# Using Virtual Reality Tumor for Cancer Treatment

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Introduction

Today, many people suffer from cancer despite the great development of medicine. In Japan, it is now said one in two people will suffer from cancer in life and cancer has been the biggest cause of death since 1981 (National Cancer Center). We can reduce the risk of cancer by having good lifestyle such as stopping smoking, saving alcohol, changing eating habits, doing exercise, or maintaining proper weight. However, we cannot prevent cancer completely.

Of course, there are some cases where cancer is completely cured by surgery or treatment with drugs, but many people, including young children, suffer from physical burdens due to surgery and side effects of anticancer drugs.

Transition of number of deaths from cancer in Japan

(Ministry of Health, Labour and Welfare)
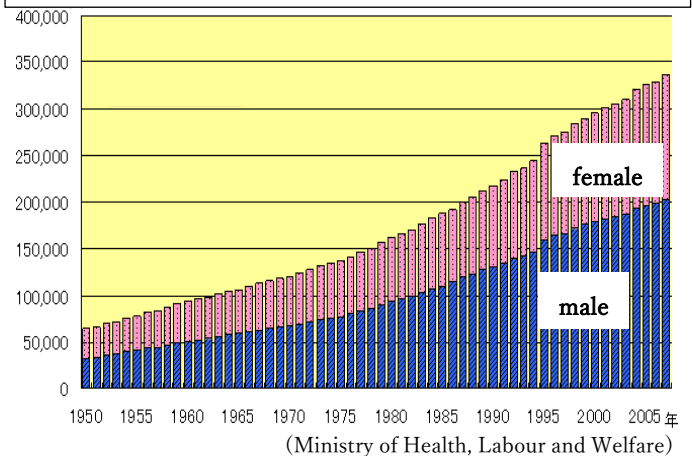
This is why I have had a dream of becoming a researcher who develops drugs with less side effects for cancer treatment. Using drugs for cancer treatment has less burden for patients than surgical treatment. I thought that using cutting-edge technology could contribute to cancer treatment and found IMAXT Laboratory which is doing research in order to make a virtual reality tumor (VR tumor) at Cancer Research UK Cambridge Institute, which interested me. I wanted to know the possibility of using VR tumor technology for drug discovery, and decided to visit a member of the IMAXT Laboratory.

There have been some examples of applying virtual reality technology to medicine so far such as simulation training of an operation or rehabilitation. However, VR has not been used in these examples for precise medical research. On the contrary, this project is innovative in terms of analyzing cancer tumors to the level of DNA and trying to use them for medical research, attracting a lot of attention.

Fundamentals

What is virtual reality tumor?

To fully understand cancer, scientists need to know everything about tumors – what types of cells are in it, how many there are and where they are located in a tumor. IMAXT laboratory at Cancer Research UK Cambridge Institute aims to build a 3D tumor that can be studied using virtual reality and which shows every single different type of cell in a tumor. (Cancer research UK Cambridge Institute)

Baking cancer cells with laser, proteins are detected. By analyzing these proteins, we can characterize each cancer cell. Then, we can see how cells with different properties are distributed by using a virtual reality tumor.
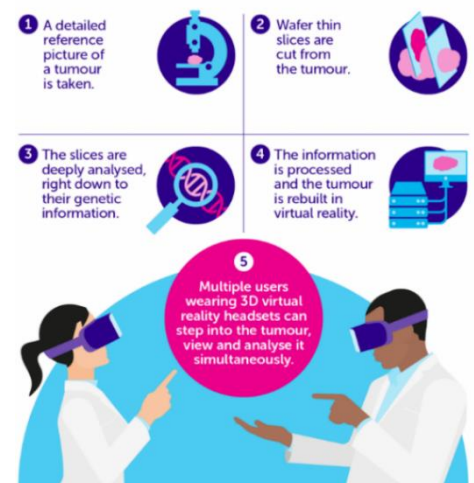
How to create virtual reality tumor

For example:

・Immune cells are distributed in a lower part of a tumor.

・Cancer cells are concentrated in this part , and so on.

Coloring a VR model and analyzing the model from various angles in a three-dimensional space allow researchers to understand how tumors are acting or what they look like. Also, VR model can be seen at the same time by multiple doctors and scientists in various fields, no matter where they are, and this will help to do better treatment for patients.

