

# Analyzing the Effective of Laser Spot Size on the Blood Clot

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**Abstract**—Blood clot is one of the series deceases for human body now a days. There are many types of blood clot depend on the location and type of the tissue. Blood clot causes when the blood flows into vessel and contact with specific material with the vessel wall. Lasers use in treatment of blood clots. The treatment of the blood clot is dependent on the type and the properties of used laser. One of the important proper of the laser is its spot size. Size of the blood clot and the laser beam have been analyzed. From the results we got the factor that gives a rescannable treatment.

**Index Terms**—Laser-Medical application-Blood clot

## I. INTRODUCTION

There are many blood deices that effect on human health, one of the most Effective, which is a wide case in the world, is the blood clot . Human life suffers of it and some time it causes a heart attack(as well as other effects on the heart).[17] There are many types of blood clot depend on type of tissue, it's size and the position (or the location).

Blood clot form when the bleeding from injured stop by blood platelets. But some time blood cells accumulate to make a blood clot and stroke at vessel wall.

Laser use in medical application widely and there are update technique especial in blood devices such as blood clot, varicose, blood vessel injured.

The treatment of blood deices usually be by one of the following methods surgery, clinical treatment or by laser with fiber optics. The laser method is , there are many types of lasers depend on type of wavelength, beam radius, power and so on....

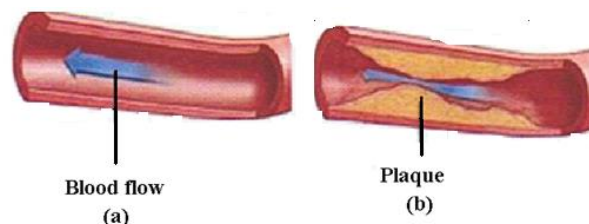
There are many research on blood clot treatment such as [1]blood clot simulation model using Bond-Graph Technique. And (Shiyal I U)[2] it measured of toughness and critical length scales for fracture mechanics of blood clot.

## II. Causes of Blood Clots [3,4]

The blood and materials carried by arteries from the heart to organs. And veins transferred it back to the heart. For some reasons some time the blood easily flow and sometimes blood through these pipes or vessel will be slow down or get blockage.

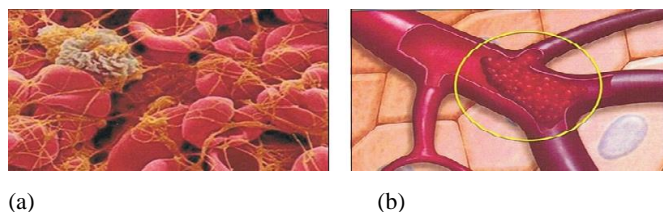
Medicines called “thinner smoke” it hard for anybody to make clotting factors, into blood clot is a clump of blood “which the blood from a liquid to a gel-like or semisolid state”. blood

Sometime there is a damage inside a blood vessel. That's when blood cells can adhesion or stick together and form a clot. The wars case of blood clot can be happened where the clot caused a blockage in the blood stream, as shown in figures (1 and 2)



Artery blood flow :- (a) Normal Artery, (b) Artery with Atherosclerosis

Fig(1) Artery Bloodstream



Fig(2) Thrombosis

The blood clot life cycle depends on number of chemical interactions for example :

- a-Platelets form a plug. when a blood vessel is damaged
- b-Grows of the clot,
- c- The growth will stop reaction.
- d-The body will breaks it down slowly. “Such as the damaged tissue heals”

As well as the cholesterol plaques in arteries have these things inside, If the

plaque breaks open, they'll start the clotting process. Most heart attacks and strokes

happen when a plaque in our heart or brain suddenly bursts.

## III. Laser perform

### A. Technique of laser

One of the modern medical applications of laser is using laser to homeostasis treatment. Usually, the laser use with optical fiber(by

Catheter System).The characteristics of laser system that important are wavelength, duration time, and beam diameter or beam spot size [13,14].

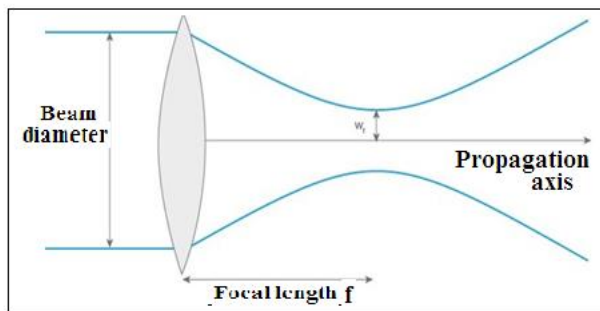
Table (1) treatment of Vera Wart by Pulsed Dye Laser, [13]

No.	Wavelength (nm)	Spot size (mm)	Energy Fluencies (j.cm <sup>-2</sup> )	Duration Time (ms)	Passes to each site
1	585	5	8.5 - 9.5	---	Not reported
2	585	5	8.1 - 8.4	0.45	3-5 passes
3	585	5-7	7 - 9.5	0.45	3-10 passes
4	585	5-8	6 - 9.5	0.45	3 passes
5	585	7	8	0.45	1 pass
6	585	5-7	5 - 10	0.45	5 passes
7	585	5	6.25 - 7.5	0.45	Not reported
8	595	5	16 - 20	1.5	Not reported

**B. Laser spot size [10,12]**

Usually a laser beam is focused called diffraction-limited if its potential to be focused to small spots is as high as possible for the given wavelength,

RMS spot size is calculated as the RMS spot radius in microns, on the focal plane of a lens. Only geometrical aberration effects are included. RMS spot size is measured on axis and at a field angle of 0.333o (the edge of the field) [16].



