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Microelement malnutrition – a progressive complication post-bariatric surgery

Abstract

Over the last decades obesity has become a worldwide issue battled by people of different ethnicities and lifestyles. One of the most effective ways in dealing with this condition and its complications is bariatric surgery. The results accomplished by introducing these procedures into the treatment are widely discussed. However, one of the most dangerous complications is often overlooked. The aim of this review is to draw attention to the relevant problem that is microelements malnutrition in patients who have undergone different types of bariatric surgeries (BS).

Keywords: microelement malnutrition, bariatric surgery malnutrition, nutritional deficiency.

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INTRODUCTION

Nowadays obesity is one of the most common diseases in the world and can be considered as a progressing epidemic affecting physical and mental health as well as the global economy. It is caused by drastic changes in lifestyle such as diet containing trans and saturated fatty acids, sedentary habits but also genetic, environmental and even microbial factors. While conservative treatment ought to be considered at the beginning of dealing with obesity, it is not always sufficient. BS is very commonly chosen to battle it as is the most effective treatment with reducing mortality by 30% and cardiovascular risk by 42% [1]. It is estimated that 256000 patients underwent this procedure in 2019 in the USA [2]. The main focus of the patients and doctors is the end result, while the overall nutritional status post-operative is often overlooked and underestimated. However, like any other surgical treatment, it could potentially cause complications which, if overlooked, may lead to further health issues.

Review Methods

An electronic research was conducted of the relevant articles through the PubMed database. The phrases "bariatric surgery", "bariatric surgery complications", "bariatric surgery malnutrition", "copper deficiency bariatric surgery", "iron deficiency bariatric surgery", "zinc deficiency bariatric surgery", "calcium deficiency bariatric surgery", "chromium deficiency bariatric surgery", "selenium deficiency bariatric surgery", "magnesium deficiency bariatric surgery", "iodine deficiency bariatric surgery" were used in the process.

Obesity

Obesity can be defined as an excessive accumulation or atypical placement of fatty tissue. Multiple studies have proven it to be the cause of countless diseases such as hypertension, osteoarthritis, type 2 diabetes, sleep apnea, dyslipidemia and many more [3]. It is mostly caused by increased energy intake relative to its demand. The WHO defines obesity as the body mass index (BMI) of at least 30 kg/m2. It is calculated by dividing the patient's weight by their height squared. In the last 30 years number of adults who struggle with obesity and its consequences has risen by 27.5% and concerns around 2.1 billion adults as of 2013 [4]. While elevated body mass is problematic in itself and may lead to future ailments, the main issue lies in the production of compounds which include but are not limited to CRP, leptin, adiponectin, IL-6, TNF- α, resistin and angiotensinogen. There are three types of fat in human body: white, beige and brown [5]. Each of them plays a different role in body's metabolism and tends to be located in different areas.

Bariatric surgery

It has been documented that BS plays an important role in reversing the complications of obesity but also introduces risks for new complications. It may cause multiple issues such as fistulas, bleeding, stenosis, intestinal small bowel obstructions, gastric erosion, herniation and nutritional deficiencies [6]. The main idea of this treatment is to decrease the calorie intake in the future by reducing the volume of meals such as laparoscopic sleeve gastrectomy (LSG) and adjustable gastric banding (AGB) modulating the uptake of nutrients by removing a portion of small bowel or procedures combining the two aspects that include Roux-en-Y gastric bypass (RYGB) or biliopancreatic diversion

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with duodenal switch (BPD/DS) [7]. While main choices are SG and RYGB, all of the previously mentioned types of surgeries modify the anatomy and/or physiology of the digestive tract and therefore interfere with the absorption process. The deficiency can apply to both macro- and micronutrients.

