

Cancer cells feed on a variety of...

By Jean-Marc Dupuis

Imagine if you could starve your cancer cells by stopping eating certain foods...

Your growing tumour would be abruptly stopped. Deprived of food, it would start to wither, shrink and then disappear.

According to some researchers, this dream can in some cases become a reality. Because this is what cancer cells need to live:

The cells can operate on two different fuels

The cells have two fuels at their disposal: glucose and fatty acids.

The cells must burn these fuels to convert them into cellular energy (ATP, or adenosine triphosphate).

For this they need oxygen, which is provided by respiration and blood.

Inside the cell, fuel and oxygen are burned in the mitochondria, mini power plants inside the cells, to produce cellular energy.

Mitochondria can function either with oxygen and glucose or with oxygen and fatty acids.

When oxygen runs out

But mitochondria do not always have enough oxygen available. For example, when you run very fast and are out of breath, your cells lack oxygen.

Fortunately, you can still run because your cells are also able to produce energy without oxygen: by *fermentation*.

Fermentation allows cells to function in the absence of oxygen. However, fermentation only works with glucose, not with fatty acids.

Cancer cells addicted to glucose

Cancer cells, which are very aggressive, reproduce rapidly, and are very numerous in one place, primarily use *fermentation* to function.

Since fermentation is not possible with fatty acids, this means that cancer cells have an enormous need for glucose.

They need 20 times more glucose than a healthy cell. So much so that *PET scans* can be used to see cancer in the body, just by looking at the cells that consume the most glucose.

Cancer cells are addicted to glucose. They are only interested in finding glucose at any price, like a drug addict, and like a drug addict they no longer take their environment into account.

If they only have fatty acids available, they are starved. The production of cellular energy decreases. Cancer cells lose their aggressiveness and their ability to multiply.

This is not the case for the other cells in the body (brain, heart and other muscles), which can live on fatty acids alone, because their behaviour is less frenetic.

Cancer cascade

Glucose is therefore the fuel for cancer cells. But eating lots of sugar increases your risk of cancer in other ways:

- The fermentation of glucose by the cells produces lactic acid, which causes acidification of the cancerous tissue, further promoting tumour growth;
- The more sugar you eat, the higher your blood sugar level and the more insulin your pancreas makes. Insulin stimulates the production of a molecule called Insulin-like growth factor-1 (IGF), a powerful hormone responsible for the proliferation of both healthy and cancerous cells.

This has led researchers to propose a no-carbohydrate diet, called the ketogenic diet, to help cancer patients.

The no-carb diet against cancer

In 2007, Dr Melanie Schmidt and biologist Ulrike Kämmerer at the Würzburg Hospital in Germany conducted a clinical study with cancer patients. They put them on a very low-carbohydrate, high-fat, high-protein diet called the ketogenic diet. No sugars, no cereals, no cakes, no pasta, no rice, no potatoes, very little fruit, only meat fatty fish, whole eggs, nuts, olive oil, flaxseed oil and some vegetables.

This was nothing new. Already in 1924, Dr. Otto H. Warburg (Nobel Prize in 1931) had published his observations on tumours: "*A diet rich in carbohydrates has a profound effect in stimulating the growth of cancer cells.*"

However, the two researchers from Würzburg ran into a hurdle: the hospital only allowed them to test the ketogenic diet on patients who had exhausted all conventional cancer therapies: surgery, radiation, chemotherapy, and even alternative therapies such as hyperthermia and autohaemotherapy (venous blood reinjected through the muscles).

This means that the patients were in very poor health. They had ovarian, breast, parotid gland, bone, pancreatic, thyroid, oesophageal and aggressive nervous system tumours that were resistant to conventional treatments. Two of them died within a month of the

Another dropped out because he found it too painful to go without sugary drinks and cereals and six others stopped for personal reasons. Two other patients left

The study was prematurely terminated due to a sudden deterioration in their health.

However, for five patients who followed the carbohydrate-free diet for three months, the results were positive. The patients stayed alive, their physical condition stabilised or improved, their tumours stopped growing and the disease stabilised.

