UNDERSTANDING THE KETOGENIC DIET’S EMERGING ROLE IN CANCER TREATMENT & PREVENTION
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INTRODUCTION
The ketogenic diet is based on the principle that eating a diet high in fat and low in carbohydrates can help you lose weight which is contrary to many traditional diets that view fat as the primary culprit of weight gain and obesity. To many, the ketogenic diet may be considered just another fad diet that will run its course of popularity. However, there is emerging scientific evidence that the ketogenic diet not only aids in weight loss but can also help people with epilepsy, diabetes and cancer.

To understand the nature of the claims of the ketogenic diet’s role in cancer treatment and prevention, it is important to understand the theories on the origin of cancer, as well as the basic biology of where human bodies get their energy. This is essential knowledge to understand how a change in energy source within a cancer cell is considered to be what is keeping the cancer cell from being fed. This change of energy potentially aids in cancer treatment and prevention. The report will conclude with two clinical studies that have taken place within the past decade to further explore any validity to the claims of the ketogenic diet’s role in cancer treatment and prevention.

BASICS OF THE KETOGENIC DIET
The ketogenic diet is based on eating a diet high in fat and low in carbohydrates. (See Figure 1) The theory of the diet is to switch a human body’s primary energy source from glucose to ketones. Glucose is a type of sugar that comes from the breakdown of food and is carried in the bloodstream to feed cells and provide energy. (KidsHealth, n.d.) Ketones are chemicals that also come from the breakdown of foods, but foods high in fat. Ketones are found in the bloodstream and are used to feed cells and provide energy when there is not enough glucose. (KidsHealth, n.d.) This switch in fuel source is believed to help with a range of issues, including but not limited to weight loss, epilepsy, diabetes, Alzheimer’s, brain health and cancer.

FOODS TO EAT
People adhering to the ketogenic diet eat a variety of foods. The foods most common in the diet are those that are high in fat, such as meat, eggs, grass fed butter, cream, fish with a higher fat content, healthy oils (olive, coconut and avocado), minimal carbohydrate vegetables and cheeses. (Mawer, 2018) The ratio of the diet can vary based on individual needs but typically is only 5%-10% carbohydrates for most individuals, and the remainder of the diet would be 55%-60% fat, and 30%-35% protein. (Wajeed & Uppaluri, 2019)

FOODS TO AVOID
To maintain a low carbohydrate diet some foods that are eliminated (or significantly reduced) are as follows: sugar, grains, breads, starches, most fruit, saturated fats, and legumes. (Mawer, 2018) These foods would fall into the 5%-10% daily intake ratio of the ketogenic diet.
THEORIES ON ORIGINS OF CANCER
In the scientific and medical community, there is not a definitive and agreed upon theory on the origin of cancer. That is prohibiting the development of a cure. There is still much to understand and more research to conduct on theories that have emerged over the past century. Cancer as a genetic disease is one of the more widely accepted theories, however, a newer theory is emerging that cancer is a metabolic disease. A surface level exploration of both theories is below.

CANCER AS A GENETIC DISEASE
One of the more widely known originators on the theory of cancer as a genetic disease was now deceased zoologist Theodor Boveri. Boveri’s hypothesis was that cancer originates from a defect during the process of cell division, specifically in regard to the stage of cell division where chromosomes are separated out. Most cancer cells when viewed with a microscope appear to have abnormalities in their DNA which aligns with this stated theory. (Seyfried, Flores, Poff and D’Agostino, 2013)
Though humans could begin with healthy cells and genes, due to the rate and frequency of cell division over a human's lifetime, the risk is high that there can be errors in cell division which lead to mutations that can cause cancer. These mutations can be inherited, meaning they are passed down through genes. Mutations can also be acquired (somatic) through external environmental factors that include cigarette smoke and radiation. (American Cancer Society, 2014)

CANCER AS A MITOCHONDRIAL METABOLIC DISEASE

Conflicting evidence of cancer being a genetic disease has led the medical and scientific community to explore other explanations. In the 1920’s Dr. Otto Warburg studied the idea that cancer could arise from an issue in energy production of a cell. In a normal cell, glucose is taken in and broken down without oxygen, which produces lactate as a byproduct of normal healthy cell functioning. However, Dr. Warburg found that in a cancer cell, glucose is taken in and broken down at an amplified rate which increases the byproduct production of lactate. When a cell has above normal lactate production, the lactate will ferment and be used for energy in a cancer cell even without the need for oxygen, unlike the functioning of a healthy cell (See Figure 2). This is scientifically referred to aerobic glycolysis, also known as the Warburg Effect. (Wilson & Lowery, 2017, p. 119)

Figure 2. Healthy Cell vs. Cancer Cell. Reprinted from NextGen Medicine by L Mailing, 2019, retrieved from
https://ngmedicine.com/could-cancer-be-a-metabolic-disease/
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This process of lactate fermenting is the main source of energy for a cancer cell and that can lead to growth and massive reproduction. This has not been found to be an efficient way to get energy for the cell, so it leads researchers to question if there is damage to mitochondria. Mitochondrial damage is usually indicative that the cell is not using oxygen effectively and this leads to developments of other characteristics that define a cancer cell. (Wilson & Lowery, 2017, p. 119)

Neither theory discussed above is perfect in explaining and defining the origin of cancer and what leads a cell to become abnormal. Through further research it is promising that humanity is getting closer to definitively understanding the origin of this disease so a cure can be found.

