. Among LMI patients with hiccups, eight who had other possible causes were excluded: two who had chronic gastritis with gastric distension, one who smoked excessively, and five who had been intubated (intubation may stimulate the glottis).

Where a nasogastric tube had been inserted, we only included patients who had hiccups before the tube was inserted and continued to have hiccups for more than 12 hours after it was removed.

After these exclusions, only seven patients were chosen for the study (five male, two female), age range 40 to 80 years, mean (SD) age, 58.14 (16.17) years.

Neurological lesion

All patients had an MRI scan, which was done on a 1.5-Tesla scanner (Vision Plus, Siemens Magnetom, Erlangen, Germany), within three days from the time of admission to hospital. Images were obtained using the fast-spin-echo method. The imaging protocol involved T1 weighted (time of repetition (TR) 570 ms, time of echo (TE) 20 ms) and T2 weighted (TR 4200 ms, TE 96 ms) transverse scan images in the horizontal plane at 5 or 6 mm intervals. Three axial sections of the medulla were identified as the lower, middle, and upper levels based on a study by Bradley.

Axial cuts were further classified into intralateral lesion loci on the basis of a study by Kim et al. The lower level was set at the termination of the fourth ventricle, and was divided into paramedian (PM), inferior-dorsal (ID), and inferior-dorsolateral (IDL) regions. The middle level was set at the centre of the inferior olivary nucleus, and was classified into PM, midlateral (ML), and dorsolateral (DL) regions. The upper level was set at the pontobulbar junction and was split into PM and ML.

RESULTS

As shown in fig 1, among LMI patients with hiccups, two cases had lesion loci at the middle and lower levels, and four

Abbreviations: DL, dorsolateral; GCC, glottis closure complex; IC, inspiratory complex; ID, inferior-dorsal; IDL, inferior-dorsolateral; LMI, lateral medullary infarction; ML, midlateral; PM, paramedian.
cases at the middle and upper levels. Although one case (patient 6) had lesions over all levels of the medulla, we included this case in the analysis because the lesions were mainly located in the middle level. The lesions in the three cases involving the lower level of the medulla were all in the DL region. Among the middle level lesions, six were in the DL region, one in the PM region, and one in the ML region. The lesions in the upper level all occurred in the ML region.

All seven subjects showed accompanying symptoms such as vertigo, dizziness, nausea/vomiting, and dysphagia. Ataxia was observed in six subjects; five experienced hoarseness, impaired sensation over half the face, and impaired sensation over the body, while three had Horner’s syndrome. One subject had nystagmus. Based on the structural involvement in LMI, five of the seven cases had involvement of the fifth nerve, with, for example, impaired sensation over half the face; six of the seven had involvement of the restiform body and cerebellar connections, with ataxia; variable numbers had involvement of the vestibular nuclei and connections, manifesting as vertigo, nausea and vomiting, and nystagmus; three of the seven cases had involvement of the descending sympathetic tract, with Horner’s syndrome; and all cases had involvement of either the ninth or the tenth cranial nerves or both, with dysphagia and hoarseness.

**DISCUSSION**

Hiccups are repeated involuntary, spasmodic, and temporary contractions of the diaphragm accompanied by sudden closure of the glottis, producing a distinguishing “hic” sound. It is suggested that hiccups are caused by the failure of the reciprocal inhibition of the valve control of the pharynx and larynx. This dynamic valve function is achieved by alternating excitation-inhibition of two structures: the glottis and larynx. The role of the central nervous system is suggested by the complex physiological mechanism of hiccup, which requires an interaction in the supraspinal polysynapsis. Peripheral hiccups can be caused by diseases at phrenic nerve level such as gastric distension.

We cannot identify the mechanism of hiccup in patients with LMI, but we can make a few assumptions. First, it is likely that there is denervation supersensitivity because palatal myoclonus is common in such patients. Loss of supranuclear control occurs in the brain stem, especially at ponto-medullary level—the so called myoclonic triangle of Guillan-Mollaret consisting of the dentate nucleus, the inferior olivary nucleus, and the red nucleus. Denervation supersensitivity leads to hiccup. Nonetheless, the region of the myoclonic triangle of Guillan-Mollaret usually involves the peduncle rather than the medulla. Hiccups occur several weeks after the onset of denervation, when enlargement of the inferior olivary nucleus is observed. The patients in our study, however, developed hiccups on the day of the brain infarction or on the next day, and brain MRI did not show any particular lesion in the Guillan-Mollaret triangle. This mechanism was therefore not able to explain hiccups in lateral medullary infarction.

Hiccups occur because LMI causes an imbalance between expiration and inspiration. The expiratory centre and the inspiratory centre are in the central medulla (Fig 2). The areas involved are known to overlap, the expiratory area being larger than the inspiratory area and extending more laterally and dorsally in the reticular formation of the medulla. The expiratory centre is also larger, and lies in the outer side of the medulla. Thus, if the lesion is around the nucleus ambiguus of the medulla, the expiratory centre is destroyed, exercise, which is useless after the neonatal period but may be restimulated by irritation along the reflex arc.

