Can we cure cancer?

Nomy Xin

Introduction

It is no longer a mystery that a group of cells within our body are constantly lurking around, waiting for the opportunities to take over the sources of nutrients. They proliferate, construct new blood vessels, and eventually destroys the function of organs. The famous Greek historical figure, Hippocrates used the words 'carcinos' and 'carcinoma' to describe these cells due to their spreading shape being similar to those of the claws of crabs. It has a more familiar name to us: cancer. By its nature, cancer is where our own body cells mutate and uncontrollably propagate, increasing at an alarming rate. Tumors are tissues composed of abnormal cells which competes against healthy tissues. Proto-oncogenes within normal body cells mutate and transforms into oncogenes which stimulates tumor growth. As our society progresses, cancer accounts for an increasing amount of death in countries that are more economically developed.

Cancer can be analyzed using histology techniques, which is a method to process tissues of tumor cells. Standards such as the TNM system assess the severity of the patient's conditions. Tumor size, progression of metastasis (or the spread of cancer cells) and conditions of lymph nodes are all different aspects that the systems assess. The more deviated the cancer cell is from normal cells, the more lethal it is, and therefore harder to treat. A cancer that has already spread across the lymph nodes and other organs are also more challenging to cure.

In addition, cancer also comes in different types, depending on the tissue where the cells mutate from. Carcinomas, adenocarcinomas, melanomas, sarcomas, leukemia, myeloma and blastoma corresponds for origins in: tissue lining organs, glandular structures, melanocytes, connective tissues, blood cells, bone marrow and undifferentiated cells. According to the type, the possibility of curing the patients also varies. Melanomas, a cancer developing from the cells that produce pigment in our skin, is very deadly. Whereas thyroid cancer grows at a very slow rate and have a cure rate of over 97% if treated appropriately.

Normally, we consider cancer as a powerful, destructive disease that cannot be controlled. Indeed, countless lives are taken by these rebellious cells: over 600,000 cancer related deaths were expected in the US in 2020 (CDC, 2019). However, it is increasingly more common for us to hear and see cases of cancer patients that fully recover from the diseases. If all cancerous cells are removed from the patient for 10 years or above and maintains in remission, it is reasonable for us to suggest the cancer is "cured". Any tumor re-emerging after 10 years is likely to have no correlation with the previous tumor. Depending on the stages and types of cancers, our current technology is potentially able to achieve the goal of "curing" according to this standard.

The hallmarks of cancer are characteristics shared by cancerous tissues which are considered contributing factors to tumor growth (Kozielski, n.d.). In this essay, discussions will discover treatments that target various hallmarks; For example, the ability to avoid immune destruction. Traditional treatments of cancer and other newly developed technologies that extends from the previous section will be analyzed. Moreover, apart from remedies, early detection and prevention of cancer will also be assessed as an alternative solution to protect our population from cancer.

The Five Pillars of Cancer Care

At the moment, cancers that have not progressed to a late stage and limited types can be cured. Mature technologies and methods of treatment targeting cancer cells are widely available across hospitals in the world. The main therapeutic approaches for cancer are referred to as the five pillars of cancer care: surgery, cytotoxic chemotherapy, radiotherapy, molecularly targeted therapy and immunotherapy.

Surgery

Surgery was the earliest developed treatment amongst the five pillars. Directly removing what is threatening the human body is indeed a direct and simple way of treating cancer. Astonishingly, ancient physician Celsus documented the surgical removal of a tumor from a patient in the first century. Many of the medical experts, for example Galen, since then have realized the importance of removing tumors before the metastasis begins. Total gastrectomy is an example of typical surgeries to remove cancerous tissues from the patient's body. The entire stomach and adjacent tissues are removed together to treat tumors developing on or around the stomach. Early stages of breast cancers and liver cancers are also typically treated with surgical removal of the primary tumor in combination with chemotherapy or radiotherapy (*What Is a Gastrectomy?*, n.d.). Surgery can also be carried out to remove high risk tissues even before tumors emerges in order to prevent cancer developing in the future.

