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Review Article

DESIGN OF EFFICIENT TRAP STRUCTURE FOR THE ANALYSIS OF SINGLE CARCINOMA CELL

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Abstract

In medical field analysis of single cell's properties is of great use. To analyze the properties of the single cell, a trapping structure is necessary. In This paper we propose different structures for trapping of cancer cells. The structure designed will be applicable to trap only cancer cells which have large size and also very hard unlike normal cells. So the normal cells passes through the region and cancer cells got struck there as more pressure will be there. Also we will find with which range velocity the blood should flow and what happens if the velocity exceeds the range.

Keywords: laminar flow, trap, velocity, cancer cell, normal cell

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INTRODUCTION

Cancer is a dreadful disease and many people are dying because of this cancer. It is generally an abnormal growth of cells in the other parts of the body [1]. The symptoms include bulging of the cancer affected portion, unwanted bleeding and many other. There are a variety of types of cancers approximately over 100 types. Of all those blood cancers is the dangerous and dreadful disease.

Tobacco usage is the main reason for maximum percentage of the cancer. About 22%[4] of the population are suffering with cancer because of this tobacco. And the remaining percentage is 10% are suffering because of obesity and unhealthy diets. The other factors which can cause cancer are exposing to radioactive materials, radiation etc. 15% of the world is affecting with cancer because of infections such as hepatitis-B,C. This hepatitis is an infection which affects liver. It is mostly transmitted from mother to child during birth and delivery time.

Many cancer diseases are curable if they are identified and treated at a right time. They are naturally eliminated by quitting smoking, maintaining healthy habits like doing exercise daily and consuming healthy and hygienic food like eating more amount of vegetables, fruits, groundnuts, grains, and dry fruits, Consuming less amount of alcohol, not eating more red meat and less exposure of dangerous sunlight that is in the afternoon during midsummer, usage of vaccination against different diseases [3]. By maintaining all the above food habits and prevention methods the cancer can be controlled and can be cured easily. In the later stages it is really difficult to cure cancer [1].

Now coming to the symptoms in the initial stages cancer will show very less symptoms or even no symptoms. Symptoms gradually appear when the growth occurs at a faster stage and in the later stages only.

Some of the symptoms include local symptoms which appear to our naked eye like bulging at a particular point and bleeding[3]. This is the later stage of cancer. Also other symptoms like systematic symptoms which is not visible to naked eye but a sudden loss of weight, fatigue and even color of the skin also changes gradually with less time. Some cancers like leukemia can also cause unconditional fever which leads to serious illness of the individual. Also some systematic symptoms are mainly caused by hormones or the other cells or molecules in the tumor part this is called paraneoplastic syndromes. Paraneoplastic syndromes include continuous constipation and dehydration which can even cause mental stress and headache.

CLASSIFICATION

There are different classification of cancer cells. The classification is mainly based on the type of cell that the tumor cells look like and it is then considered as the main starting stage of the tumor. Cancer is usually represented using carcinoma sarcoma as the suffix with the Greek or Latin word for that particular specific organ or tissue. The different types of tumor are Carcinoma ,Sarcoma,Lymphoma and leukemia,Germ cell tumor and Blastoma

1.Carcinoma: This type of cancer is mainly derived from epithelial cells. This type of cancer mainly include different types of cancer like lung cancer[6], pancreas cancer, breast cancer and colon cancer.

2.Sarcoma: This type of cancer mainly arrives from bones, cartilage, fat and nerve. Each of the above described will develop mainly from the cells which are present outside of bone marrow[8].

3. Lymphoma and leukemia: These two types of cancers mainly arise from blood-forming cells. These mainly occur in the middle part of lymph nodes and are often described as more dangerous as the total blood is spoiled because of this cancer and the total body will get effected and there is high chances of death in this condition[6].

4. Germ cell tumor: This type od cancer is mainly occurring from pluripotent cell which mainly occurs in testicle and the ovary. This type of cancer mainly causes damage to the genes and also may be responsible for spoiling the health of future generation [9].

5. Blastoma: This type of cancer mainly derives from not fully developed cells which is also called embryonic tissue. This type of cancer will be identified mainly in pregnant women and even can transfer from mother to child.

Prevention: The majority of cancer cases occur due to environmental factors. Environmental factors include the life styles of the people[10]. Generally the cancers which are caused by these environmental factors are generally curable and approximately 70 % of the chances are there to cure these cancers. The remaining 30 % of cancers occur because of consumption of ore amount of alcohol, excess usage of tobacco, Overweight or obesity, Unhealthy food habits, not doing exercise every day and lack of physical fitness, air pollution, water pollution, sound pollution, environmental

pollution. Some environmental cancers are not even controllable like radiation etc and the only way to prevent this type of cancer is less exposure to sun mainly in the summer and in the afternoon [3].

