Monitoring epilepsy in the brain with a wireless system

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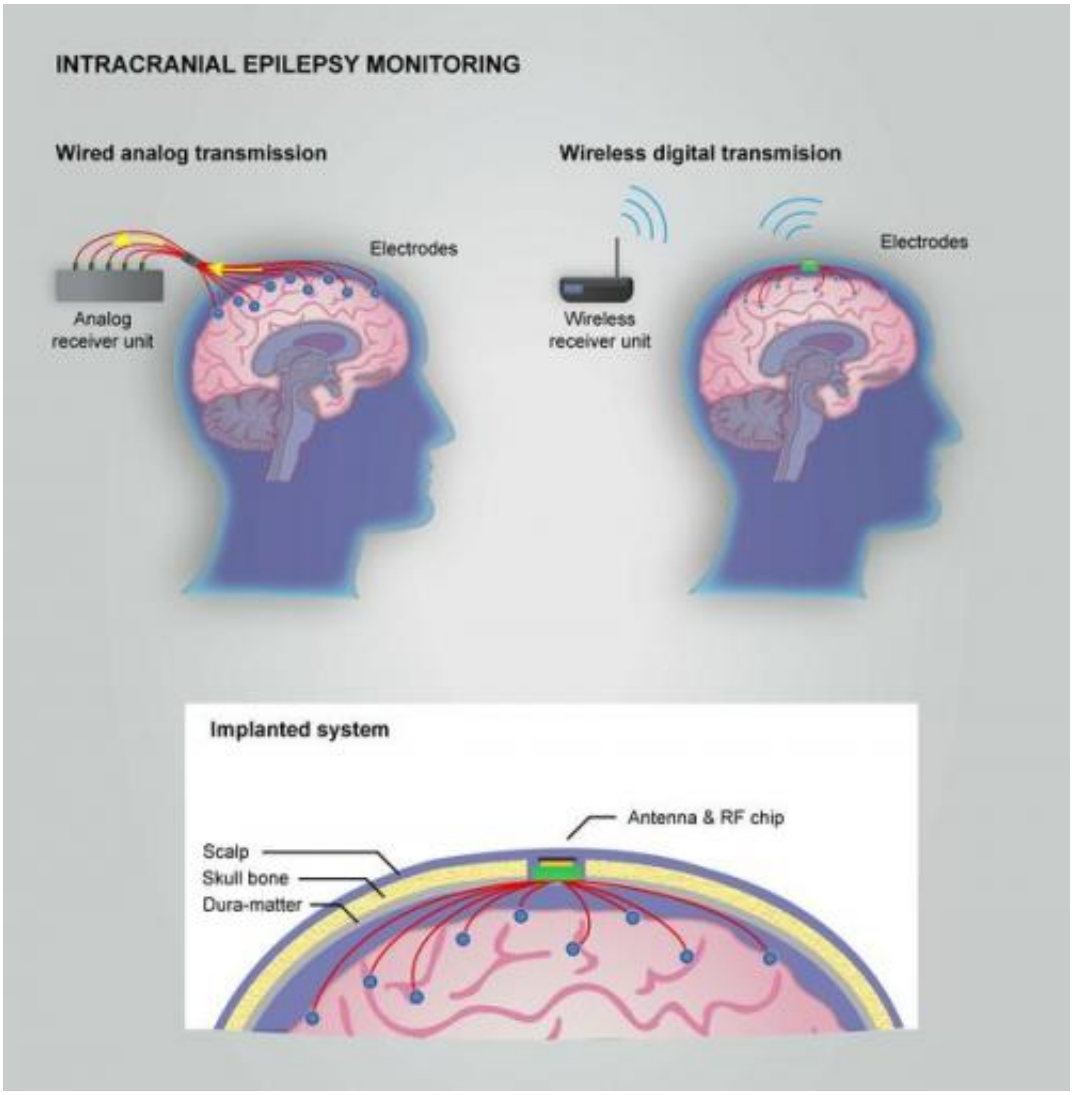

A new system of wireless microelectrodes aims to detect the location of epilepsy in the brain with high precision. This technique, under development at EPFL, is much less invasive than the current method. It will allow patients to go about their daily life while their brain activity is being monitored.

The large majority of the 50 million people around the world who suffer from epilepsy can be treated by anticonvulsant drugs. Yet a handful of patients do not respond to the standard treatment. More and more of them are turning to surgery to give them back a normal life. The principle is to locate, with the help of electrodes, the region in the brain that is the source of the epilepsy and, in the most serious cases, remove it.

The current presurgical phase is complex and highly invasive. Patients undergo a cranial operation to have electrodes implanted on the surface of their cortex. Once the wound is closed, the patients must remain in bed in intensive care for several weeks with wires passing through their cranium. The electrodes are connected the entire time to a recording machine, which is used to identify the source of the epilepsy during seizures.

Researchers at EPFL are now developing a network of wireless microelectrodes that will monitor the patients' brain activity with great precision, without requiring them to remain confined to their hospital bed. Gürkan Yilmaz presented this research as part of his doctoral thesis, conducted in collaboration with doctors and researchers from Inselspital (University Hospital of Bern). A number of in vivo tests have been carried out successfully.

Greater precision and less damage to the brain

The new wireless method still needs a cranial operation, but it offers a

number of advantages. In addition to suppressing cumbersome wires and sparing patients the ordeal of staying in intensive care during the presurgical phase, it extends the monitoring time, thanks to the reduced risk of

infection. The source of the epilepsy can also be identified more precisely. "We are developing electrodes that are less than 100 micrometers in diameter, versus 10 millimeters for electrodes used in traditional intracranial electroencephalograms," says Yilmaz. "As a result, measurements are much more precise, and the fewest possible neurons are removed during the operation. This allows us to minimise the damage that can result from this type of operation."

With the new system, which consists of a network of electrodes, a microchip and an antenna, the electric signals are captured and processed under the skin in a miniaturised station. The internal device is powered from the outside by wireless power transfer, more specifically by electromagnetic induction. Thanks to this energy, the internal system can process a large amount of data, and then transfer the results to an external unit. "We could use a mobile phone to receive the data, but for reasons of data security, it is not the preferred method," says Gürkan Yilmaz. At this stage, in vivo tests have been successfully run on laboratory mice.

Innovative, less invasive therapies

Medical doctors are showing a significant interest in this technology. Claudio Pollo, a neurosurgeon in charge of epilepsy surgery at Bern University Hospital, explains the potential represented by such a system. "We would be able to observe epileptogenesis at the level of a few cells rather than tens of thousands of cells," he notes. "This would enable us to remove smaller epileptogenic zones, and to develop innovative therapies. For example, when a given region cannot be removed, we could deliver

electrical stimulation to the lesions to prevent seizures." And this type of surgery produces excellent results. "The recovery rate is nearly 80%, when talking about temporal lobe epilepsy. More and more children are operated on, and this drastically changes their future."

In the laboratory, the researchers continue their work. Their goals include adjusting the size of the electrodes so that they can measure the activity of a single neuron.

Epilepsy in figures

- Epilepsy is the most common cerebral disorder in the world.
- Around 50 million people are affected.
- Most people can be treated with anticonvulsant drugs, but a small number of patients do not respond to that treatment and must undergo surgery.
- In Switzerland, 80 to 100 epilepsy operations are done every year. Of these, 20-30% require an invasive presurgical phase in order to locate the region that will potentially be removed.
- The success rate of surgery is around 80%.

More information: "Wireless Power Transfer and Data Communication for Intracranial Neural Implants Case Study: Epilepsy Monitoring": infoscience.epfl.ch/record/203690

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