The effectiveness of the ketogenic diet lies in the strict adherence to a diet as low in carbohydrates as possible. When carbohydrates run out, the body produces ketone bodies derived from fats which can provide energy for the body and brain but which are of little use to the cells cancer. In the Würzburg researchers' study, only two patients were able to reduce their dietary carbohydrate intake sufficiently to produce a lot of ketone bodies. These preliminary results are therefore quite remarkable and the researchers already see this as an alternative solution for the treatment of cancer, without waiting for the terminal stage of the disease [1].

Two children helped by the ketogenic diet

The first human experiment with the ketogenic diet in cancer treatment was conducted in 1995 by oncologist (cancer doctor) Linda Nebeling, on two children with brain tumours. Linda Nebeling is currently at the National Cancer Institute in the USA.

Both children responded positively and the progression of the disease was completely stopped in one of them, who was still alive 10 years later, by continuing to follow the ketogenic diet.

It is obviously impossible to draw general conclusions from such a small experiment. However, the ketogenic diet is now of interest to many medical teams around the world.

Dr Thomas Graeber, a professor of molecular and medical pharmacology, published a study with his colleagues in 2012 showing that glucose deprivation activates a metabolic amplification and signalling loop leading to cancer cell death [2].

Studies published this summer 2013 in the journal *Plos One* indicate that cancer mice on the ketogenic diet show improved survival compared to a control group not on the diet.

Combined with hyperbaric oxygen treatment, which consists of saturating the cancer cells with oxygen, the survival of the animals was increased by 78% [3].

These results obviously offer great hope for patients.

Essential warnings

But beware, the ketogenic diet causes certain problems, so it is strongly advised against following it without medical supervision. It can cause severe fatigue, as the body needs to get used to working without sugar stores. The ketogenic diet also has a deficit of :

- Fibre: this causes constipation or paradoxically diarrhoea, which can be relieved by taking fibre supplements such as psyllium or pectin;
- Potassium: Most of our potassium comes from fruit and vegetables, which are sources of carbohydrates. You should therefore take a potassium supplement or choose low-carbohydrate vegetables (kale, asparagus, aubergines, cucumbers, broccoli, celery, lettuce, leeks, watercress) and avocados.

Above all, the ketogenic diet should not be undertaken in cases of :

- Kidney, liver or heart failure and recent heart attack,
- Insulin-dependent diabetes, and non-insulin-dependent in the absence of medical supervision,
- Pregnancy - breastfeeding,
- For all persons beyond 4 weeks, without medical follow-up,
- Growth period (child, adolescent),
- During diuretic or corticoid treatment in the absence of medical supervision,
- In case of eating disorders,
- Following a surgical operation,
- In fatty acid metabolism diseases (porphyria, pyruvate carboxylase deficiency and other rare genetic diseases).

L mimicking your cancer risk

Without going as far as the ketogenic diet, a low-carbohydrate diet is beneficial both in preventing cancer and in improving its treatment. To limit your risk of feeding a glucose-hungry tumour:

- Reduce your consumption of processed, industrial food, such as ready meals, refined (white) flours and foods made with them (sandwich bread, white baguette, pastries, white pasta) as well as sugary drinks and juices;
- Eat cereals in quantities appropriate to your physical activity: you can do without them if you do not exercise;
- Look for colour on your plate: colourful vegetables and fruits are rich in antioxidants that reduce inflammation (blueberries, red grapes, tomatoes, green vegetables). There are, of course, several important exceptions such as cauliflower, horseradish and asparagus which, although white, are excellent for your health;
- Avoid grilling and frying as much as possible;

- Favour good quality fatty products: small oily fish, nuts of all kinds, extra virgin olive oil, rapeseed oil, avocados, organic eggs enriched with omega-3 if possible;
- Avoid fatty industrial products: salad dressings, ready-made mayonnaise, and of course all toasted and salted snacks;
- Adapt your lifestyle to reduce the causes of stress: change your job, your place of residence, your activities if these do not allow you to be reasonably relaxed in your life;
- Limit the use of toxic products in your home: household products, varnishes, glues, plastics;
- Drink one or two glasses of good wine a day, preferably red.

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