Also many vaccines are made available to detect and treat cancer [2]. In the olden days it is really difficult to treat cancer because of lack of medicines and poor people cannot afford but in the recent years the days have changed there are many vaccines to prevent cancer but the only issue is we have to detect cancer in the early stages only.

There are less chances of curing of cancer cells once they got hardened and even if we go through laser screening also they cannot be cured because the cells in the tumor forming area gets large size and also very hard to touch.[11]. The main motto of this project is to identify the cancer cells in the blood with most probability that means even small size cancer cells also should not escape through our design. Because of the poor diagnosis only many people are losing their lives. The person who got affected from cancer seems like a normal person in the initial stages [12-15]. But when the cancer starts growing gradually day by day then life will be a disaster and it is really difficult to survive until and unless you have good will power.

There are certain differences between a normal cell and a cancer cell. They are Cancer cell is hard to touch and the size of the cell is very huge. Nuclei which is mainly heart of the cell also loses its size and shape.

The arrangement of cells in the cancer cell is different from normal cell that is in normal cell the cells are arranged in series but in the cancer cells more cells accommodated in small place. There will be a loss of normal feature that means there is a loss of shape and morphology.

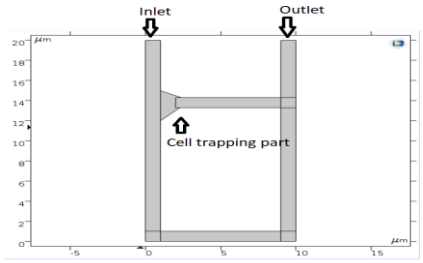

Figure 1: General model for trapping of cell

The above shown figure is used to trap cancer cells. The main problem we identified in this model is as this is a vertical cross section, if the force increases then there are fewer chances for trapping of cancer cells in cell trapping part [16-18]. So we designed an efficient model for trapping of cells in this paper.

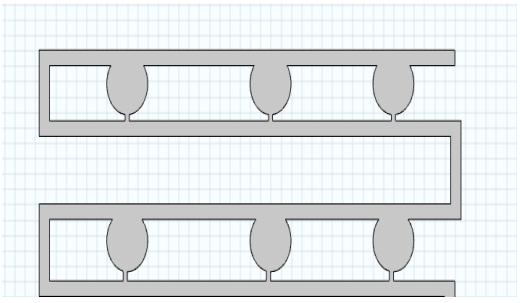

Figure 2: latest model for trapping of cell

The above described design that is figure 2 is helpful to trap cells efficiently even though there is more force as the design is horizontal flow so gravity acts on the cells and intentionally tries to push the cells into the trapping region.

DESIGN METHODOLOGY:

In this project the structure will be created in such a way that only single cell is trapped and with most probability. The below represented structure defines our ideology for trapping single cell and after cell is trapped in the specific region the flow will forward to the next regions continuously.

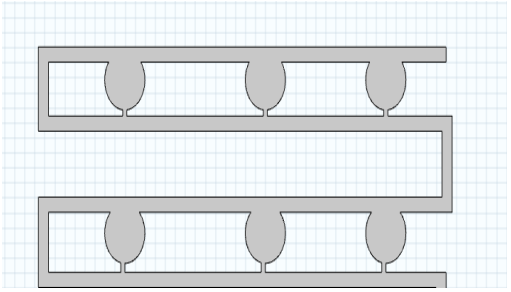

Figure 3: model for trapping of cell

From the above design we can draw three important parts. The parts are mainly important to analyze the structure easily and help to identify the inlet flow of blood and also outflow flow of blood and the trapping region.

The parts include: Inlet, Outlet, Cell trapping region

Inlet: The inlet is the region through which the blood flows through the structure defined. Through blood the cancer cells as well normal cells flow. The width of this would be 100micro meters so as a result big size cancer cells, small size cancer cells and large cancer cells all will flow through the inlet.

