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Modern Approaches to Diet Therapy of Patients before and After Bariatric Surgery

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I. INTRODUCTION

Currently, bariatric surgery is developing significantly as one of the most effective methods for reducing body weight. Recent studies show that metabolic surgery leads to a significant improvement in the quality of life of obese people and a decrease in their risk of death. Despite the positive effects of surgical intervention, many operated patients have new problems associated with the rapid loss of large weight. Examples include nutritional deficiencies, changes in drug pharmacokinetics, repeated weight gain, and psychological difficulties associated with changes in body constitution and dietary restriction. Therefore, a properly selected diet plays an important role both in the preoperative preparation of patients and in the postoperative recovery of the body, preventing the occurrence of such pathological processes as dumping syndrome and reactive hypoglycemia.

Preoperative nutritional preparation. Despite low mortality, surgical complications (anastomotic leaks, bleeding, and infections) after bariatric interventions remain frequent (5–20%) and depend in part on factors such as age, sex, and comorbidities of the patient [3]. Therefore, careful preparation of patients for surgery is necessary, which involves the regulation of the diet in order to improve the preoperative metabolic background of the body.

Over the past decades, numerous studies have been conducted that have shown that patients with severe obesity were deficient in many micronutrients compared with patients with normal body weight. Researchers analyzed the vitamin status of 110 patients with severe obesity, in whom extremely low concentrations of vitamins A, B6, C, 25-hydroxyvitamin D, and lipid-standardized vitamin E were determined [4]. Other authors examined blood sera from 200 severely obese patients and found that 38% had low iron, 24% had low folic acid, 11% had low vitamin B12, and 81% had hypovitaminosis D (with 55 %, there was a pronounced deficiency < 30 nmol/l) [1, 5]. The diet of overweight patients is most often of poor quality, diverse and high in calories, which leads to a violation of the nutritional status of the body. For example, excessive consumption of simple sugar, dairy products or fats can lead to vitamin B1 deficiency [6, 7]. In addition, it is known that inflammation of adipose tissue and increased expression of hepcidin, a systemic protein that regulates iron, can affect iron status [8].

Low-calorie and very-low-calorie diets. The need for a preoperative weight loss of 5-10% is explained by the possible difficulties that the surgeon faces during the operation, since the presence of visceral fat can increase the complexity and risk in patients with any type of abdominal surgery. Thus, laparoscopic surgery in patients with severe obesity is difficult due to the thickness of the abdominal wall, possible thickening of the mesentery and hepatomegaly. Non-alcoholic fatty liver disease (NAFLD) is a condition often complicating obesity that can lead to increased fatty liver, mainly in the left lobe, making the liver more susceptible to injury and bleeding. During laparoscopic bariatric surgery, hepatomegaly and visceral fat in the left hypochondrium may limit pre-exposure of the operative field, increasing the conversion rate and operative time [9].

Preoperative weight loss can be achieved with several options, such as a low calorie diet (LCD) (800–1200 kcal/day), a very low calorie diet (VLCD) (600 kcal/day), or a low calorie diet combined with intragastric balloon placement (IVB).). To date, there is no consensus on which method provides the best results in terms of weight loss, patient compliance, tolerability and acceptability. A comparable case-control study reported that intragastric balloon placement prior to gastric banding surgery significantly reduced the rate of conversions and intraoperative complications [22]. Likewise, pre-operative IVD can provide significant weight loss before bariatric surgery, being faster, cheaper, and with fewer side effects compared to IVF [18]. Theoretically, preoperative weight loss with ONCD reduces liver size and intra-abdominal fat mass, which in turn reduces blood loss, short-term complications, as well as operative time and length of hospital stay [13]. A systematic review confirmed that ONCD leads to significant weight loss (from -2.8 to -14.8 kg) and a decrease in liver size (5–20% of the initial volume), but did not find a reduction in perioperative complications [3, 10]. However, a recent study differentiating ONCD from pre-surgery NCD showed that despite the high efficiency of NCD in reducing preoperative total body weight (5.8% to 4.2%), there was no significant difference in liver volume loss. , changes in biochemical parameters, the frequency of surgical complications and length of stay in the hospital [15].