Cytotoxic Chemotherapy

Cytotoxic chemotherapy, in contrast, functions by disrupting the normal function of cellular components like DNA, endoplasmic reticulum and mitochondrion. As this branch develops, doctors typically divide chemotherapy according to their purposes. In many occasions, neoadjuvant chemotherapy is used to decrease the size of tumor which decreases difficulty of surgical removal. Adjuvant chemotherapy takes place after the surgery or radiotherapy, to clear remaining cancer cells (*Chemotherapy to Treat Cancer*, 2015). In addition, the chemotherapy agents can be again regrouped based on the nature of these chemicals. Alkylating agents are a group of agents that directly damage DNA during any phase of the cell cycle. Antimetabolites are another classification of drugs that substitute the building blocks of RNA and DNA for tumor cells. Cisplatin, for example, mainly targets a variety of cancers like sarcoma, small cell lung cancer and lymphoma. This alkylating-like drug is being referred to as the 'Penicillin of cancer' (*Cisplatin - The Penicillin of Cancer*, 2019). Cisplatin was the first big chemotherapy drug and it can be applied in a wide spectrum of situations. In cases where cancer has metastasized and grown beyond control, chemotherapy is not used to completely cure the disease. Discouraging as it sounds, treatment for patients at this stage is only used to slow down the progression of cancer or to ease the symptoms. Although it means cancer cannot be cured in these cases, scientists are still looking for other solutions to battle this issue.

Radiotherapy

French physicist Antonie Henri Becquerel's discovery of radioactivity is another familiar story to us. Radiation is the result of the decaying of atoms resulting in the release of ionizing radiation or particles. Around 40 years after this discovery, the French oncologist Henri Coutard presented a shocking revelation of radiation's clinical value at the Congress of Oncology, Paris. He treated larynx cancer with multiple treatments of radiation with no severe side effects as a result. This is perhaps one of the earliest cases of radiotherapy, using the ionizing energy to damage DNA within the cells, thereby diminishing proliferation of cancer cells. External beam and internal beams are the two major types of radiotherapy, each suited for different conditions. External beam radiotherapy emits radiation from a machine exterior to the patient onto a portion of the patient's body while the rest of the body can then be unharmed by the treatment. On the other hand, a liquid or solid source of radiation is injected, swallowed or placed into the body of patients. Depending on the type of cancer, radiation therapy can even reach to a five-year survival rate of above 90% ("radiation therapy | Definition, Types, & Side Effects | Britannica," 2019). This statistic indicates a promising outcome of radiotherapy, since a higher percentage of cancer can be controlled by the treatment. However, radiotherapy is not always feasible because a single tissue can only receive a limited amount of radiation during patient's life time. Luckily, the existence of various other methods allows doctors to use alternative treatments that can replace the function of radiotherapy.

Targeted Molecular Therapy

Surgery, chemotherapy, and radiotherapy are measures that aim at killing or removing cancerous tissues. Targeted molecular therapy similarly focuses on switching on or closing certain pathways, ultimately instructing the tumor to stop by its own mechanism. Small-molecule drugs passes through plasma membranes easily and aims targets pathways that can be inhibited or activated in the cells. Monoclonal antibodies are artificial antibodies that can attach to the cancer cells which can can collaborate with the body's immune system or other toxins to help the destruction of tumors (*Evolution of Cancer Treatments: Surgery*, 2014). Despite resistance and selectivity of this treatment, target molecular therapy is still a popular choice of medication not only because of its effectiveness, but also due to the improved quality of life for patients. In situations when patients only have a few months to live, side effects of chemotherapy and surgical treatments may be avoided by using targeted molecular therapy.