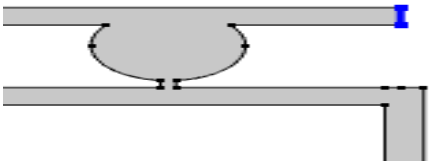

Figure 4: Inlet through which blood will be sent

Outlet: The blood which is flown inside passes through several regions and also through several trapping regions and finally comes out through outlet. Simply outlet is defined as a part through which the entered blood will flow out

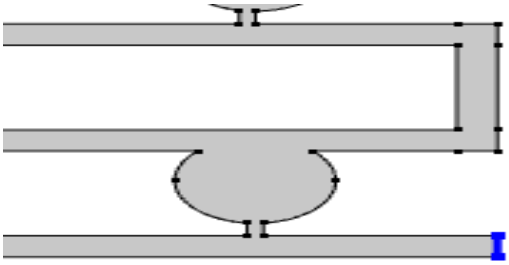

Figure 5: Outlet region from which blood will flow through next regions and also outside

Cell Trapping region: The trapping region is the region which is a narrow opening through which more amount of blood flows because of pressure accumulated in the region because of small opening. Generally the size of the trapping part is in the region of 10-15 micro meters because the normal cells will generally be less than 10 micro meters. So to trap cancer cells the range should be more than 10 micro meters.

Figure 6:Cell is trapped in the small opening from big circle to next pipe.

The cancer cells which are hard cells are more than 15 micro meters size. These include small size cancer cells and medium

size cancer cells and large size cancer cells as well. So there is more probability for trapping of cancer cells.

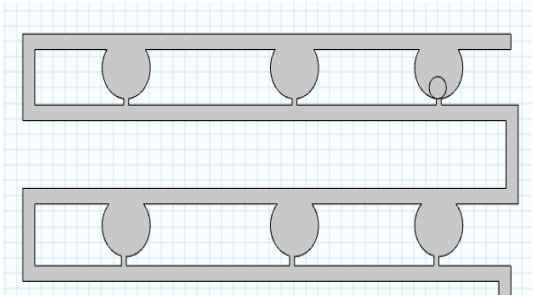

Figure 7: A single cell trapped in the trapping region and prevents the flow .

The cell gets trapped due to high pressure in the small opening. The probability may further increase if we can build the similar type of structures for different layers and for long distances. That means if the number of trapping regions increases it may increase the probability of all cancer cells being trapped in the trapping region and easy to analyze.

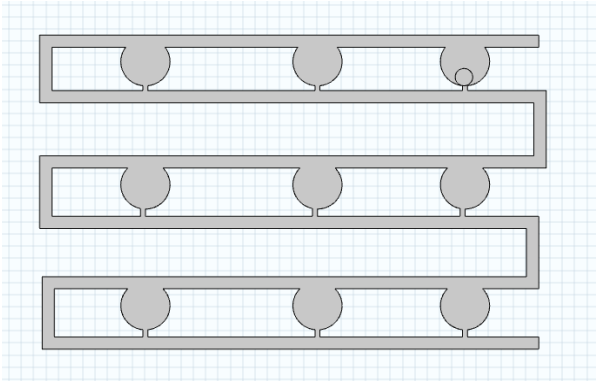

Figure 8: Continuous trapping regions for trapping more cells easily.

From the above simulation model we can identify that the cells trapping regions are increased because of increasing of probability of trapping so that no cancer cell should escape from outlet. It is a type of analyzing which analyzes the intensity of cancer that is whether the cancer is in the earlier stages or not. Also we can come to a conclusion that the cancer is curable if it is in the earlier stages and can take most care for eliminating of cancer from the person's body.

METHODOLOGY FOR IDENTIFICATION:

Normal cells along with cancer cells flow through the inlet. The velocity plays a major role in the implementation part because if the inflow velocity increases then there is a chance that the cells might not trap in the trapping region and may flow continuously and to outside through outlet. If this happens then the importance of this structure cannot be identified. So a particular velocity should only be used.

Measuring of velocity: As described velocity is the important factor in trapping of cells. The velocity should be less than 10^5 m/sec. If the velocity increases the range then there is no flow through the trapping region and the structure becomes useless. So careful determination of velocity should be necessary.

In COMSOL we are using stream line concept which determines the flow of blood through the chambers by lines. The more the number of lines the more the rate of flow of blood. This is the important part as we can identify rate of flow is more in the trapping part which is the main reason for having more pressure and also cells being trapped there.