More recently, the very low calorie ketogenic diet (VKD) has been proposed as a new effective and safe method for achieving effective preoperative weight loss. Although ONCD leads to faster weight loss, it should be taken into account that any very low calorie regimen leads to a catabolic state and increased oxidative stress, which can adversely affect surgical outcomes. In addition, a ketogenic diet based only on a protein substrate can induce an adaptive response in a number of organs with potentially unsafe physiological changes in the perioperative period.

Volkova A.R. et al., in an uncontrolled study, assessed the compliance, safety, and efficacy of a consistent dietary regimen in patients before a planned bariatric surgery (ONKD for 10 days, then NKD for 10 days, and then NKD for 10 days). The study showed an adequate short-term reduction in body weight and waist circumference without dangerous changes in renal, hepatic and metabolic functions. Weight loss was similar to that obtained with NCD and better than with NCD [17]. A similar 30-day sequential regimen was used in another uncontrolled study that found significant reductions in weight, waist circumference, and visceral fat, as well as improvements in a number of clinical parameters, including glycemic and lipid profiles before bariatric surgery. In addition, a hallmark of this sequential regimen was a decrease in liver volume by an average of 30% [19]. Finally, in the third non-randomized study, patients received either ONCD or ONCD within 3 weeks prior to metabolic surgery. ONKD did not have significant advantages over ONKD in terms of weight loss, but had better results in surgical outcomes, having a positive effect on postoperative hemoglobin levels and length of stay in the hospital. However, in this study, no data were obtained on a decrease in the volume of the liver and visceral fat [19, 22].

In conclusion, there is general agreement on the beneficial effects of moderate weight loss in the immediate preoperative period on surgical and anesthetic outcomes. The effectiveness of the use of ONKD and an intragastric balloon as an interim therapy before HD is consolidated in the literature, while ONKD is becoming increasingly important in the preoperative period. Large randomized trials addressing these issues are needed, in particular, aimed at accurately studying the effect of these diets on changes in liver and visceral fat volumes.

Nutritional regulation after bariatric intervention. Most bariatric surgeries are characterized by the reduction of the stomach cavity and/or the creation of a small gastric sac. According to postoperative dietary protocols, a liquid diet with a low amount of sugar is recommended for the first 24 hours after surgery, since during this period, in addition to a small volume of the stomach, postoperative intragastric edema also persists. In the following days, it is advisable for patients to prescribe a liquid or the most gentle food, which implies a gradual smooth transition from liquid food to a thicker one [3]. This process takes an average of 2 to 4 weeks and involves a gradual transition from liquid food to a thick creamy consistency, and then the inclusion of solid chewable components in the diet. This recommendation will prevent the manifestation of postoperative vomiting and reduce the risk of possible regurgitation of food eaten. Also, before discharge, patients should receive proper advice from a qualified nutritionist about the subsequent dietary regimen [4].

At the end of an early postoperative diet, patients should be consulted periodically about their diet in order to obtain long-term positive results in order to maximize the effectiveness of the bariatric procedure and reduce the risk of subsequent weight gain. The focus of dietary counseling should be the adaptation of eating behavior and the acquisition by patients of healthy, high nutrient diets [24].

Intake of protein and protein supplements. In the first months after the operation, the weight of patients rapidly decreases, mainly due to the loss of muscle mass [10]. Adequate protein intake serves as a protective mechanism against muscle loss during rapid weight loss, however, often the intake of protein foods is significantly reduced after HD, mainly due to intolerance to protein-rich foods in the stomach. Current guidelines recommend a minimum target protein intake after HD of 60 g/day and up to 1.5 g/kg of ideal body weight per day [3], but in some cases (infectious process, pregnancy) a relatively high amount of protein (up to 2, 1 g/kg ideal body weight per day). Given the difficulty of achieving this goal with natural products alone, it has been proposed to use liquid protein supplements (30 g/day) as a means of promoting adequate protein intake in the first months after HD [2].

