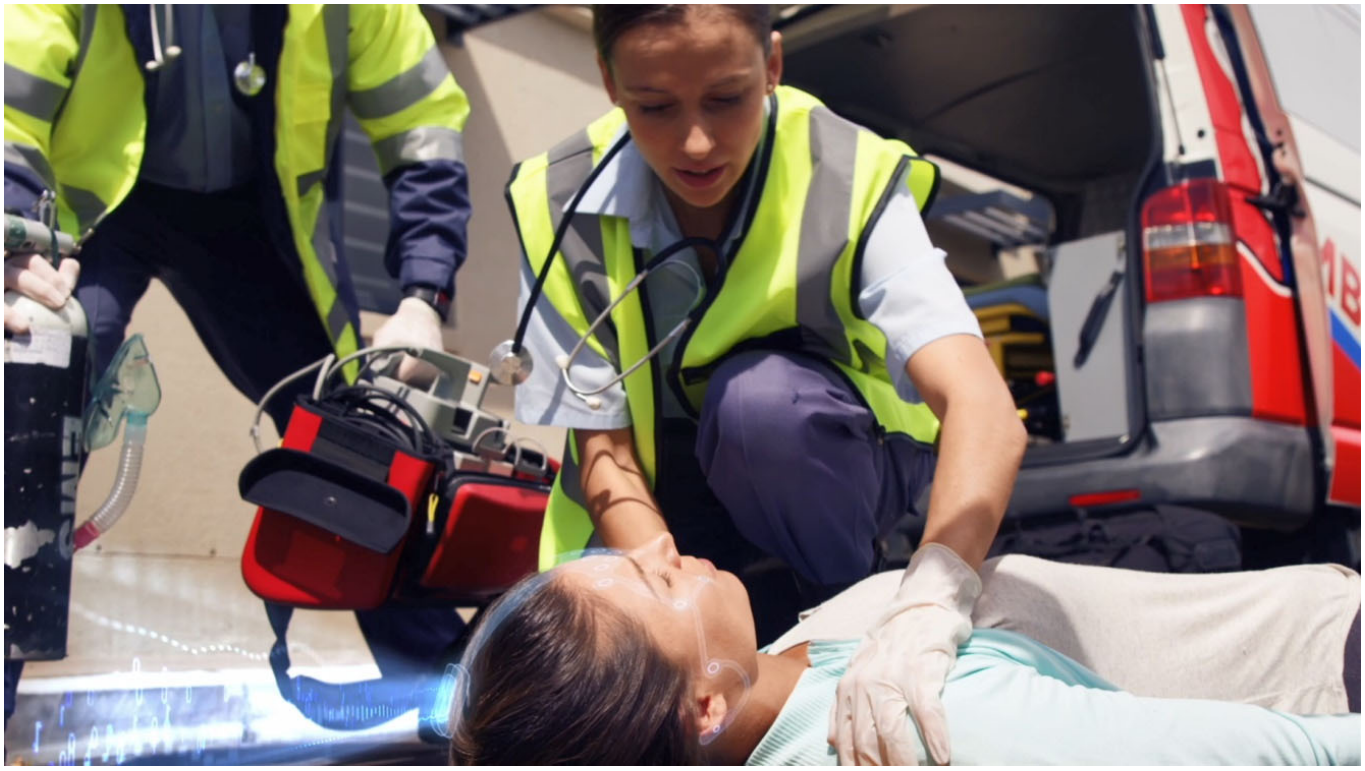
Progress in the capture and analysis of Biosignals for EEG

New electrode technology and AI analytics solve challenges in neurological emergency, acute and intensive care medicine



According to the German Society for Neurology (DGN), neurological emergency medicine, alongside surgery and internal medicine, has become the third most important area in hospital emergency admission[i]. According to the DGN, around 260,000 people suffer a stroke annually in Germany alone[ii]. Epileptic seizures, cerebral hemorrhages or traumatic brain injuries are also among the neurological emergencies that paramedics and medical personnel in emergency rooms and clinics are regularly confronted with. Decision-making for the treatment and prevention of permanent damage to the health of the patients requires fast and precise recording and evaluation of the brain signals. This is usually done using electroencephalography (EEG), which, however, has hitherto been associated with a whole series of challenges – especially in emergency and acute medicine. Medical technology specialist, Bittium, summarizes the most challenging areas and explains how the interaction of a new generation of electrodes with advancements from the field of wearables and mobile technology, paired with analysis functions based on artificial intelligence (AI) helps to solve these challenges.

The situation in neurological emergencies can usually be described as follows: an ambulance is called and paramedics or an emergency doctor recognize that the emergency could, for example, be an epileptic seizure. If the muscle cramps do not stop after a few minutes, they need to inject anticonvulsants, as prolonged attacks can be life-threatening. The disadvantage of this procedure, however, is that when the patient arrives at the clinic, a diagnosis of the seizure that is important for the follow-up treatment is no longer possible using the EEG. An

immediate EEG examination would therefore be of great advantage for sustainable treatment success. For the patients that suffer non-convulsive status epilepticus an EEG would be even more important since a seizure causes irreversible damage to the brain after 30 minutes and since muscle contractions are missing the patient would not be treated with anticonvulsants. So far, however, this has been problematic in rescue operations and often also in the emergency room.