Knowledge about cancer

How cancer progresses

① normal cell ②abnormal cell ③become cancerous ④tumor formation ⑤metastasis and infiltration
            (gene injury)

https://www.coopsapporo-cs.jp/premium_service/detail/342

Example of a relationship between cancer cells and normal cells.

Abnormal cells grow and spread to normal cells surrounding them(③).

When cancer calls are gathered and form cancer tumor, cancer cells become easy to move and cancer spread to other organ(④,⑤).

Methodology

This research was made through the interview with Dr Dario Bressan.　The interview was taken place on August 1st at Cancer Research UK Cambridge Institute.

Meeting with Dr. Dario

Cancer Research UK Cambridge Institute

I thought that virtual reality tumor might be useful for drug discovery, and asked the following questions:

Question 1. What are the advantages and disadvantages of the VR tumor? (What is the difference from other methods like CT scans or gene panel tests?)

Question 2. Can you use a VR model to test the efficacy of drugs?

Question 3. Is it possible to verify the relationship between cancer cells and other normal cells around them by using VR model?

Question 4. Are there any ways or possibilities to use this technology for drug discovery?

Results

Dr Bressan's answers:

Question 1. What are the advantages and disadvantages when using VR tumors? (What is the difference from other methods like CT scans or gene panel tests?)

Answer 1:

VR is not an alternative to any other method to collect patient data. VR does NOT generate data, it is just a tool to visualize tumor. Therefore, there no "advantages" or "disadvantages", they are different things.

CT scans and gene panel tests are both excellent ways to collect data. our tools cannot really be applied to patient yet, although we hope they will in the close future.

The main advantage of VR tumor is that it is easier to display very big amounts of data in a way that is more immediate for humans to understand. This enable us to learn detail structure of tumor and characterize it.
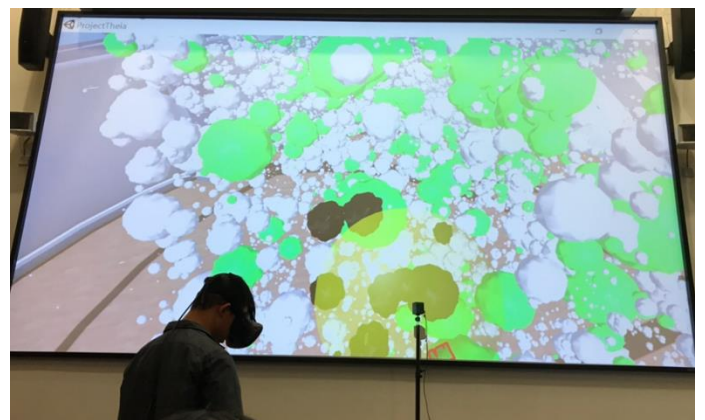
What a VR tumor looks like

Question 2. Can you use a VR models to test the efficacy of drugs?

Answer 2;

  VR model is just a method to analyze the tissue and visualize it. If we want to do that, biological model is necessary. You can use this to know how exactly each drugs acting. For instance, there are two or three different types of cells in a tumor, drug is affecting one, but it is NOT affecting the other.

Sometimes, 90% of the tumor cells are killed by a drug, but the 10% are remain which are actually most dangerous. That is very important to know.

Question 3. Is it possible to verify the relationship between cancer cells and other normal cells around them by using VR model?

Answer 3;

The idea means the reason for doing research. We can measure what normal cells and cancer cells surrounding them look like. We don't see them interacting at a real time because this is the sample taken off from a patient. If we know that a tumor cell is expressing a gene which has a certain function, and normal cell is expressing another gene which responses to that, we have a pretty good evidence interaction between them.

Question 4. Is there any ways or possibilities to use this technology for drug discovery?