THE KETOGENIC DIET AND CANCER PREVENTION
Early on scientists discovered that human body cells are fueled by glucose and this was thought to be the only fuel source for their life and functioning. Since human cells limit glucose storage, it was often believed that any fasting that lasted more than eighteen days would result in death. This idea was challenged and that is how an alternative fuel source was discovered: ketones. (Wilson & Lowery, 2017, p. 11-12)

UNDERSTANDING THE SCIENCE OF KETOSIS
As stated previously, glucose (typically from carbohydrates) is a human body’s primary source of energy and fuel. If a human body dramatically reduces carbohydrate intake, eventually the glucose storage is depleted forcing a cell to look for an alternative fuel source. The body first begins to produce glucose by other means, typically from the liver, but then once that is depleted and no longer sufficiently fueling the body, ketogenesis begins and the body is fueled by ketones instead of glucose. Ketones also get produced by the liver. (Wajeed & Upallari, 2019)

Due to the amplified rate of glucose intake of a cancer cell, the body cuts off glucose as a source of fuel and energy by putting the body into a state referred to as ketosis. This gives the cancer cells the alternate fuel of ketones, which is believed to inhibit the growth and multiplication of a cancer cell. (Wilson & Lowery, 2017, p. 124)

For most individuals, ketosis can be achieved by fasting for an extended period of time or by following the ketogenic diet with a 5% ratio of carbohydrates to fats and protein. (Belluz, 2018)

THE KETOGENIC DIET AND CANCER TREATMENT
There is evidence suggesting that nutrition needs to be addressed when facing the diagnosis of cancer. The ketogenic diet regulates blood sugar levels when the body enters the state of ketosis, and that is expected to stop the growth of a cancer cell due to its dependence on glucose for fuel.
CLINICAL STUDY: USE OF KETOGENIC DIETS IN ADULT PATIENTS WITH CANCER

The School of Health Science at the University of Manchester (The University) in the UK compiled a series of clinical trials that used the ketogenic diet in adult patients with cancer. The University included any studies that had been conducted using the ketogenic diet for more than one week that were either testing the outcome of the diet before, after or during cancer treatment. The University was able to include eleven studies with a total of 102 participants. (Sremanakova, Sowerbutts and Burden, 2018)

While the analysis goes into further detail, it is not conclusive that the ketogenic diet had an impact. This was due to a series of factors which included that less than half of the participants failed to adhere to the diet. For some that did follow the diet it was not clear that the ketosis state was maintained. There were positive outcomes observed in some patients in a couple of the studies when the patients were either in early stages of cancer treatment or were diagnosed with a brain tumor. It is impossible to conclude the role played by the ketogenic diet even in those positive outcomes due to the limits of the data and potential bias. In conclusion, the evidence supports further exploration of the ketogenic diet as there were no life-threatening concerns. Also, it did seem viable and potentially effective if there would be better follow through from the patients adhering to the diet. (Sremanakova, Sowerbutts and Burden, 2018)

CLINICAL STUDY: DECLINE OF LACTATE IN TUMOR TISSUE AFTER THE KETOGENIC DIET

In Germany, a study was conducted to see how the ketogenic diet impacted head and neck squamous cell carcinoma (HNSCC). This was an ideal cancer to study because aerobic glycolysis is one of the primary energy supplies for the tumor. (Schroeder, Himpe, Pries, Vonthein, Nitsch and Wollenberg, 2013). As a reminder, aerobic glycolysis is also referred to as the Warburg Effect mentioned earlier under Cancer as a Mitochondrial Metabolic Disease.

The study hypothesized that the ketogenic diet should be able to stop fueling the tumor because the diet will stop glucose as the fuel source. The lactate becomes the fuel source which will decrease the lactate concentration in the tumor. After the study concluded, it showed the ketogenic diet as having strong potential to impact cancer with aerobic glycolysis. There was a decrease of 35%-65% in tumor growth in both humans and mice with brain tumors in the cerebrum. Since the study also showed that HNSCC do respond to nutrition, it was concluded that it is worth further exploration to understand the full potential of the ketogenic diet. (Schroeder, Himpe, Pries, Vonthein, Nitsch and Wollenberg, 2013).

SUMMARY

Nutrition is becoming part of the dialogue concerning a multitude of human ailments and health concerns. The ketogenic diet is being included in this discussion due to the diet’s claims in helping patients with diagnoses ranging from epilepsy to cancer. There has been a focus on the science of how human body cells function and the ability of the ketogenic diet to provide an alternative fuel source to normal cell functioning. There are many more clinical trials and studies that need to be conducted to understand the implications of the
impact of the ketogenic diet on cancer treatment and prevention. However, there is first more that needs to be understood in regard to the origin of cancer. Once the scientific and medical community find these answers, treatment and cure options can be fully vetted and made available to those facing a diagnosis of cancer.
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