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Review Article

Cardiorespiratory abnormalities during epileptic seizures

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ABSTRACT

Sudden unexpected death in epilepsy (SUDEP) is a leading cause of death in young and otherwise healthy patients with epilepsy, and sudden death is at least 20 times more common in epilepsy patients as compared to patients without epilepsy. A significant proportion of patients with epilepsy experience cardiac and respiratory complications during seizures. These cardiorespiratory complications are suspected to be a significant risk factor for SUDEP. Sleep physicians are increasingly involved in the care of epilepsy patients and a recognition of these changes in relation to seizures while a patient is under their care may improve their awareness of these potentially life-threatening complications that may occur during sleep studies. This paper details these cardiopulmonary changes that take place in relation to epileptic seizures and how these changes may relate to the occurrence of SUDEP.

1. Introduction

Epilepsy affects nearly 1% of the general population [1,2]. Epilepsy can be classified by seizure type, underlying causes, epilepsy syndromes, and by events taking place during the seizures. Seizure types are broadly classified by whether the source of seizures is localized (focal or partial seizures) or diffusely distributed (generalized seizures) in the brain. Generalized seizures can be further classified according to their effects (tonic–clonic seizures, absence seizures, myoclonic seizures, clonic seizures, tonic seizures, and atonic seizures). Focal or partial seizures can be further classified into simple partial (where only a small part of the lobe is affected and the person does not lose awareness of the surrounding) or complex partial (a larger part of the hemisphere is affected and the person loses consciousness and awareness) seizures.

Approximately 35% of individuals with epilepsy do not adequately respond to medications and are thus considered "medication resistant." [3] Sudden death is 20–40 times more common in people with epilepsy (and especially so in poorly controlled seizures) as compared to people without epilepsy. Sudden unexpected death in epilepsy (SUDEP) is one of the leading causes of death in young and otherwise healthy adults with epilepsy (see below for further details) [4,5]. SUDEP is much less frequently seen in children [6]. Epileptiform discharges are often activated by sleep and tend to occur 14 times more frequently in non-rapid eye movement (NREM) sleep than in wakefulness [7] and, therefore, sleep stage and sleep/wake state may influence the likelihood for a seizure to occur, with seizures occurring most frequently in NREM sleep, followed by wakefulness, and less likely during rapid eye movement (REM) sleep [8]. As such, the deleterious effects of seizures and SUDEP are more likely to occur when patients emerge from the sleep state [9].

A significant proportion of patients experience cardiac/or pulmonary dysfunction due to seizures (details follow). These changes may worsen the seizure prognosis/outcome and are believed to be related to, at least in part, the occurrence of SUDEP. This paper details these cardiopulmonary changes that take place in relation to epileptic seizures and how these changes may relate to the occurrence of SUDEP. Sleep physicians are often involved in the care of epilepsy patients on an increasing frequency and a recognition of these changes in relation to seizures may improve their awareness of these potentially life-threatening complications that occur during sleep studies.

2. Respiratory changes during seizures

The respiratory center [10] (Fig. 1) consists of four nuclei located in the medulla oblongata and pons of the brainstem. The inspiratory center (also known as the dorsal respiratory group) is located in the dorsal portion of the medulla oblongata and causes

