Electrolyte Disturbance and the Mechanics of Swallowing: An Interdisciplinary Investigation

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Abstract

Background: Patients in the hospital often get electrolyte abnormalities, and it is known that electrolytes impact on neuromuscular systems for instance swallowing. This study looks into how electrolyte abnormalities can lead to dysphagia, its different severities, among hospital patients.

Methods: One hundred fifty (150) patients were hospitalized and dysphagia was clinically assessed hence these participants were included in right away. Key electrolytes escuding serum sodium, potassium, calcium and magnesium were performed and the results compared with dysphagia clinical studies which made use of the Clinical Swallowing Evaluation and video fluoroscopic Swallow Study (VFSS)

Results: The study established negative and significant correlations with calcium levels ($r = –0.62$; $P<0.001$) and magnesium levels ($r = –0.58$; $P<0.001$) with severity of dysphagia. Such as those of sodium and potassium but relatively lower strength. More severe cases of dysphagia were exhibited by patients with low levels of both calcium and magnesium and high levels of magnesium.

Conclusions: The findings show that calcium as well as magnesium disturbances strongly associate with dysphagia. There is an indication that control of sodium and phosphate electrolyte levels in patients with dysphagia may be fundamental. It has been established hence that electrolyte imbalances should be routinely checked and treated as part of the clinical approach in patients with swallowing difficulties in the general hospital

Keywords: Electrolyte imbalance, Dysphagia, Swallowing disorders, Hospitalized patients, Calcium, Magnesium.

Introduction

Electrolytes such as sodium, potassium, calcium, and magnesium salts are involved in critical processes in the cell, which are especially important in the processes of muscle contraction and nerve conduction. Changes in electrolyte levels can have profound clinical implications as they are distributed in most body actions including the neuromuscular system involved in swallowing (Renkema et al., 2008) which is the complex process of coordinating muscle and nerve actions. Impairment of this function leads to a condition called dysphagia, which has several serious health consequences, including aspiration pneumonia, malnutrition, and dehydration (Smithard et al., 2007).

Electrolyte Imbalances in Clinical Settings

Electrolyte imbalances represent a common clinical picture in most settings and do not see any boundaries in the stable or unstable disease population. There are several common clinical manifestations like

hyponatremia, hyperkalemia, hypocalcemia, and hypomagnesemia which are recurrently reported in patients with renal insufficiencies, cardio, and chemotherapy (Arampatzis et al., 2012). These electrolyte concentrations can be sustained for a short or prolonged time resulting in damage to the strength and the coordination of muscles which in turn can pose a threat or blunted the swallowing reflex (Sarwal et al., 2013).

Connection between Electrolytes and Mechanics of Swallowing

Swallowing is multi-muscular activity that is tightly controlled and performed in a proper order: it is coordinated with what we understand as electrolyte homeostasis. Muscle contraction and relaxation are influenced by calcium and magnesium since both are essential for action potential initiation and propagation (Groher&Crary, 2015). Suboptimal concentrations of these electrolytes are likely to impact the proper sequence of muscle contractions essential for swallowing to occur.

Gaps in Literature

The link between electrolyte levels and the general muscular weakness affecting more than one muscle group/muscle throughout the body is known, less focus has been placed to understand the role of these disturbances in the swallowing process. Most studies available now regard electrolyte disturbance as having generalized neuromuscular consequences whilst very few consider the biomechanical nuances of swallowing (Leder& Suiter, 2014).

Research Aims

This study proposes to address the identified gaps in the existing literature in the following manner:

1. Establishing how electrolyte disturbance leads to changes in the dynamics of swallowing.
2. Conducting a comparative analysis to determine the components and the degrees of swallowing dysfunction with different dysphagia types.
3. Creating practical measures for treatment of some aspects of dysphofia caused by electrolyte imbalances including nutrition improvement in severely ill patients.

The research will extend the current knowledge of how electrolyte management interacts with swallowing funciiton, thus optimizing practice and the lives of the patients.

Literature Review

Introduction to the Role of Electrolytes in the Body

Electrolytes which may include sodium, potassium, calcium and magnesium are important ions in the human body which also assist in the contraction of muscles as well as nerve function. These ions are integral in the creation and transmission of action potentials, which are necessary for muscular and neurological actions (Palmer & Clegg, 2015). Such operations are possible only in the presence of optimal concentration of these ions and is particularly important in the various muscles required to swallow in a complex manner.

Electrolyte Imbalances and Muscle Control

Electrolyte disturbances could compromise normal functioning of the neuromuscular system. For instance, a lack of potassium in the body or an excess of it, hyperkalemia, and hypokalemia respectively, could weaken

or paralyze muscles which are important contraction ans control (voluntary/involuntary) aspects of the swallowing mechanism (Mount &Zandi-Nejad, 2008). On the other hand, Swallowing may be negatively affected by isotonic involuntary muscle spasms known as tetany which could result from a lack of calcium in the system (Shane and Dinaz, 2006).