However, a small randomized trial has questioned the effectiveness of protein supplements in curbing muscle mass [14]. In the course of the trial, Oppert et al. divided 76 patients into 3 groups: group 1 - patients with a standard diet after HD, group 2 - with a standard diet and whey protein supplementation (48 g/day) and group 3 - with a standard diet , taking protein supplements, and doing supervised strength training (1 hour, 3 times a week). Loss of lean body mass did not differ between groups, while an increase in muscle strength was observed only in the group receiving protein in combination with exercise [11]. The results of this small study highlight the importance of incorporating strength training into post-HD physical activity [12].

Iron: Iron deficiency with or without anemia is common after gastric bypass, biliopancreatic bypass, and duodenal switching [20], but also occurs after sleeve gastrectomy and less frequently after adjustable gastric banding [24]. Several factors play a role in the occurrence of iron deficiency after bariatric surgery.

First, iron absorption occurs mainly in the duodenum and proximal jejunum, i.e. sections of the intestine that affect certain types of operations. Secondly, decreased gastric acid production and accelerated gastric emptying interfere with the reduction of iron from the ferric (Fe 3+) to the absorbable ferrous state (Fe 2+). Third, the intake of iron-rich foods (meats, fortified cereals and vegetables) is often insufficient after surgery. Based on this, iron is included in oral multivitamin and mineral preparations recommended after HD, especially with the addition of vitamin C, which promotes increased absorption of iron in the body [2, 15].

Vitamin B12: Cobalamin deficiency occurs after certain surgical procedures (gastric bypass and sleeve gastrectomy) that cause decreased gastric acid production and reduced availability of intrinsic factor. Cobalamin stores are usually high, so vitamin B12 deficiency is rare in the first year after surgery, but tends to decrease over time [6].

Despite the lack of evidence-based recommendations, vitamin B12 supplementation is generally recommended after gastric bypass, sleeve gastrectomy, biliopancreatic bypass, and duodenal switching [15]. Absorption of vitamin B12 mainly requires the presence of intrinsic factor, but approximately 1% of oral vitamin B12 is passively absorbed even without it. Thus, an oral dose of this vitamin of 350-500 mcg/day is considered sufficient to ensure the absorption of the daily requirement for vitamin B12 [11]. Alternatively, the following regimens are suggested: 1 mg/month intramuscularly, 3 mg every 6 months intramuscularly, or 500 micrograms intranasally every week [4].

Folic acid: Folic acid deficiency is rare after bariatric surgery because folic acid absorption occurs throughout the small intestine [8].

Calcium and Vitamin D. Calcium absorption occurs predominantly in the duodenum and proximal jejunum, aided by vitamin D in an acidic environment. Therefore, calcium absorption will decrease after any bariatric procedure. Regarding vitamin D, it is a fat-soluble vitamin, absorbed mainly in the jejunum and ileum. No significant decrease in vitamin D levels has been observed after sleeve gastrectomy or adjustable gastric banding [7]. The most important consequence of a combined calcium and vitamin D deficiency is bone demineralization. Thus, even in the absence of conclusive data on the long-term risk of fractures after bariatric surgery, routine calcium and vitamin D supplementation after gastric bypass and malabsorption procedures is strongly recommended [16].

Obese patients often have vitamin D deficiency at baseline; this deficiency should be corrected before surgery with oral vitamin D. Also, after surgery, a regular intake of 1200–2000 mg/day of calcium is recommended along with 400–800 IU of vitamin D [21]. This standard supplement is often insufficient to maintain adequate vitamin D levels in patients with malabsorption, and much higher oral or parenteral doses may be required. Thus, the adequacy of calcium and vitamin D supplementation should be checked in all patients with regular monitoring of markers of bone mineral metabolism. Supplementation may be considered adequate when serum calcium, bone-specific alkaline phosphatase or osteocalcin, vitamin D, and parathyroid hormone (PTH) levels are normal [7].