Answer 4;

We can figure out what is important in the tumor cells. For instance, if we see the interaction in immune system, and use some proteins or genes to escape the immune system, that is a pretty good target to use a drug against. Right now, Drugs that attack cancer cells often attack normal cells, too. A VR tumor allows us to narrow the target which should be attacked. This will help to increase the safety use of drugs.
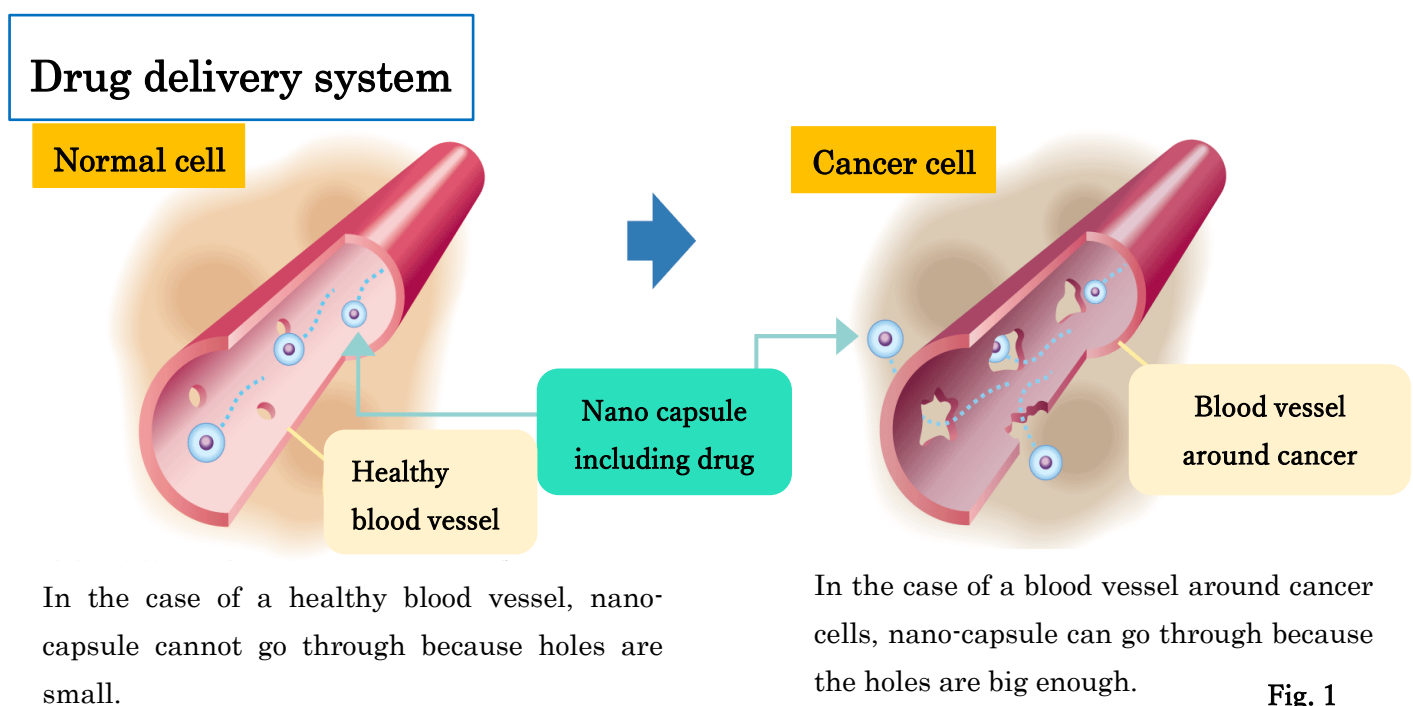
Discussion

It's difficult to use a VR model for drug discovery, but we can learn many things that can be useful for drug discovery such as how drugs acting on tumors and which type of cells we should target.

Also, Dr Dario said, "If we figure out which proteins we should target new drugs to, we can collaborate with drug making companies to design drugs."

Metastasized cancer has the same properties as a primary nest. For example, if the colon is the primary nest, the lung cancer which metastasized from colon has characteristic of colon cancer. So, we have to use an anti-cancer agent which is effective in colon cancer to treat lung cancer. It is difficult to determine where a primary nest is in an advanced stage of cancer, and this sometimes prevents us from deciding a treatment policy.

Now, the project team has succeeded to create breast cancer model. If tumor models of other cancer are created, characterized, and applied to each patient, it will be useful to determine how to treat the cancer faster and more accurate.

VR tumors enable us to learn the detail structure of tumor, the relationship between cancer cells and normal calls, and the target which we should use drug against. I think if these aspects are combined, a drug delivery system, which uses nano-capsule, will be developed.