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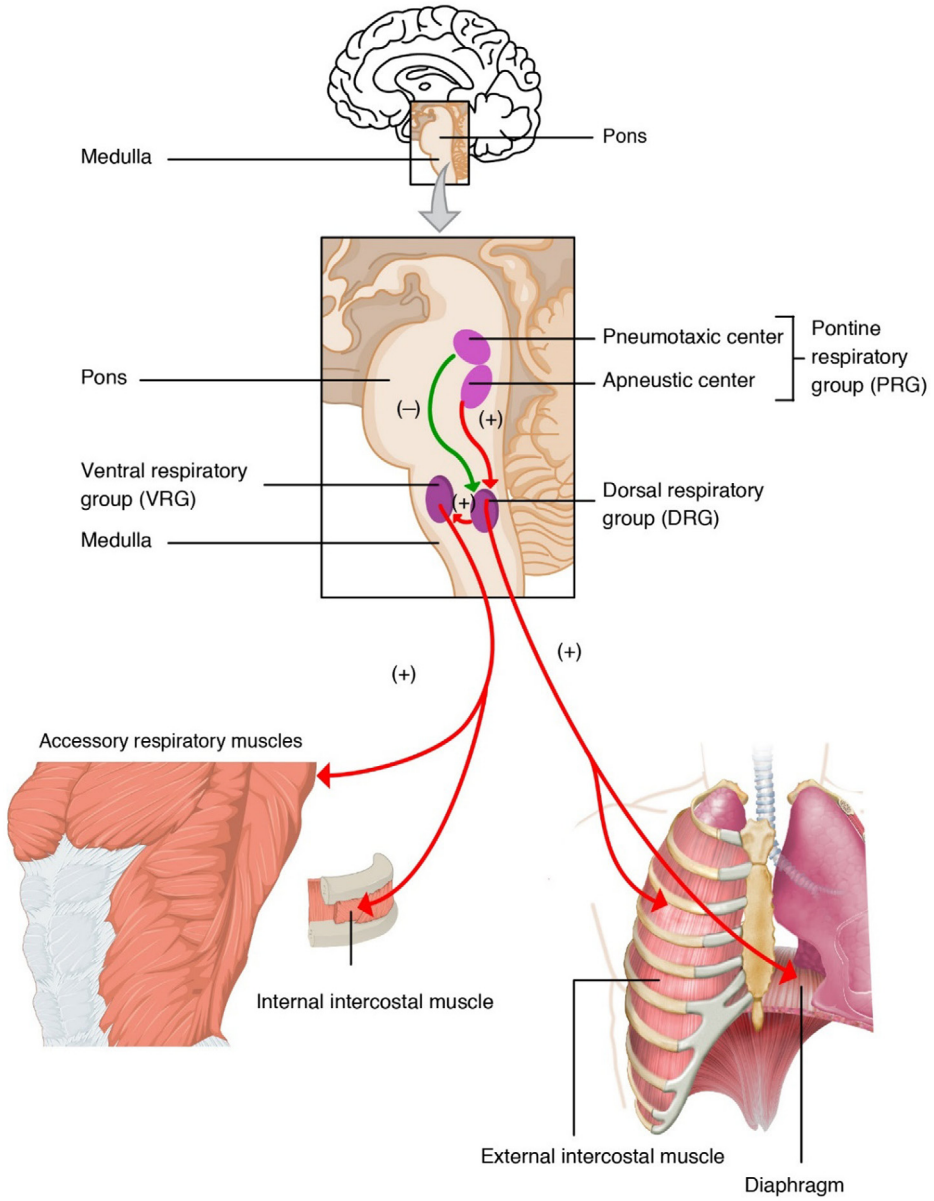

Fig. 1. Respiratory centers of the brain. Figure sourced from Wikimedia commons and republished under the Creative Commons Attribution 3.0 Unported license. (http://commons.wikimedia.org/wiki/File:2327_Respiratory_Centers_of_the_Brain.jpg).

inspiration when stimulated. The expiratory center (ventral respiratory group) is located in the anterolateral part of medulla oblongata, anterolateral to the inspiratory center. The pneumotaxic center is located in the upper part of pons and it controls the rate and pattern of breathing. This center is inhibited by impulses from the ventral respiratory group. The apneustic center is located in the lower part of pons. This center discharges stimulatory impulses to the dorsal respiratory group to stimulate inspiration, discharges inhibitory impulses to the ventral respiratory group to inhibit expiration, and receives inhibitory impulses from the pneumotaxic center and from the lung stretch receptors – thus in turn limiting inspiration. An abnormal input to these respiratory centers during seizure-associated neuronal activation leads to many of the respiratory changes observed with seizures.

Respiratory changes occurring in relation to seizures are seen with generalized as well as focal seizures, especially those arising from the mesial temporal structures. These changes have been repeatedly demonstrated in numerous studies and include central and obstructive apneas, hypoventilation, hypercapnia, and desaturation with acidosis, bradypnea, and tachypnea [11]. Most important of these changes is the respiratory depression causing central apnea. Figure 2 depicts tachypnea accompanying a tonic seizure followed by postictal central apnea, which could be a mechanism for SUDEP, especially if the patient was in prone position and the apnea was prolonged.

Much of the research evaluating the occurrence of respiratory changes in seizures has been done in adults. Bateman et al. (2008) prospectively analyzed the occurrence of ictal hypoxemia in localization-related epilepsy in 56 patients with 304 seizures [13]. They found that ictal hypoxemia was associated with seizure localization (temporal seizures), lateralization (right-sided seizures), male gender, longer seizure duration, and contralateral spread of seizures. Tezer et al. (2009) in a case–control study on two patients reported that apneas were associated in patients with right temporal and paracentral epilepsy [14]. Seyal et al. (2010) reported a severe and prolonged increase of ictal and postictal