A clinical introduction to epilepsy and the technological developments for detection and management of the condition

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Introduction

Epilepsy is one of the most common neurological condition in the UK affecting any person at any age regardless of race or social class (Richardson, 2014). It is a condition affecting over half a million people in the United Kingdom. This means that it affects one person in every hundred people (NHS Choices, 2014). Epilepsy may present as short-term to prolonged periods of vigorous shaking (WHO, 2016). Physical injuries such as broken bones may occur occasionally due to these episodes however more often bruising can occur (WHO, 2016). In some parts of the world, there is a stigma attached to the condition (WHO, 2016). Although it can affect anyone, it is commonly diagnosed in childhood and in people over the age of 65 (Epilepsy Research, 2014). The specific cause of epilepsy has been reported to be unknown however it may develop from a brain injury, stroke, brain tumour, infections of the brain, various congenital defects and some genetic mutations (WHO, 2016; Longo, 2012; Pandolfo, 2011). On a global scale it had been reported that out of 22 million people who have epilepsy, nearly 80 % of these cases occur in the developing world where onset is common in children and adolescents (Newton, 2012; Lancet, 2015; WHO, 2016). However in the developed world onset is more frequent in babies and the elderly (Wolters, 2010). In the elderly it has been reported that an unprovoked seizure could occur in about 5 – 10 % of people by age 80 (Wilden and Cohen-Gadol, 2012). Chances of a second seizure then increases by 40 % to 50 % (Berg, 2008). People with epilepsy may experience limitations in their ability to carry out certain activities such as driving (Devlin et. al. 2012).

In recent years, important technological advancements have been made in the diagnosis and treatment of seizure disorders (Fisher et. al., 2014). However our understanding of the detecting these mechanisms by which epilepsy develops, is still incomplete and there may be room to improve detection mechanisms. Technological advancements to detect and manage seizure disorders whether in the domestic or care home setting is periodically designed to detect tonic and clonic seizures. Although there has been numerous technological advancements to detect and manage tonic and clonic seizures, the potential need for detecting incontinence, vomiting, sweating and salivation while acknowledged is not seen to be a detection feature in a variety of devices available on the market. This white paper highlights the prevailing features about current detection systems and existing technology capable of detecting further numerous classical signs and symptoms. The technological advancement at Alert-it care alarms will be reviewed for more specialized and comprehensive discussions of this topic.

What is the difference between Epilepsy and Seizures?

Epilepsy is a group of neurological diseases characterised by epileptic seizures with a long-term risk of being recurrent seizures (Chang and Lowenstein, 2003; Fisher et. al, 2014; Duncan et. al. 2006). To understand the difference between Epilepsy and Seizures, it is important to appreciate the how the brain communicates at a basic level. Nerve cells in the brain communicate with one another through electrical activity induced by complex chemical changes (Epilepsy Foundation, 2014). Conventionally there is a balance between cells which excite and cells which inhibit other brain cells from sending messages (Epilepsy Foundation, 2014). An imbalance between this excitatory and inhibitory activity causes abnormal electrical impulses in the brain cells. This results in a sudden surge of electrical activity (too many nerve cells in the brain fire too quickly causing an electrical storm) which is what causes a seizure (Shalev, 2015). Seizures is not a disease but are symptoms of many different disorders affecting different parts of the brain (Epilepsy Foundation, 2014). Seizures may affect behaviour, movement and experiences depending on the affected lobes (Epilepsy Foundation, 2014). Some people who have seizures without a known cause has been reported to possibly experience another within 6 months. If a seizure is caused by brain injury or an infection it is then reportedly more likely for more seizures to occur hence the development of epilepsy (Epilepsy Foundation, 2014).

Epilepsy is a neurological disorder where repeated seizures occur originating in the brain (Epilepsy Foundation, 2014; Epilepsy Society, 2015; Mayo Clinic, 2016). There are more than 40 types of epilepsies which is based on the type of seizures and location in the brain. Due to its complexity the causes or epilepsy has been categorised into a three main groups: idiopathic (no apparent cause), cryptogenic (likely cause) and symptomatic (identified cause) (Epilepsy Society, 2015).

Seizures can be categorised into two groups: partial or focal seizures (seizures start from one area of the brain) and primary generalised seizures (seizures involve the whole brain). The primary difference between these two groups is how and where they start in the brain. A partial (focal seizure) occurs when the electrical discharge happens in one area of the brain. This group of seizures may originate from a head injury, infection of the brain, stroke, tumour or cortical dysplasias (changes in the brain formed before birth). Sometimes no known cause is found although genetic factors may contribute to some partial seizures. Partial seizures may be divided further based on the individual's ability to respond (awareness) or consciousness (Schachter, 2013). During a primary generalised seizure the rampant electrical activity synchronously involves both sides of the brain. This group of seizures can be due to hereditary factors (Schachter, 2013).