Immunotherapy

The fifth pillar, immunotherapy belongs to a larger category of biological therapy, and it is this characteristic thar differs it from the other four pillars. Treatment plans help the immune system of patients to control the growth of cancer cells. In cases of cancer, the cells avoid the immune system by genetic changes that interferes with the normal destruction process carried out by the immune system. CAR T-cell therapy is one of the most developed immunotherapy treatments, specifically targeting blood cancers. T cells, a major component of the immune system is extracted, genetically engineered, cultured, then returned to the patient's body. The modified T cells produce receptors known as chimeric antigen receptors on their surfaces. These are synthetic molecules which aids the recognition and attachment of T cells to cancer cells. Acute lymphoblastic leukaemia is one of the most common cancers in children, with almost no options of treatment prior to the development of immunotherapy; Children could only wait for stem cell transplant to replace their cancerous blood cells. However, an early trial of the CAR T-cell treatment showed that 27 out of 30 patients underwent a full recovery from previous cancer symptoms (*CAR T Cells: Engineering Immune Cells* *to Treat Cancer*, 2019).

Newer treatments

It is true that in many other cases of cancer, curing the diseases are still beyond our limits. Pancreatic cancer has a five-year survival rate of 7.2%; Glioblastoma, an aggressive cancer that develops in the brain and spinal cord has an even lower five-year survival rate of 6% for people at the age between 55 and 64 (Cancer.org, 2020a). The effectiveness for the treatments mentioned above cannot be guaranteed for every single cancer patient. Surgeries often cannot completely remove all cancerous cells, while other treatments can often induce dangerous side effects. Yet just as we have seen in the past century, scientists are still searching unexplored realms for potentially even more effective remedies for cancer.

Anti-body Drug Conjugate

Just recently, The FDA has approved the 100th antibody product. This specific type of treatment for cancer has only 35 years of history. Amongst the newest antibody products, ADC (the anti-body drug conjugate) is gaining more attention from the researchers despite only 11 drugs are currently being licensed. One example of ADC is brentuximab vedotin, licensed for treating anaplastic large cell lymphoma and Hodgkin lymphoma. These compounds are actually complex molecules formed by the attachment of artificially manufactured antibodies and drug molecules. ADC allows a site-specific delivery of cytotoxic agents to the targeted cancer cells. It is achieved due to the spectrum of cell surface markers unique to lymphocytes. Drawbacks such as resistance is still present in the development of ADC; However, amongst the different technologies discussed in this section, ADC might be the most promising because ADCs are designed to target cancer cells. The same level of cytotoxic effect can be achieved with a much lesser dose, therefore limiting the harm to healthy cells. Some cytotoxins that were once unable to be used alone due to their devastating effects on healthy cells now exist as new options for patients with the help of ADC technology. (Mullard, 2021)

Neutrophil Elastase

Another cutting-edge discovery is focused on neutrophil, a type of white blood cells in our bodies which help the healing of wounds and infections. In fact, our blood system naturally secretes neutrophil elastase, ELANE, which selectively kills cancer cells. Different to ADC, which functions in mediating cell proliferation through site-specific pathways, neutrophil elastase has a significance in wide range of cancer cell types. This discovery may even lead to the development of broad-spectrum antitumor treatment – similar to the broad-spectrum antibiotics we have for treating infections-meaning a potential cure for most patients. In the future, neutrophil elastase and related immunotherapy may allow doctors to cure cancers that have no remedies in our time. (Cui et al., 2021)

Tumor Image Sensor

Apart from these biochemicals interacting with cancer cells on a molecular level, new surgical instruments also aid operations to better clear tumor tissues from the patient's body. As previously discussed, sometimes due to limitations in the technology and conditions, parts of the tumor may remain unremoved, which often leads to the reemergence of cancer. Is there a better way for doctors to eradicate them completely? It is hard to imagine, but the answer to this question could lie within an animal: mantis shrimp. These arthropods, commonly found in the tropical seas, are not particularly friendly in nature. Their punches are one of the most powerful attacks, and can exert up to 60 kilograms of force on their prey. Of course, scientists did not base their research on this violent behavior. Instead, their extraordinary vision has inspired the creation of unusual cameras that aids surgeries to remove cancer. Normal human eyes have three types of photoreceptors, whereas mantis shrimps have up to twelve photoreceptors. A six-channel color/ near infrared image sensor was developed, and this invention provided surgery with near-infrared fluorescence image guidance. The near-infrared is beyond the wavelength of light that we can observe, and probes that are equipped with this sensor can detect the difference of light reflected by healthy tissues and tumor tissues. The accuracy reaches an estimation of 92%, which effectively helps prevent metastasis or regeneration of cancerous tissues. In reality, this technology may be the most helpful for most cancer that are caught early. Relatively low cost and effort of hospitals is required to implement this technology; While combining this technology with minimally invasive surgeries means that not only are the surgeries more successful but also more affordable for patients. (Blair et al., 2021)