Persistently elevated serum parathyroid hormone levels with normal vitamin D levels and inappropriately high serum calcium levels should raise the suspicion of primary hyperparathyroidism. In post-bariatric patients with established osteoporosis, pharmacological treatment with bisphosphonates may be considered. Before treatment with bisphosphonates, vitamin D deficiency must be completely corrected to avoid severe hypocalcemia, hypophosphatemia, and osteomalacia.

Thiamine: The human body has a low ability to store the water-soluble vitamin thiamine (B1) and, without regular and adequate intake, can quickly deplete its stores. Often, a short period of incessant vomiting that disrupts regular food intake in post-bariatric patients can provoke thiamine deficiency [5, 15]. Symptomatic thiamine deficiency has been described after several weeks of uncontrollable vomiting after any bariatric procedure, usually as a result of mechanical complications such as stoma stenosis after gastric bypass, excessive tension or slippage of the band after gastric banding, and gastric edema after sleeve gastrectomy [13]. Typical manifestations of thiamine deficiency are peripheral neuropathy or Wernicke's encephalopathy and Korsakov's psychoses [4]. These neurological symptoms worsen rapidly and may lead to permanent neurological deficits. Thus, oral or parenteral thiamine (50–100 mg/day) should be included in every post-bariatric patient with persistent vomiting, even in the absence of supporting laboratory data [20].

Specific nutritional complications after HD

II. VOMITING AND REGURGITATION

Food intolerances and behavioral errors can cause episodes of vomiting or regurgitation during meals, which patients often describe as "regurgitation" or "food jamming" [14]. Such symptoms usually resolve on their own, sometimes may occur in the first months after surgery and are considered a normal variant in patients still adapting to the new gastric anatomy [6]. However, in the case of persistent (> 6 months) and/or frequent vomiting, surgical diagnosis should be considered. Persistent vomiting, severely disrupting normal food intake and greatly reducing energy intake, may precipitate the onset of an acute thiamine deficiency condition, which must be promptly prevented.

Diarrhea and steatorrhea. After malabsorptive bariatric surgery, stool disorders are often observed. Patients undergoing biliopancreatic shunting or duodenal switching frequently reported intestinal symptoms that may impair quality of life or interfere with social functioning (increased bowel movements with loose stools or diarrhea, fecal urgency, abdominal distention, and odorous flatulence) [13]. These symptoms are associated with malabsorption of fats and carbohydrates, as well as bacterial overgrowth.

Hypoglycemia and dumping syndrome. One of the underestimated complications after HD is postprandial reactive hypoglycemia. According to the Whipple triad, the diagnosis of hypoglycemia after HD implies the presence of neuroglycopenic symptoms (hot flashes, weakness, loss of consciousness), a blood glucose concentration of less than 3.0 mmol/L (54 mg/dL) and relief of symptoms with carbohydrate intake [7, 12]. The true prevalence of hypoglycemia associated with HD is unknown, partly due to a lack of consensus on the definition and diagnosis of this condition [8]. A one-year randomized trial comparing the effects of sleeve gastrectomy (SG) with gastric bypass gastric bypass (GAG) showed that the incidence of hypoglycemic episodes, as determined by continuous glucose monitoring, differed between the two procedures (29% versus 14%) [6]. GARR was associated with more severe episodes of hypoglycemia, and patients had an overall greater number of reactive hypoglycemic episodes than patients with WG. This fact was explained by the inadequately high postprandial hyperinsulinemia observed after GARR, regardless of the glucose level [12]. There was a study that demonstrated that levels of glucagon-like peptide-1 (GLP-1) were increased 10-fold after meals in patients undergoing OAR. Patients with GARD are often unaware of low glycemia due to progressive adaptation to hypoglycemia. In addition, FARR has been described to reduce symptomatic and hormonal responses to hypoglycemia [25].