Time-consuming and complicated application of the EEG electrodes

The biggest challenge, in order to be able to carry out an EEG quickly, especially in emergency and acute medicine, is the application of the electrodes. In conventional medical EEG devices, 20 or more electrodes are applied over the entire head of the patient. The electrodes must be distributed 100% synchronously. For example, if there are deviations in the positioning of the electrodes on the right and left sides of the patient's head, this can falsify the values of the EEG recordings. A practiced EEG-MTA (medical-technical assistance) usually takes typically of 20 minutes to attach the electrodes.

EEG caps, in which the electrodes are already incorporated, brought a first time-saving alternative. However, these must first be prepared with a special gel. Afterwards, the position of each contact must be checked. Especially in the hirsute area of the head, the hair must be pushed aside for each electrode so that there is sufficient skin contact. This method therefore also requires specially trained personnel and in good scenarios can still take around 10 minutes to apply.

For this reason, two problems arise: firstly, the time factor, which plays a decisive role in emergency medicine, and secondly, the need to have access to specially trained specialist staff at all times. Of course, not every ambulance can be equipped with specialists for all possible medical incidents and diagnostic devices. EEG-MTAs and neurologists are also usually not on site around the clock in the emergency room either.

A new generation of electrodes with technology from the field of wearables now promises a solution to this problem. A smaller number of electrodes, which are only applied to the hairless area of the front of the head, can deliver precise EEG signals. In the latest versions of mobile EEGs addition, the electrodes also do not have to be attached individually, but are fixed in a band so that the exact positioning is already specified.

The advantages are obvious – not only can the electrodes be attached much faster; it is also so uncomplicated that paramedics and emergency personnel can also derive an EEG without special training

Disability in treatment

Another disadvantage of previous EEG electrodes was their complex wiring, which hindered treatment, especially in emergency medicine.

In an emergency room, several doctors and medical personnel often have to treat the patient at the same time. An EEG system with conventional electrodes, which are connected to a monitor via cables, is very cumbersome. Such a system is much less suitable for rescue workers and patient transport.

In the new generation of mobile EEG systems influenced by wearables, the electrode band is connected directly to a very compact transmitter that displays the signals wirelessly on a monitor, so the patient's mobility is not impaired. This transmission ensures high signal quality and also enables long-term EEG measurements.

Complex data analysis

The evaluation of the EEG data has also been very complex so far. As a rule, EEG recording is monitored visually and up to now, this could only be evaluated by trained specialists. But the time required for the evaluation was also very high. The specialists can rarely sit next to the patient for a long period of time to view the recordings in real-time. In the retrospective evaluation, however, large amounts of records had to be checked and evaluated in order to identify deviations and new incidents. Since the patients are mostly sedated, no one would notice another attack, unless someone is looking at the EEG curves at the very moment of the incident.

Such a problem is of course particularly precarious in emergency and intensive care medicine. This topic is however also relevant for non-life-threatening EEG applications in which EEG recordings are to be made over a longer period of time. These areas of application include Migraine Headaches, which affect around 15 percent of the population[iii], and sleep disorders.

The latest generation of EEG systems meets this challenge by using artificial intelligence. After many years of research, it has been possible to use intelligent algorithms to analyze the EEG recordings. While this cannot replace neurologists or trained MTAs, it is a great relief and time-saving measurement the medical staff benefits from enormously when it comes to patient care.

The AI functions for intelligent evaluation of the EEG recordings create an overview of the individual recorded measurement cycles and evaluate trends. Based on certain values, the medical staff can immediately see whether all values are in the “green zone” or whether, for example, there has been a new incident recently. If the values are outside the norm, the responsible doctor or a specialist can be consulted immediately. Thanks to the analyzed recordings, the responsible medical expert can immediately find the important observation period and can then take a closer look at the corresponding measurement curves.

Touch panel PCs/tablets can also be used to record mobile EEG systems and to simplify the EEG application in practice. The system’s software covers all the standard functions of modern EEG systems, but is also easy and intuitive to use for medical and care personnel who are not familiar with EEG software. The patient's EEG data can be transferred to a data cloud via the clinic network, so that a neurologist can immediately view the recordings and analytics, and can give instructions from any location. This not only saves time in everyday clinical practice – it can also increase the chances of survival in acute emergencies.

Outlook: The combination of competencies in biosignal analysis and medical technology with mobile technology and functions based on artificial intelligence can help to solve challenges in EEG applications that medical professionals have struggled with for a long time. Rapid measurements under field conditions and in hospitals help to speed up the patient's treatment and diagnosis process significantly.

In addition to recording the data in the device's memory, wireless real-time monitoring of mobile EEGs also enables highly secure data transmission for remote monitoring. In the future, EEG recordings will be transmitted

to treating specialists within clinic networks. If there is no specialist on-site, such systems also enable transmission to specialist clinics or experts at other locations.

Since the devices are not only easier to use, but also compact and suitable for mobile use, even rescue workers could apply the EEG electrodes in the field and transfer the data to specialists, instead of just taking standard measures before transport. Remote monitoring for long-term recordings could also be used on an outpatient basis in the future. This would not only make life easier for patients and clinic staff, but also enable cost savings. After applying the electrodes and the compact transmitter, the patients could leave the clinic and, for example, perform a 24-hour EEG recording at home.

About the expert

Andreas Wagner has been active in the medical technology industry for over 30 years. The expert in medical technology and healthcare projects has a university degree in clinical engineering and has been part of the management team in the DACH region for Bittium since 2019.

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[i] *https://www.medica.de/de/News/Archiv/Notfall_Neurologie_in_der_Notaufnahme*

[ii] https://www.bmbf.de/upload_filestore/pub/Digitalisierung_in_der_Medizintechnik.pdf

[iii] https://bit.ly/2A2cSlr