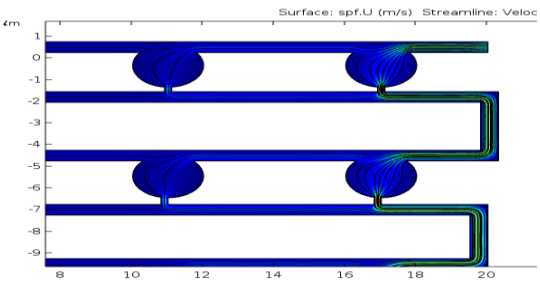

Figure 9: Streamline simulation of results

The above simuation shows the streamline flow of blood. The lines represents the rate of flow of blood. It is observed that the rate of flow of blood is more in the trap region from the diagram. Also as the structure goes to next chambers the rate of flow decreases because the flow mainly maximises to the trap region because of small size. And as we all know gravity also plays a major role so the flow generally flows down. So this is the main reason of having more lines in the bottom region.

Generally for designing of any equipment we may use different materials like glass and other materials which should not conduct electricity but it should give accurate results. So the material considered should be based on the requirement. Blood is another material or simply component we used in the simulation. The blood consists of both cancer cells and normal cells will be flown throughout the design.

RESULTS

Designing will be completed and now simulation results. The COMSOL software provides good environment for these types of design and the simulation results are as follows.

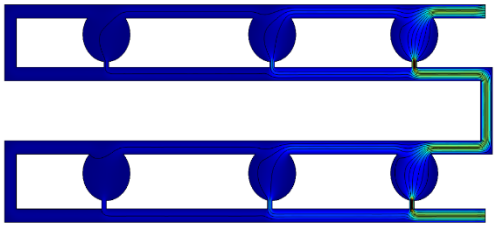

Figure-10: Simulation results if no cell is trapped.

The above diagram represents the simulation results if no cell is trapped. The blue color region defines the rate of flow is low and also the lines will define the same thing. And the dark colored which is brown colored indicates the rate of flow is more and the lines also indicates the same thing.

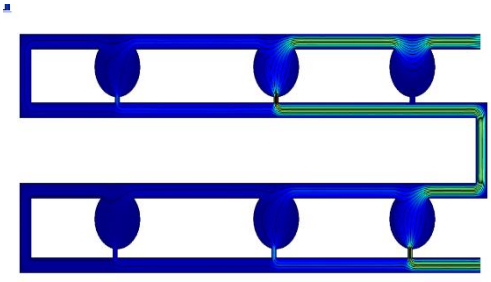

Figure 11: Simulation results after a cell is trapped

The above simulation results show the structure when a cell is trapped. A single cell is being trapped in the trapping region and as a result the flow is then concentrated to next trapping region. The flow will enter up to half only and the remaining will flow to next layers.

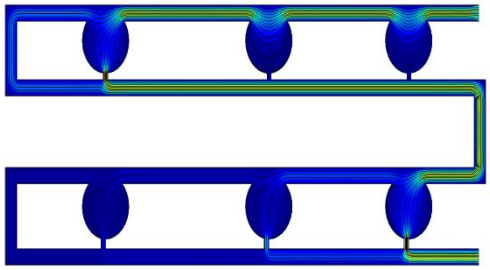

Figure 12: Simulation results after two cells are trapped

The above simulation results show the structure when two cells are trapped. A single cell is trapped in two trapping regions and as a result the flow will mainly concentrate onto the final trapping region as seen in the above results. The first and second trapping regions have cells trapped so the flow will not go forward and will push back to next layers.

DETERMINATION OF VELOCITY VALUES

Velocity determination is the crucial part as described earlier. The project also defines what value of velocity should be considered for efficient flow of blood through the different layers.

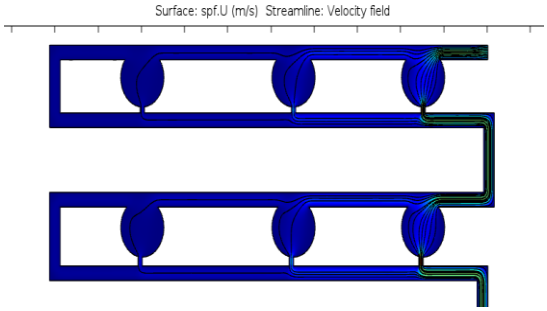

Figure 13: Simulation results when velocity is 0.001m/s

The velocity in the above case is 0.01m/s. It is the minimum velocity with which the blood should flow through the different regions. In this condition the simulation will be normal and if no cells are trapped the blood flow through the layers easily.

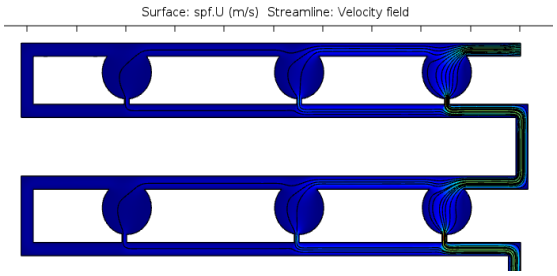

Figure 14: Simulation results when velocity is 10m/s

When the velocity is 10 m/s there is a slight change in the flow rate which we can observe from the above simulated results. The change can be identified easily by seeing the lines. There is a variation of lines which defines the change of rate of flow.