Epileptic Seizure

Partial (focal) seizures

Simple: Small part of the brain is affected. Often the person will have an aura (strange sensation), strange taste in mouth, funny rising feeling in stomach, and sudden feeling of fear, dejavu, stiffness, twitching or an odd sensation in parts of the body resulting in the person feeling upset or disorientated. The seizure may move on to different parts of the body.

Complex:

They may make strange noises, postures –won't respond to talking – few seconds to minutes.

Secondary generalised: Happens in when a simple or complex focal seizure spreads so that it affects both sides of the brain resulting usually in a tonic clonic seizure.

Generalised seizures

Tonic:

Persons body suddenly goes stiff and usually fall backwards and down if they are standing. Although the person briefly loses consciousness, this seizure is very short, they will recover quickly.

Clonic

Tonic-Clonic: this is when the person stiffens then shakes (most common) the person will be unconscious. At the start the body will suddenly go stiff, cry out, bite tongues, notice blood or saliva around mouth, they will fall down, body rhythmically jerks or convulses for a few minutes before gradually stopping. Muscles relaxes and tightens in time.

Absence: can be typical or atypical. The person is absent or goes blank and unresponsive for a few seconds happening many times a day. The person won't be aware if they are briefly unconscious but they may be aware of missing conversation. More common is children, young adults. A typical absence-physical movement of head or body and longer than absence seizures.

Myoclonic: Brief jerking of muscles on arms or legs, affecting one side or both sides of the body. May happen in the morning or in clusters (many happen in a small amount of time).

Atonic: Persons body suddenly goes floppy. If they are standing up they usually fall forwards likely injuring their face (sometimes known as drop attacks). Very short and people recover quickly.

Definition of Epilepsy

Epilepsy was given an official definition in 2005 by the International League against epilepsy (ILAE) and was theoretically described to be a disorder of the brain characterised by an enduring predisposition to generate epileptic seizures. This definition has been practically applied as two unprovoked seizures, less than 24 hours apart (Fisher et al, 2005). The definition was revisited because many people with epilepsy have more than one type of seizure and may have other symptoms of neurological problems as well (Epilepsy Foundation, 2014). In addition epilepsy was considered to be resolved in people with age-dependent epilepsy but have past the age or have been seizure free for 10 years (with no medicines for the last 5 years) (Fisher et. al., 2014). There exists treatment which can cause epilepsy to be resolved however it does not guarantee it will not return (Fisher et. a., 2014). Although traditionally referred to as a 'disorder' epilepsy has been now considered to be a 'disease' by the ILAE because it conveys a more perpetual interruption of normal function (Fisher et al., 2005). Whereas the term 'disorder' implies a functional disturbance which is not necessarily lasting (Fisher et al., 2005). This definition was designed for clinical use and to clarify when an 'enduring predisposition is present. The ILAE considers allowable to use the old definition or a definition devised as long it is clear (Fisher et. al., 2014).

Supporting organisations

Individuals affected by epilepsy are given support by a variety of organisations. International efforts are joined by the World Health Organisation, International League Against Epilepsy and the International Bureau for Epilepsy (WHO, 2012). Within the UK The Joint Epilepsy Council serves the UK and Ireland however other main organisations do exist alongside such as Epilepsy Action, Epilepsy Society and Epilepsy Research UK (NICE, 2012a). They mainly work towards increasing awareness and acceptance of those with the disease as well as promote research for treatment and management. Support groups also exist to help families of individuals with epilepsy (Nice, 2012b).

DIAGNOSIS and TESTS

The onset of a seizure and its underlying cause is usually observed when making the diagnosis for epilepsy (NICE, 2012b). Neuroimaging diagnostics tools such as electroencephalogram (EEG) that look for abnormal brain wave patterns, and CT scans or MRI look at structures of the brain are used as part of the diagnostic procedure (NICE, 2012a). Even with these advanced technological tools, it is still not possible to determine the specific epilepsy syndrome and at times, EEG monitoring may need to be accompanied by video in difficult cases (NICE, 2012a). Typically, the EEG displays brain activity patterns which can be used to determine the risk of seizures and it also rules out problems

of heart rhythms. However, it is usually recommended after an epileptic seizure has happened. Generally the EEG is used to distinguish the type of epilepsy present and can be used to diagnose epilepsy in children after the second seizure. EEGs may not be reliable due to false positive effects. For individuals who are affected by epilepsy during sleep or are sleep deprived, the EEG may be useful (Nice, 2012b). If an individual experiences a first non-febrile seizure, then a CT scan and MRI is recommended for detecting structural problems around the brain (NICE, 2012). The MRI provides superiors imaging however CT scans are more sensitive at detecting bleeding and is easily available (Wilden and Cohan-Gadol, 2012). In adults it is essential to exclude other causes of epilepsy such as electrolyte abnormalities. It is possible to diagnose a central nervous system infection through a lumbar puncture although this is not routinely used. Children may need additional tests such as urine and blood testing to look for metabolic disorders (Nice, 2012; Sheila and Farrell, 2004).

