公益財団法人　セコム科学技術振興財団
研究成果報告書

研究課題名

超伝導磁気センサーを用いた非侵襲的に脊髄機能と心房細動の予測ができる革新的な診断装置の開発。高齢者の転倒・寝たきりを防ぐ「脊髄・不整脈ドック」を目指して

Development of an innovative diagnostic device for spinal cord function and prediction of atrial fibrillation

研究期間

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Abstract

Spinal canal stenosis, in which the spinal cord or nerve is compressed in the spine, causes numbness and paralysis in the limbs, triggers falls, and can lead to individuals becoming bedridden. The number of patients with spinal canal stenosis is estimated to number several million and the number affected is expected to increase further with population aging. Accordingly, provision of adequate medical care is required. Advances in diagnostic imaging equipment such as magnetic resonance imaging (MRI) in recent years have facilitated the diagnosis of spinal cord and nerve compression. However, many people have no neurological dysfunction, even when nerve compression is visible on MRI, and false-positive MRI results are a problem. Electrophysiological examinations that measure electrical nerve activity are effective for functional diagnosis of the nerve, but it has not been possible to noninvasively measure the electrical activity of the spinal cord, which is located far from the body surface. Meanwhile, atrial fibrillation frequently causes cerebral infarction and heart failure. Although abnormal excitation of the pulmonary vein is involved in the onset of atrial fibrillation, it is difficult to diagnose this condition from the exterior of the body because the vein is located deep within the body, similarly to the spinal cord.

The purpose of this research was to develop a biomagnetometer for the spinal cord (magnetospinogram) to establish a diagnostic algorithm for neural dysfunction and to detect excitation of the pulmonary vein using this magnetometer.

In preliminary research in 2012, we examined optimal sensor placement for general purposes and worked to reduce costs for commercialization, ultimately designing a new device. Artifact contamination due to electrical stimulation of nerves has been a major obstacle to data analysis, but we succeeded in developing an algorithm to eliminate stimulus artifacts. With this algorithm, neural activity could be evaluated in the early stage after stimulation.

In full-scale research in 2013-2014, we developed a new biomagnetometer system and a real-time position estimation system for marker coils. With this system, measurements can always be made at optimum positions, and diagnostic accuracy was improved. To reduce running costs, we also successfully developed helium recondensing equipment. Continuous operation for an extended period of time is also possible, and the annual running cost can be reduced by about 10 million yen.

For cervical spine measurement, we performed magnetospinography in healthy volunteers and established age-specific control data. We also clarified the nerve conduction velocity of the spinal cord and the neural activity in the intervertebral foramina, publishing these results in the authoritative academic journal Scientific Reports. Furthermore, we also clarified that dysfunctional sites can be diagnosed in patients with cervical myelopathy.

For the lumbar spine, age-specific control data of healthy subjects in their 20s to 60s were established.

For the heart, we established a method for detecting excitation of the pulmonary vein, evaluated the pulmonary vein excitation of healthy volunteers and atrial fibrillation patients, and clarified that the cardiac magnetic field measurement is superior to the conventional electrocardiogram.

During the second year of full-scale research in 2014, we discussed commercialization of the

magnetospinogram with a company and we decided to jointly develop the magnetospinogram toward medical approval and eventual marketing. Accordingly, we declined to apply for this grant in 2015.

We sincerely appreciate this grant and the scientific advances it has helped us to achieve.