Iron

Iron is a vital component of heme and plays a key role in oxygen transportation. Its lowered levels are commonly connected to obesity due to constant inflammation. In this state elevated levels of hepcidin produced by the liver and adipose tissue among others inhibit this mineral's absorption. By blocking ferroportin, iron becomes trapped within the cells, preventing its release into the bloodstream [8]. It may seem that reducing body fat alleviate iron deficiency but the patients undergoing malabsorptive surgeries disrupt iron absorption. It is exacerbated by blood loss and increased gastric acid secretion due to its reduced surface [9]. The main indicators of iron deficiency are skin pallor, impaired concentration, headache, dizziness, tachycardia, low tolerance of physical activity, hair loss, koilonychia.

Zinc

Zinc serves as a necessary cofactor for numerous metabolic reactions. Moreover, it participates in protein synthesis and manages gene expression [10]. Symptoms presented by patients with decreased zinc intake may vary depending on how severe the lack of this element is. Lack of appetite, impaired healing, dry skin, lethargy, hypogonadism in adolescent men, immunodeficiency and slowed growth may occur [11]. This element's deficiency is linked to taste changes which affected from 73% to 82% of patients who had undergone either RYGB or laparoscopic RYGB and around 46% of patients post-laparoscopic AGB. While a definitive connection has not been made, the two conditions seem to coexist fairly commonly and occur around the same time, suggesting there may be a relationship [12]. There has also been a case of a direct link of early zinc deficiency post-malabsorptive BS to the patient developing optic nerve neuropathy and dermatitis despite introducing the proper supplementation and conducting required follow ups [13]. However, it not only affects the initial year after the surgery but also the years that follow if proper nutrition and supplementation are neglected [14].

Copper

Cooper is a crucial cofactor in enzymes such as: cytochrome c-oxidase, superoxide dismutase and lysyl oxidase which take part in in various chemical reactions required for proper metabolism trajectory [15]. Copper deficiency is very often connected with BS. Monitoring copper levels is not a common occurrence hence it is impossible to estimate the number of cases affected by the lack of this mineral but it is mainly associated with RYGB and BPD [16]. Copper deficiency symptoms include aenemia, fatigue and weakness, skin and hair hypopigmentation, frequent infections, hyperthyroidism, changes in taste and smell and a variation of neurological symptoms. There have been instances of copper deficiency that leads to pancytopenia and neurological complications that subsided with daily supplementation indicating a strong connection [17].

Calcium

Calcium is an omnipresent element in human body. It is the key component of bones and teeth as hydroxyapatite, facilitates blood clotting, is essential for muscle function, regulates various cellular activities, maintains general cell functions and participates in signal transmission between neurons. Calcium homeostasis is regulated by parathyroid hormone (PH), vitamin D and calcitonin. PH is secreted from parathyroid glands after the calcium levels in bloodstream decrease. As a result, the bone metabolism process accelerates and this mineral is released. Vitamin D operates in multiple locations. In the intestines it accelerates calcium absorption from food, in kidneys it stimulates its reabsorption from the urine and finally, it effects bones similarly to PH. To antagonise these processes when calcium levels are elevated, calcitonin is released from the thyroid parafollicular or C-cells. It regulates bone resorption by inhibiting osteoclast function in bones. Apart from that, it promotes calcium excretion in kidneys and disposes of it through urine [18]. Hypocalcemia is mainly observed after malabsorptive rather than restrictive procedures [19]. It may lead to tetany, brittle nails, osteoporosis, weak tooth enamel, increased risk of cavities, and tooth decay, cardiovascular complications, thrombo-embolic disorders.

Chromium

Chromium is an essential mineral that supports various metabolic processes in the body, particularly those related to glucose and lipid metabolism. Its impact on protein metabolism has not been definitely proven. Chromium deficiency is a very rare occurrence and often does not cause clinically relevant symptoms [20].