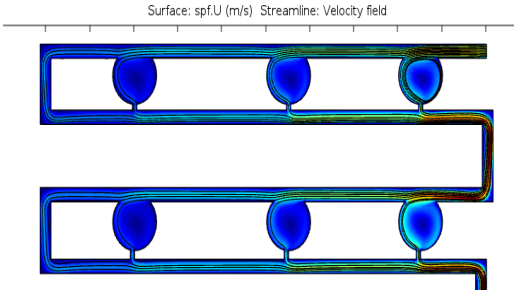

Figure 15: Simulation results when velocity is 100m/s

When the velocity is increased from 10m/s to 1000m/s then we can identify the variation of flow rate. The flow rate gradually decreases in the trapping region. So as a result cell flow will also be less in trapping region. So cancer cells may not get trapped. So it should not be considered.

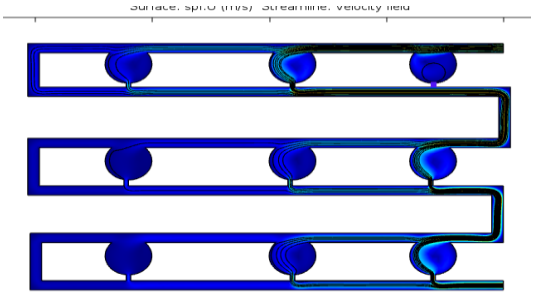

Figure 16: Simulation results when velocity is 10m/s

The above simulation results show the regions of trapping when the velocity is 10 m/s and a cell are trapped. When the velocity is 10m/s and a cell is trapped the flow concentrates to the next regions quickly and if all the regions of the first line are filled with cells it will passes through second layer.

If the number of regions also increases the flow rate will be zero in the last region and the rate of flow gradually decreases from first layer to last layer.

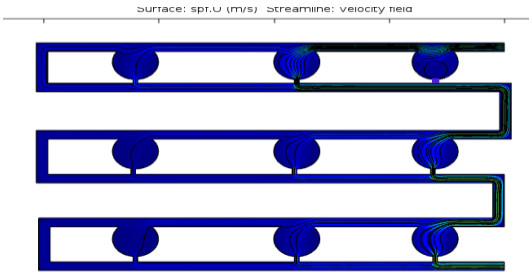

Figure 17: Simulation results when velocity is 10m/s and cell is trapped

This is the ideal condition as the flow rate is 15m/s there is a flow of cells from inlet until the last region. So there is a high chance of cell getting trapped if the flow is through all chambers. So 15m/s is the ideal flow rate.

OBSERVATIONS

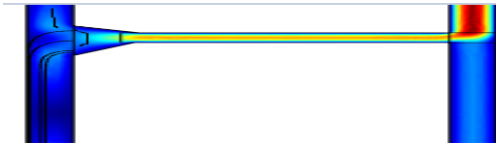

Figure 18: Simulation results when velocity is 10m/s in previous paper

The above simulation shows that the fluid flow is mainly concentrated downwards which we can observe from the lines from the figure 18. So there is less chance of trapping cells in trapping region.

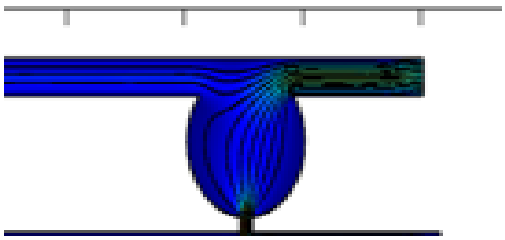

Figure 19: Simulation results when velocity is 0.1m/s in latest design

Where as our new design is the improved version of trapping of cells. So there is a huge chances of trapping of cells which we can even observe from the lines of the above simulation figure. More lines are concentrated in the trapping part which defines the trap as most efficient one.

CONCLUSIONS

Finally, we conclude that the simulation of methodology for trapping of cancer cells is successfully done and the trapping part is mainly useful to trap single cells and also defined to cancer cells. This is one of the most accurate methods to trap single cells and also to trap cancer cells. Also we determined the range of velocities to be used for effective trapping of cells. So by selecting the velocity in particular range we can determine whether cell is trapped in the trapping region or not. Also we determined the efficient trap methodology.

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