VitalEEG™

Wireless EEG Headset

White Paper

Introduction

Acute neurological situations, seen in the intensive care unit (ICU) and emergency department (ED) for example, have a relatively high incidence, as well as the potential patient impact of severe neurological injury. In many cases, evaluation using EEG is critical for accurate diagnosis and treatment. However, implementation of EEG as a routine diagnostic tool has been relatively limited due to the availability of resources, mainly qualified staff. One solution is the use of limited EEG electrode sets for rapid EEG evaluation. With quick and easy-to-use electrode application solutions (both equipment and staffing), there can be an improvement in time to care, expanded utilization to point of care, and refinement of referrals for advanced or full EEG services, thus optimizing the use of these valuable but limited resources.

Incidence of acute neurological situations and barriers

There are a number of acute neurological situations that require timely identification and diagnosis, including neurovascular incidents and seizures. Acute neurovascular events, such as stroke, affect a patient in the U.S. every 40 seconds (Rosamond, et al., 2008), and subarachnoid hemorrhages impact 30,000 patients in the U.S. each year (Labovitz, et al., 2006). Neurological emergencies are common and frequently devastating (McMullan, Knight, Clark, Beyette, & Pancioli, 2010). Non-convulsive status epilepticus (NCSE) has been found in 22-33% of patients after TBI, 3-26% after subarachnoid hemorrhage (SAH), and 3-17% after intracerebral hemorrhage (Claassen, et al., 2013).

However, due to the limitation in advanced resources, only the most urgent clinical situations tend to be evaluated with full EEG. In the ICU, studies have shown the benefit of EEG monitoring, with 22% of ICU patients experiencing seizures related to TBI (Vespa, et al., 1999) and an additional 12% of ICU patients with SAH encountering seizures (De Marchis, et al., 2016). These patients suffering from acute neurological issues, such as seizures and neurovascular risk secondary to stroke or SAH, have seen the greatest advantage from EEG monitoring.

As stated by McMullan, et al., this evaluation often requires advanced diagnostics and treatment at specialized centers and can result in delays of diagnosis and treatment (McMullan, Knight, Clark, Beyette, & Pancioli, 2010). One of the barriers is the limitation in resources (staff and equipment) required for full and traditional EEG evaluation. Many hospitals do not have the staffing to allow 24-hour coverage for full EEG services, and some facilities have no EEG services offered at all. One of the primary reasons for this is a lack of not only equipment but also staff, as there is a nationwide shortage of qualified and highly skilled neurodiagnostic technologists (ASET - The Neurodiagnostic Society, 2019).

In some facilities with limited availability after hours, supplemental coverage can be provided by on-call EEG staff. This is not only cost intensive but also introduces additional potential delays to diagnosis and treatment. In one study (Jordan & Schneider, 2009), the time from after-hours EEG order to time of recording averaged between 1.5 and 2.3 hours, likely longer at many facilities. Another study, by Kolls, et al., found that using non-EEG-trained staff to perform EEGs using templates yielded a three-hour reduction in time to initiate recording (Kolls, et al., 2012).

Delays in the initiation of EEG, and therefore initiation of treatment, could result in a negative impact on patient care and outcomes (McMullan, Beyette Jr, & Shutter, 2012). This early EEG has both a diagnostic yield, as well as a significant contribution to decision-making for treatment at specialist review (Prakash, et al., 2015). With a delay in the identification and treatment of non-convulsive status epilepticus (NCSE), in particular, there is an increase in risk, an increase in duration of NCSE, and a decreased effectiveness of treatment (Jordan & Schneider, 2009). NCSE can be diagnosed only with EEG, and delays can have a significant impact on neuronal damage (measured by lactate/pyruvate and increased ICP), morbidity and mortality (Vespa, et al., 2007).

"Hybrid" staffing models and rapid application

Even in facilities with full EEG services, staffing challenges can result in a lack of readily available EEG personnel during off hours and delays in the initiation of EEG monitoring when ordered by clinical staff. In some cases, on-call staff are utilized during off hours, or "hybrid" staffing models are used with nursing staff as adjunctive EEG clinical initiators utilizing templates or reduced montages to initiate studies. These hybrid models can result in increased availability and speed to acquisition for EEG recording (Ehrenberg, Rodriguez, & LaRoche, 2017; Alawaki, Ehrenberg, & Rodriguez-Ruiz, 2018), with minimal impact on short-term recording quality (Kolls, et al., 2012). Further, some studies have shown a cost savings associated with using non-EEG-trained staff for initial electrode application and study initiation. Kolls, et al., found that leveraging staff and avoiding transfers to advanced centers resulted in over $250,000 of cost savings (Kolls, Lai, Srinivas, & Reid, 2014).

Rapid-application, limited electrode montage solutions

As per the ACNS critical care consortium consensus statement (Herman, et al., 2015), limited electrode sets (<16 channels) may be used for rapid screening of EEGs in emergency situations. These limited electrode arrays could possibly be applied by neurology residents and nursing staff. These reduced electrode headsets could be used while awaiting the more resource-intensive full EEG (>16 channels), which they recommend to institute as soon as possible. This can allow for rapid initiation and screening of EEGs in critical situations, or when resources are limited, to decrease delays in identification and treatment of critical neurological conditions.

Conclusion

The incidence of acute neurological situations potentially benefitting from EEG monitoring is high; however, utilization has remained relatively low. This is likely due to the amount and level of resources required for full EEG evaluation and the availability of those resources in many point-of-care scenarios. Hybrid staffing models and rapid-application, limited montage EEG designs are one potential solution and are in line with the professional consensus and literature.

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