Modulation of Swallowing Mechanisms by Electrolytes

It has been established that electrolytes have a direct effect on the ionized calcium concentration of individual muscle spindles, and thus on the synergic activity of numerous muscles required for efficient swallowing. Of utmost importance in this regard is calcium ion concentration which enhances the binding of myosin and actin strategems, which, in turn, give the calcium contractile proteins their contractile properties. When the muscles are tense, magnesium helps relax them by acting as a natural blocker of calcium ions. Swallowing is likely to be efficient if the contraction and relaxation…the pharyngeal muscles are done in quick succession as 'constrictions 'and 'relaxations'. Nevertheless, disturbances in electrolyte concentrations will cause a disruption of this equilibrium (Groher&Crary, 2015).

Dysphagia related to Electrolyte Imbalances

There are some sporadic literature accounts regarding the correlation between dysphagia and dehydration but unfortunately a lot of this research has focused on disease prone populations, especially the elderly, who are prone to electrolyte abnormalities. There has been research evidence which suggests that any acute change in the levels of electrolytes can worsen already existing dysphagia signs or bring about new swallowing problems (Leder& Suiter, 2014). Nonetheless, there are little in the way of thorough investigations available that address the question of the changes in swallowing mechanics brought about by the imbalances and the issues of the one-off adjustments of these imbalances to potentially alleviate dysphagia.

Research Endeavors Yet to Be Explored

Despite the existing substantial body of research touching on the impacts resulting from electrolyte imbalances for both muscle and nerve functions, there is scant literature analyzing the effects these imbalances have on swallowing. Most of the current research misses an important detail in biology which emphasizes which electrolytes have the most effect on swallowing and the conditions necessary for this to happen. Moreover, there is hardly any research into treatment approaches that target dysphagia through the management of electrolyte abnormalities in severely ill patients (Smithard et al., 2007).

This review of literature explains, in detail, the critical interdependence between electrolyte homeostasis and the swallowing function while aiming for more research to be done in this region. This particular body of literature postulates and substantiates the idea that the impairment of electrolytes has a large functional effect on swallowing center yet appropriate studies should be done to come up with sound clinical solutions to the problem.

Methodology

Study Design

This research was an observational, cross-sectional study conducted at a tertiary hospital. This study focused on the link of electrolyte disturbances and the swallowing mechanics of patients in the hospital.

Participants

All patients with a diagnosis of any level of dysphagia identified clinically during the study period and age 18 years or older and were admitted in the course of the study were enrolled. Exclusion criteria included patients with such CNS comorbidities such as stroke or Parkinson's, patients on mechanical ventilators, and patients who were not able to consent voluntarily and had no guardian to consent on their behalf.

Electrolyte Assessment

The levels of sodium, potassium, calcium, and magnesium were evaluated in blood samples obtained at the time of admission and on a routine basis through the course of stay in the hospital. Blood samples collected from the patients in the above manner were analyzed in the hospital using lock of biochemical automated equipment.

Swallowing Assessment

The swallowing function was evaluated with the two major methods.

- Clinical Swallowing Evaluation (CSE): It was done by well-designed speech therapist and focused on qualitative assessment of swallowing ability and presence of signs of dysphagia.

- Video fluoroscopic Swallow Study (VFSS): This was done to ascertain objectively the mechanics of swallowing and the presence and extent of dysphagia.

Data Collection

Informed consent was secured from all participants or their authorized representatives prior to study enrollment and demographics information including the medical history, electrolyte panel results and swallowing assessment outcomes were entered and saved into a password secure electronic database. Function data relating to swallowing were arranged in groups according to different severity levels of dysphagia.

Statistical Analysis

To assess the relationship between electrolyte disturbance and swallowing mechanism or motor function, correlation coefficients (Pearson r) for continuous variables and Chi-square tests for categorical variables were used. A multilevel model was estimated to account for age, gender and comorbid variables simultaneously. The results were presented using frequency tables and performed on the SPSS software (Version 26.0, IBM Corp., Armonk, NY, USA). Results are considered significant at p-values below 0.05.

Ethical Considerations

The study was commenced after obtaining permission from the ethics committee. All proceedings in the study were in accordance to the ethical standards laid by the competent authorities in human experimental matters and based on the Declaration of Helsinki.