Dumping syndrome refers to the postprandial onset of a constellation of symptoms caused by the rapid movement of high-calorie foods from the stomach into the small intestine. The syndrome was classically defined by a sharp increase in the osmolarity of the intestinal contents with the entry of fluid into the intestinal lumen, intestinal distention, fluid sequestration, a decrease in intravascular volume and hypotension [11]. However, the altered secretion of the gastrointestinal hormone GLP-1 described after bariatric surgery probably also plays a role in the pathogenesis of this syndrome. It is believed that dumping syndrome is typical for gastric bypass surgery (70–75% of patients in the first year after surgery), but its manifestation after sleeve gastrectomy has also been described (in 40% of patients 6 months after surgery).

Symptoms are often nonspecific, but the correct diagnosis is facilitated by the use of the Sigstad diagnostic scale, based on the weighting coefficients assigned to the symptoms of the syndrome: an index above 7 points indicates dumping (Table 1) [14].

Table 1.
Symptoms of dumping according to the Zigstad scale

Shock	5
Fainting, syncope, loss of consciousness	4
Desire to lie down or sit down	4
Feeling short of breath, shortness of breath	3
Weakness, fatigue	3
Drowsiness, apathy, falling asleep	3
heartbeat	3
Anxiety	2
Dizziness	2
Headache	1
Feeling of heat, sweating, pallor, stickiness of the skin	1
Nausea	1
Feeling of heaviness in the abdomen, flatulence	1
Borborygmus	1
Belching	1
Vomit	4

According to the time of occurrence after eating, dumping symptoms are classified into early and late. Early dumping is the most common, accounting for 40% after OAR and RG, while late dumping occurs in only 25% of patients [5, 9]. Early symptoms are predominantly vasomotor (palpitations, flushing, and fainting) and gastrointestinal (abdominal pain, diarrhoea, bloating, and nausea) occurring within 15 minutes of eating, while late symptoms (tremor, sweating, aggression, fatigue, weakness) , confusion, hunger and fainting) occur 1-3 hours after eating, when glycemia reaches a minimum level.

Food intolerances and changes in food preferences. The inability of the patient to cope with changes in eating behavior due to gastric restriction (rapid eating, insufficient chewing or drinking during meals) often leads to food intolerance. Food intolerances tend to decrease over time, but intolerances to certain foods may persist even in the long term. Studies have reported marked reductions in hunger and greater postprandial satiety after HD, resulting in smaller meal sizes without a compensating increase in meal frequency [6, 14].

However, it should be noted that over time, routine supplementation does not provide absolute protection against deficiencies due to individual differences in micronutrient absorption, nutritional requirements, and regularity of regimen. Hence, periodic laboratory routine monitoring for nutrient deficiencies is recommended. Nutritional supplementation should be individualized according to micronutrient deficiencies [6]. A reasonable scheme for minimal periodic monitoring of nutrition after bariatric procedures is presented in Table 2.

Table 2.
Minimum Recommended Surveillance for Nutritional Deficiencies After Bariatric Surgery

	RBJ	WG	OAR	BPSh(DP)
Visits	every 6 months in the first year, thereafter once a year	every 3-6 months in the first year, thereafter once a year	every 3-6 months in the first year, thereafter once a year	every 3 months in the first year, thereafter 1-2 times a year
Research	KLA, platelets, electrolytes, iron, ferritin, vitamin B12, folate, Vitamin D, PTH	KLA, platelets, electrolytes, iron, ferritin, vitamin B12, folate, Vitamin D, PTH	KLA, platelets, electrolytes, iron, ferritin, vitamin B12, folate, Vitamin D, PTH, Calcium in daily urine osteocalcin	KLA, platelets, electrolytes, iron, ferritin, vitamin B12, folate, Vitamin D, PTH, Calcium in daily urine osteocalcin, Vitamin A, Vitamin E Albumen

RBJ: adjustable gastric banding; RG: sleeve gastrectomy; GARR: Roux-en-Y gastric bypass; BPS(DP): biliopancreatic shunting (with a switch to the duodenum).