TOAD- AI Diagnosis

Lastly, one unexpected participant appears on our list of newly developed methods to help curing cancer patients. Artificial intelligence is used by some scientists to help the diagnosis of cancer that cannot be tracked to its origin easily. Once a certain size and stage is reached, cancer cells can spread around the body: the process of metastasis begins. It is highly likely for people to be first diagnosed by their secondary tumors instead of their primary tumors. Cancer of unknown primary, CUP, has a bad prognosis. In these situations, the challenge of treating cancer drastically increases. Luckily, TOAD, a programmed artificial intelligence is trained to classify tumors of patients as either primary or metastatic. The 22000 pathological analysis of cancer samples feeds the AI with adequate information. TOAD significantly reduces the extra time required for additional examinations in the traditional procedures and therefore greatly increases survival possibilities for cancer patients. Moreover, TOAD predictions of the locations the origin of CUPs can have a precision of up to 63%. This percentage may be not as convincing from a patient’s perspective. However, TOAD displays an increasing trend of precision as more data is provided. Researches suggest that the more we use this method, perhaps the better the AI becomes and so chances of curing should rise. (Lu et al., 2021)

Early detection

Many of the approaches to treat cancer shows a better prognosis when the cancer is treated at an earlier stage. Characteristics of certain cancer makes it difficult to achieve early detection. For example, pancreatic cancer is commonly caught at late stages. However, a new blood test offers people a way to prevent such threats. Cheap and convenient tests can detect extracellular vesicles, small globules that communicate with other cells in the blood stream, based on the binding of nanoparticles. The gold nanoparticles change light-emitting properties and allows the invisible tumor cells to be detected, similar to the mantis shrimp-inspired sensor. The early testing stage has a limited sample size of 59, meaning it requires more experiments to tests the validity of the blood test. Nevertheless, it still has the potential to greatly reduce the cost and difficulty to treat pancreatic cancer (*Cancer*, n.d.).

Prevention

This aspect of reducing cancer threats is also common in our daily lives. Preventing cancer can be achieved by maintaining healthy lifestyles, exercising on a regular basis and avoiding contact with carcinogens. Tobacco accounts for more than 30% of all cancer deaths (CDC, 2019), while obesity increases risk of breast cancer. Madeline Drexler suggests in one article that cancer rates can be reduced by 70% without any development on current therapies (*The Cancer Miracle Isn't a Cure. It's Prevention.*, 2019). However, people do not always adhere to advices of health experts. In economically developed regions, cancer deaths are much higher due to the stress and exposure to carcinogens. Balancing our daily work and maintaining personal health might be the key to the eliminate cancer deaths across the globe, as it avoids the invasion of abnormal tissues from the first place.

Conclusion

In conclusion, this essay has discussed the traditional therapies and newer technologies targeting cancer. Even though we cannot cure all cancer patients, the future prospect of the treatments is still very bright. From prevention to remedies, there are countless ways for us to find solutions in achieving the goal to eliminate the disease of cancer. In the field of medicinal sciences, advancement of treatment methods for cancer is like the 'differentiation' of our existing knowledge. Our current embryo of medicinal technology is still at a youthful stage. Each and every new discovery serves as the signals, triggering the division of the stem cells. Endless possibilities await a mature, organized system to form. Hence perhaps one day, cancer will only remain as an intriguing chapter in our biology textbooks.

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