Magnesium

Magnesium is a cofactor in over 300 reactions in human metabolism and overall cell function. It has been proven to participate in maintaining normal blood pressure and glucose levels, the transmission of signals between nerves and muscles or synthesizing polypeptides and nucleic acids [21]. Even though patients post BS are often lacking in both macro- and micronutrients, various studies prove that magnesium deficiency is not a common occurrence after RYGB [22]. Hypomagnesemia may appear as hypertension, fatigue, nausea, vomiting, loss of appetite, abnormal heart rhythms, numbness, tingling, and seizures. It is also linked to depression. Although studies in general have been inconclusive, some prove strong connection between the two [23].

Iodine

Iodine is an essential element for thyroid hormones synthesis. Thyroxine (T4) and triiodothyronine (T3) are produced and released from the thyroid follicular cells [24]. Iodine is essential for regulating overall metabolism and is crucial for neurodevelopment in fetuses and children, as well as for the proper functioning of organs and tissues. In a healthy adult, the body typically contains 15-20 mg of iodine, with 70-80% of it stored in the thyroid gland. For a developing fetus, iodine deficiency is a leading cause of preventable intellectual disability, making the iodine status of pregnant women and women of reproductive age a significant international public health concern. Iodine deficiency is among the most prevalent nutrient deficiencies, estimated to affect 35-45% of the global population. It is the leading cause of goiter, impacting approximately

2.2 billion people worldwide. However, it is important to note that not all cases of goiter are due to iodine deficiency [25]. Significant dietary sources of iodine include iodized salt, dairy products, eggs, seafood, fish, and seaweed. Iodine is primarily absorbed in the proximal small intestine through the sodium-iodine symporter. About 90% of ingested iodine is eventually excreted in the urine. The most commonly used indicator for assessing iodine status is urinary iodine concentration (UIC). While UIC is not a reliable biomarker for an individual's iodine status due to considerable day-to-day variation, the median UIC in spot samples can be effectively used to evaluate the iodine status of a population.

In a prospective observational cohort study, participants aged 18 and older from an iodine-sufficient region, scheduled for elective bariatric surgery (laparoscopic sleeve gastrectomy or laparoscopic Roux-en-Y gastric bypass), were enrolled. They assessed changes in UICs in patients with obesity before and after bariatric surgery. UICs increased three months post-surgery compared to baseline. The conclusion was that in iodine-sufficient areas, bariatric surgery does not lead to iodine deficiency or significant changes in thyroid function. Different surgical procedures, despite varying anatomical alterations in the gastrointestinal tract, do not significantly impact iodine absorption [26].

Selenium

Selenium is required to regulate and control the activity of the thyroid gland which stores most of this element's reserve in human body [27]. Selenium deficiency concerns around 2% obese patients with this number increasing to 11-15% post BS [28]. As an element crucial to proper conversion of T4 into T3 its deficiency is mainly presented as symptoms of hypothyroidism such as fatigue, dry and flaky skin, constipation, cold intolerance, unintentional weight gain or myxedema coma. It is a very rare condition but should not be underestimated as it may be lethal to the patient. It is triggered by an infection in patients with hypothyroidism. Its symptoms are overall swelling, dropping of the upper lid, enlarged tongue, goiter [29].

CONCLUSIONS

Bariatric surgery is often chosen as the main strategy for battling obesity due to its durable satisfactory results. However, it may be followed by plethora of complications. The ones manifesting in the perioperative period are thoroughly treated while the long-term ones may go undetected until severe symptoms are experienced by the patient which is why the follow-ups are so necessary. BS's alteration of the digestive tract is permanent and the effect of it may occur at any point in time, especially malnutrition but with proper supplement intake, dietary modifications and medical care can be prevented or treaded in time.

ABBREVIATIONS:

BS – bariatric surgery; BMI – body mass index; LSG - laparoscopic sleeve gastrectomy; AGB – adjustable gastric banding; RYGB – Roux-en-Y gastric bypass; BPD/DS – biliopancreatic diversion with duodenal switch; UIC–urinary iodine concentration

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