MANAGEMENT

Treatment for epilepsy through drug medication is usually administered after the second seizure however for higher risk individuals, medication may be taken after the first seizure (Nice, 2012b). For individuals who are drug resistant, other treatment options are available and they include a special diet, neurostimulator implants or neurosurgery. The following sections will explain how to manage epilepsy.

Immediate care: If an individual has an epileptic seizure where medical help is not immediately available, it is important to position them correctly; turning the person with an active tonic-clonic seizure onto their side (recovery position) is a safe way to prevent fluids from getting into the lungs (Michael and O'Connor, 2011). It is not advisable to insert fingers or objects in the individuals mouth as this may result in the person vomiting (Michael and O'Connor, 2011) Seizures which last for more than 5 minutes, or if two consecutive seizures occur within an hour without the return of normal level of consciousness, it is then considered a medical emergency also known as status epilepticus (Nice, 2012a; Wheless, Willmore and Brumback, 2009).

Medications: Epilepsy is mainly treated with anticonvulsant medications and are usually for long term treatment. The prescription is based on type of seizure, health problems, age and lifestyle (Nice, 2012b). Medications such as Phenytoin, carbamazepine and valproate appear to be equally effective in both partial and generalized seizures (Nolan et. al., 2013; Smith, Marson, Clough and Williamson, 2002). In the United Kingdom, carbamazepine or lamotrigine are recommended as initial treatment for partial seizures, with levetiracetam and valproate as secondary treatment option due to issues of cost and side effects. Seizures that are well controlled on a specific treatment do not need routine checks of the medication levels in the blood (Nice, 2012a). Weaning off

medication may be necessary in some individuals who are seizure free for two to four years although about 30 % of the total population with epilepsy tend to have recurrance during the first six months (Nice, 2012b; Neinstein, 2008). It has been reported that ceasing medication in possible in about 70 % of children and 60 % of adults (Nice, 2012b).

Surgery: In 60 – 70 % of cases surgical intervention may achieve total control of seizures (Duncan, 2007; Birbeck, Hays and Vickrey, 2002). Procedures include: removing the hippocampus through the resection of the anterior temporal lobe, removal of tumours and removal of parts of the neocortex (Duncan, 2007). Another procedure commonly carried out is the corpus callostomy which does not ure the condition but reduces the number of seizures (Duncan, 2007). Following surgery medications may be withdrawn (Duncan, 2007). For individuals who are not able to undergo surgery Neurostimulation may be another option (Nice, 2012a). There are three effective stimulation treaments which are specifically for people who do not respond to medication: vagus nerve stimulation, anterior thalamic stimulation, and closed-loop responsive stimulation (Bergey, 2013).

Diet: It has been reported that a ketogenic diet could decrease the number of epileptic seizures and in some cases eliminate them. This diet consists mainly of a diet that is high in fat and low in carbohydrates with adequate amounts of protein (Martin, Jackson, Levy and Cooper, 2016). This is a positive option for individuals who do not improve with either medication or surgery (Martin, Jackson, Levy and Cooper, 2016). However as the diet is strict, only about 10 % stay on this diet due to issues of effectiveness and tolerability (Levy, Cooper and Giri, 2012) even though it is unclear why it works (Bernard, 2009). It's effectiveness can be hindered by side effects such as stomach and intestinal problems in 30%, and possible concerns of long term concerns of heart disease (Levy, Cooper and Giri, 2012). Exercise has been proposed as possibly useful for preventing seizures with some data to support this claim (Arida, Scorza, Scorza and Cavalheiro, 2009; Arida, Cavalheiro, De Silva and Scorza, 2008).

Alternatives: Individuals who avoid therapy altogether may reduce epilepsy by minimising triggers for example taking necessary measure, in those who are sensitive to light, using a small television, avoiding video games, or wearing dark glasses may be useful (Arida, Cavalheiro, De Silva and Scorza, 2008). Biofeedback based on the EEG waves has some support in those who do not respond to medications (Tan et. al., 2009). Alternative medicine, including acupuncture, psychological interventions, routine vitamins and yoga, have no reliable evidence to support their use in epilepsy (Cheuk and Wong, 2014; Ramaratnam, Baker and Goldstein 2008; Ranganathan and Ramaratnam, 2005; Ramaratnam, Sridharan and Panebianco, 2015).

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