Findings

Participant Characteristics

The research involved 150 adults who were diagnosed with varying degrees of dysphagia (swallowing dysfunctions) and were hospitalized. Their mean age was 67 years, 55 % were males (n = 83) and 45 % were females (n = 67). Common associated diseases were, gastrointestinal disorders, renal failure and cardiovascular disorders. Demographics of the participants are contained in Table 1.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Total (N=150)
Age, mean ±SD (years)	67 ±12
Gender (male),%	55%
Underlying Conditions, %	
- Gastrointestinal Disorders	30%
- Renal Failure	25%
- Cardiovascular Diseases	45%

Electrolyte Levels and Swallowing Assessment Outcomes

Patients with severe dysphagia were mostly noted to have electrolyte imbalances, with hypocalcemia and hypomagnesemia being the most common. Table 2 outlines the average electrolyte values of the patients for the first days in the unit.

Table 2: Admission Electrolyte Levels in Relation to Dysphagia Scores

Electrolyte	Mean Level	Standard Deviation	Reference Range
Sodium (mmol/L)	138	3.5	135-145

Potassium (mmol/L)	4.2	0.7	3.5-5.0
Calcium (mg/dL)	8.5	1.1	8.6-10.2
Magnesium (mg/dL)	1.7	0.4	1.7-2.2

Range of Strong Negative Correlation Between Electrolyte Levels and VFSS Scores

Important negative associations between calcium and magnesium levels and the severity of the swallowing disorder as determined by the VFSS measurement were developed statistically and they are illustrated in Table 3.

Table 3: Correlation between Electrolyte Deficiencies and Greatest Degree of Dysphagia Measured on the VFSS

Electrolyte	Correlation Coefficient	P-value
Calcium	-0.62	<0.001
Magnesium	-0.58	<0.001
Sodium	-0.23	0.018
Potassium	-0.15	0.088

Note: The more negative the value given for the correlation coefficient the worse the clinical picture appears with respect to dysphagia and associated electrolyte level.

Discussion

This research attempted to assess the link between electrolyte disturbance, the mechanics of swallowing, and the relationship between these two parameters, based on some of the other studies in which the relationship between electrolyte imbalance and dysphagia has been documented. The conclusion reached stated that electrolyte imbalance especially calcium and magnesium was found to be more frequent among cancer patients with more severe forms of dysphagia.

Interpretation of Findings

Calcium and Magnesium Deprivation in Mechanisms of Swallowing: The negative correlation stating an inverse relationship between calcium or magnesium concentration surplus and the severity of neck related complications suggests that these two elements are extremely crucial for muscle contraction and energy generation. Neurotransmitters that enable muscular expansion are imperative in the contraction process. Magnesium is responsible for reducing over exertion however muscle contractions vital for the process of swallowing start with calcium (Groher&Crary, 2015). A deficit of these electrolytes might result in a reduced swallowing reflex response and an increase in the chances of aspiration and other signs related to dysphagia.

Potential Mechanisms: The swallow disorder can be associated with the observable electrolytic disturbances for several reasons. A Hypocalcemic state and hypomagnesemic state can elevate the action potential threshold of muscle cells that coordinate all essential contractions required to aid the process of swallowing (Shane and Dinaz, 2006). Further these disturbances may aggravate or increase the intensity of most baseline conditions such as muscle weakening that already deteriorate patients 'ability to successfully complete the process of swallowing.

Clinical Significance: The findings illustrate not only the strong relationship between electrolyte imbalances and dysphagia but reinforce the conclusion that dysphagia can be better managed in the palliative care population by incorporating electrolyte replacement as part of the routine plan of care. Preventive electrolyte management of the critically ill population may help reduce the prevalence and consequences associated with dysphagia, hence benefiting patients and cutting down costs for the healthcare system.

Strengths and Weaknesses

Strengths: This study aims to cover an understudied clinical need which is noteworthy. Clinical assessments and objective techniques (VFSS) in diagnosing dysphagia offer a holistic view of the objective effects of electrolyte imbalance on patients with dysphagia.

Weaknesses: Nonetheless, there are several weaknesses of the study that need to be highlighted and addressed. Both objects of analysis were examined simultaneously, making it impossible to determine the causal link between the two strategies. A longitudinal study design would more appropriately address the timing and cause-and-effect relationships. Furthermore, the remoteness is limited to a single tertiary care hospital, such patients reported may not represent the general population.

Future Directions

Future directions could focus on longitudinal approaches that follow patients over time and monitor their electrolyte balance and ability to swallow. It would also make sense to conduct the study at more than one center in order to be able to generalize the findings better. Looking at treatment trials that alter electrolyte concentrations to see if it may help in modulating the severity of dysphagia will provide a concrete basis for management plans.

Conclusion

The clinical factors identified in this study are associated with dysphagia in this patient population. The data provided by this study are useful in managing the disorder although it is recommended that denser studies are conducted. Being able to manage electrolyte levels is critical in order to improve swallowing function and also improve the overall management of these patients.

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