The neuroanatomical centre for hiccups is not well known, although the central connection is presumed to be a part of the brain stem which probably interacts with its respiratory centres, phrenic nerve nuclei, medullary reticular formation, and hypothalamus. The afferent pathway is made up of the sensory branches of the phrenic and vagus nerves and the dorsal sympathetic fibres, while the efferent pathway is formed by the motor fibres of the phrenic nerve. Hiccups have central and peripheral causes. Central hiccups occur with lesions between the pathway from the central nervous system to the phrenic nerve, mainly in diseases of the brain stem such as ischaemic stroke, dolichoectatic basilar artery, tumours, encephalitis, and multiple sclerosis. The role of the central nervous system is suggested by the complex physiological mechanism of hiccup, which requires an interaction in the supraspinal polysynapsis. Peripheral hiccups can be caused by diseases at phrenic nerve level such as gastric distension.
Lateral medullary infarction with hiccups

In animal experiments, hiccup-like responses can be generated by electrical stimulation of the medullary reticular formation lateral to the nucleus ambiguous at the rostrocaudal level, between 1 mm and 2.5 mm rostral to the obex of the fourth ventricle of a cat. This is mainly the region of the dorsolateral medulla, where the nucleus ambiguous is located—including the vagal motor neurones projecting to the larynx and the premotor neurones that control the diaphragm. Thus lesions in this region induce hiccups, as they affect the laryngeal motor neurones which control the glottis and the premotor neurones which control the inspiratory muscles. If the nucleus raphe magnus—with GABAergic inhibitory cells in the medullary reticular formation of the outer region of the nucleus ambiguous—is destroyed hiccups are induced. The clinical features of hiccups in LMI have been described. The frequency of hiccup is around 12–36% in this condition. Nonetheless, the frequency of LMI itself is relatively low, and most studies involved only 20 to 40 patients, with differing frequencies of LMI. Data from a previous study on LMI showed that 44 of 172 patients (around 26%) developed hiccup. In our study, seven of 51 patients (14%) developed hiccup.

Hiccups in LMI are often accompanied by symptoms involving the fifth, ninth, and tenth cranial nerves, with nausea and vomiting. In the present study, all the affected patients had symptoms involving either the ninth or the tenth cranial nerve or both, six involved the cerebellar connections, five had symptoms of fifth cranial nerve involvement, and all cases had symptoms caused by involvement of the vestibular nuclei and their connections (figs 2 and 3). From our analyses of symptoms and lesion locations, we thought that the hiccup centre—the possible area of involvement necessary to produce hiccups—was placed in the region of the cerebellar, vestibular, and ninth, tenth, and fifth cranial nerve nuclei, and their connections with the middle part of the medulla. The lesion appears to be mainly in the dorsolateral region of the middle medulla. One might expect that such a lesion could also induce hiccups through an imbalance between expiration and inspiration, because it is situated around the respiratory area. This has been suggested in previous studies.

Unfortunately, our study has some limitations. Only 1.9% of all cerebral infarcts are in the lateral medulla, and our yield of only seven patients reflects this. It is therefore difficult to obtain enough patients for an adequate sample. In addition, few of the patients with LMI developed hiccup. Patients with dysphagia and secondary hiccup caused by oral secretions or irritation of the airway from dysphagia cannot easily be distinguished from those with a central cause. From previous studies, however, LMI patients experience hiccups during sleep before developing dysphagic symptoms, and the hiccups do not cease in parallel with recovery from the dysphagia. While MRI is the preferred imaging technique for vertebrobasilar territory infarcts, and we used an anatomical approach at three different levels and two or three intralevel areas in the medulla in order to minimise errors in locating the infarcts, there may nevertheless be sources of investigational bias; these could arise from variations in the thickness of the MRI slices and the gaps between them, and uncertainties in forming the reference line used to section the brain stem.

Conclusions

Around 14% of patients with lateral medullary infarcts had hiccups in our study, mainly when the lesions occurred in the dorsolateral region of the middle medulla. There was a close correlation between hiccups and symptoms of cerebellar, vestibular, and fifth, ninth, and tenth cranial nerve involvement. Although there may be arguments against assigning a simple lesional location to such a complicated process as
hiccup, the development of hiccup does appear to be related to lesions in the dorsolateral region of the middle medulla. A larger study is necessary to define the anatomical correlates of hiccup with more certainty.

Authors' affiliations
M H Park, B J Kim, S B Koh, M K Park, K W Park, D H Lee, Department of Neurology, Korea University Medical College, Seoul, Republic of Korea

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REFERENCES