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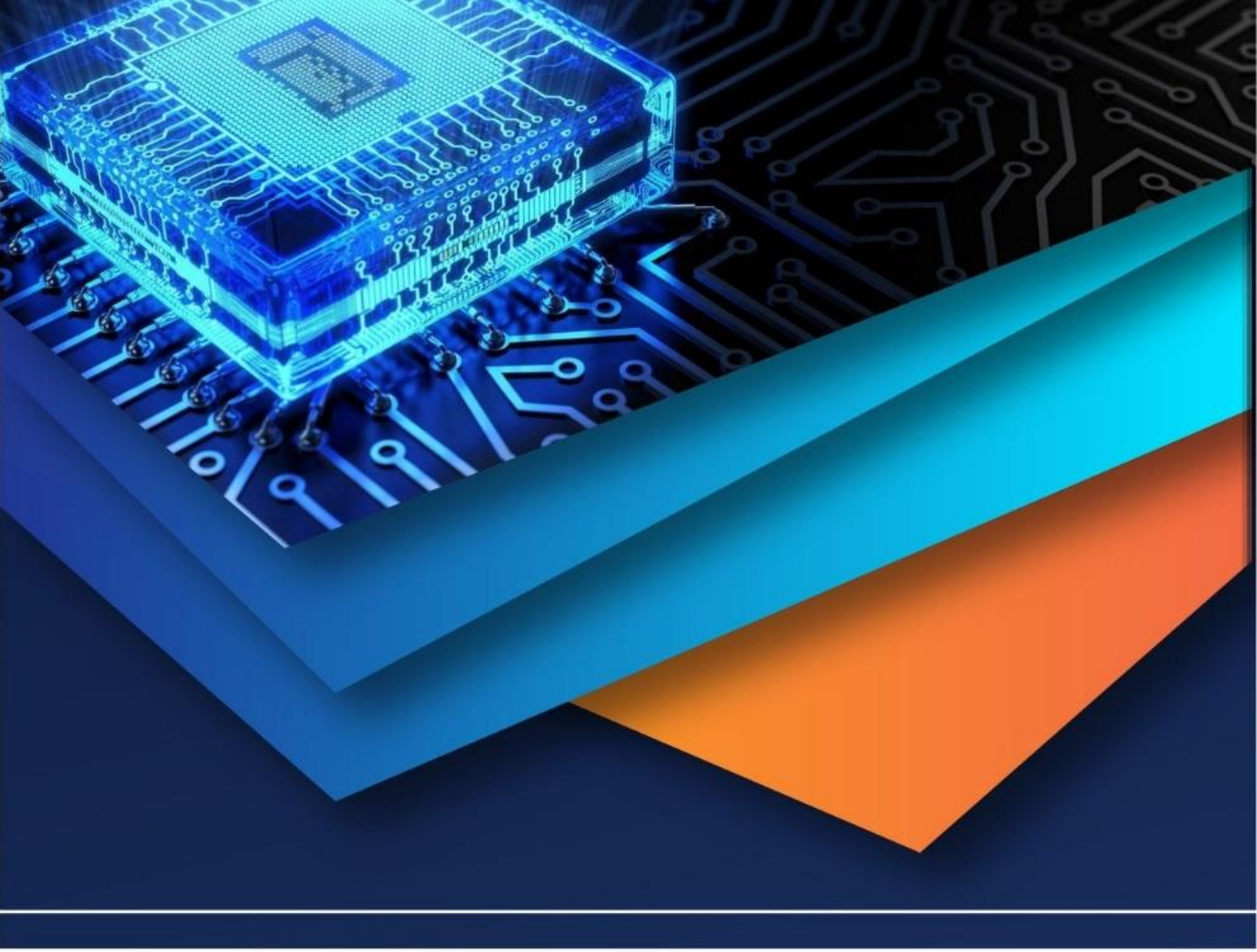

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