Drug delivery system

Normal cell

Cancer cell

Nano capsule including drug

Healthy blood vessel

Blood vessel around cancer

In the case of a healthy blood vessel, nano-capsule cannot go through because holes are small.

In the case of a blood vessel around cancer cells, nano-capsule can go through because the holes are big enough.

Fig. 1

The system can deliver drugs only to cancer cells, because the capsule including drugs go through a blood vessel around cancer cells(Fig.1). So, we can reduce side effects greatly. Also, economic burden is reduced because we can deliver drugs accurately and a small amount of drug is enough to treat. To establish this system, information from a VR tumor will contribute a lot.

Furthermore, I think there is some possibility that information about gene (stated in question 3) will be able to develop a method of gene therapy using nano-capsule. Now, it is a big problem for gene therapy to discover a virus vector which is safe (does not have pathogenicity) and effective (carries genes surely and is not killed by a immune system of people). A gene therapy which uses nano-capsule is important because it is free from this problem. This plan has already been studied.

As I wrote in Fundamentals, cancer cells gradually spread to surrounding normal cells by gaining nutrient from blood vessel around them. I think if we know the relationship between cancer cells and other normal cells, it will be useful to develop a method to stop cancer progression like cutting off the nutritional source of cancer cells. Cancer metastasize when cancer cells move through blood vessels and lymph vessels to other organs. So, this method will enable us to stop cancer metastasis, too.

Currently, it is impossible to see a VR model varying over time. However, this will allow us to observe a process of cancer progression and cancer death. Also, there are problems of safety and applicability to use some data from VR model because it's just a sample and does not correspond to each patient. I hope that this technology will be improved to deal with these problems and widely used.
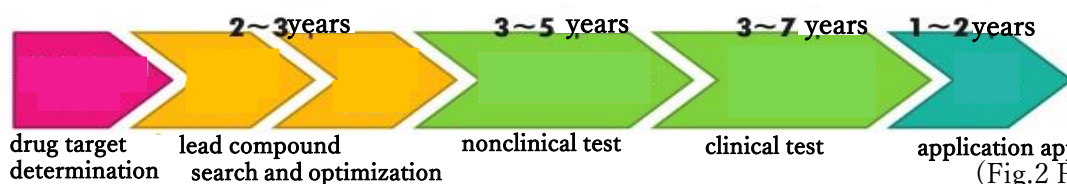
Conclusions

What is necessary to fewer side effects of drugs for cancer treatment?
1. Learning the details of the structure of cancer
2. Finding the target using drug against
3. Searching substances or method that can be useful and effective for treatment
4. Conducting tests in order to confirm the safety of the drug

Throughout the interview with Dr Dario, I have learned a VR tumor is a great tool in learning a structure of cancer and finding the target of the drug.

Now, it is difficult to use a VR tumor to search substances or methods which are useful for drugs and to check the safety of them because a VR tumor is just a tool to visualize a cancer tumor. I hope this technology will be improved, and these things will be possible.

It takes a long time to develop new medicine. Especially, nonclinical test, which uses animals to test the safety of drugs, takes three to five years, and clinical test, administering drug candidate to healthy adults or patients, takes three to seven years (Fig.2). This has been one of the biggest problems in drug discovery.

2~3years 3~5 years 3~7 years 1~2years

drug target determination   lead compound search and optimization   nonclinical test   clinical test   application approval

(Fig.2 Process of drug discovery)

I think if these improvements come true, the time amount of that has been taken for experiments until now will be greatly reduced. This will allow effective drugs to reach patients faster. Also, innovative drugs may be developed because more ideas can be verified.

A VR tumor just has been developed, but a concrete way to use it has not been established yet. However, it can be applied to not only for drug discovery but also for various research on cancer treatment because it allows us to get important information about cancer. Depending on how to make use of this technique, the possibility is endless.

Though it was good that I could have a clear purpose about my research, but I shouldn't have excessively concentrated on drug discovery to have a wide perspective about cancer research. For example, it would have been good to able to ask more about the use of VR tumor in fields of other than drug discovery. The next time when I conduct research, I want to make use of this reflection and study further to realize a society where everyone can live a healthy life.

Acknowledgement

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