Fig(3) Laser Beam diameter

From the behavior of the light ,the propagation of a laser beam diameter will change along the optical path , so according to a Gaussian beam the radius of the laser beam (w) will change the axis (z) which define by following:

$$w(z) = w_0 \sqrt{1 + \left(\frac{\lambda z}{8\pi w_0^2}\right)^2} \dots\dots\dots (1)$$

where w0 is the beam waist (the smallest radius of the Gaussian beam) and is the Rayleigh length:

$$Z_R = \frac{\pi w_0^2}{\lambda} \dots\dots\dots (2)$$

The beam diameter is simply twice the beam radius and can be measured anywhere along the propagation axis.

When a Gaussian beam focus with a lens of focal length f, the beam waist (or laser spot size equation) becomes:

$$w_f = \frac{\lambda f}{\pi w_0}$$

At the focus point the spot size will be very small, and when it is out of focus (defocus) , the beam size varies along the optical axis. Measuring the path of spot size position of laser beam will give us different radius of spot size, there are a relation between the spot radius and value of defocus (where if the value of defocus increase the radius will increase put sully the intensity will decrease.

**C. Clot Treatments**

The laser thrombolytic is an international procedure that can removes clot by delivering microsecond pulses. The removal of clot result in a restoration of blood flow while maintaining vascular integrity.

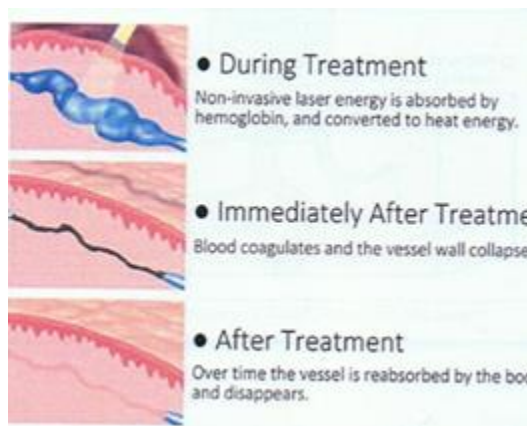
The clot treatments will take following procedure:

1. By laser:

Exposure the blood vessel (clot exposure) to the laser, this process will effect on the clot by:

- a-Heat it and dissolving.
- b-Breakup the blood clot.

After that by time the clot will disappear as show in the fig(4) [10,11]:



Fig(4) Show the exposure stages of blood vessels to the laser

2. By medications which affect the Clotting Process.

Some drugs stop platelets from signaling each other so they won't stick together.

The life cycle of a normal blood clot depends on a series of chemical interactions .Aspirin, Clopidogrel (Plavix), Dipyridamole (Persantine), Prasugrel (Effient), Ticagrelor (Brilinta), Ticlopidine (Ticlid)

The spot size is one of the main characters of the laser beam. Where spot size has a relation with wavelength. Power, and type of the tissue. All those parameters will effect on the penetration depth as shown in the fig(5) [7].

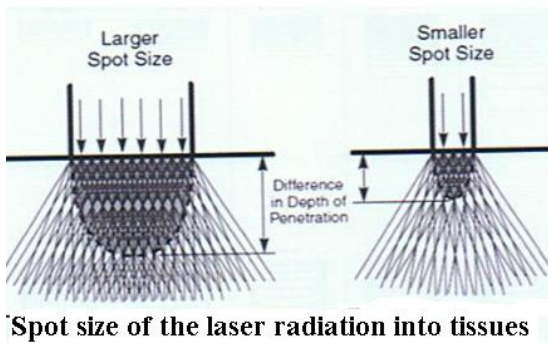
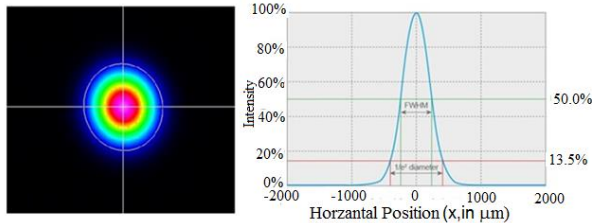


Fig ( 5 ) Laser spot size inside the tissue[7]



Fig(6) Beam radius and spot size

Usually, human body contain organs and different type of tissue which surrounded by different substances such as hemoglobin, water, blood tissue, each one has specific penetration depth. So, when the laser beam incident on the area, it will be absorbed by blood vessels and rupture of the thrombus bounds.

Choosing a laser wavelength must be carefully, avoiding absorbing the beam by other tissues, this means the laser color (wavelength) must not be same as the color of the tissues. Table ( 2 ) show some elements of materials with its wavelength[5,6,12]:

Table ( 2 ) Show some elements and its color (wavelength). [5,6,12]

No.	Element	Wavelength (nm)
1	Tissue	400-600
2	Blood	250-960
3	Hemoglobin	400-800
4	Skin (white)	633-700
5	Skin (dark)	700
6	Clot bond	22.5
7	Water	1200-300
8	Bond	488-1064
9	Muscle	515
10	Brain	633-1064

IV. Results and discussion

The main parameter of laser which effect on the result is laser intensity which represent the focused laser beam applied in the region of tissue

interaction with the photon this case represents the depth along the direction of the laser radiation can be occur by two forms:

- 1-Irradiation (power density) the power of laser per unit area (w/cm2).
- 2-Fluency (energy density) which is the power density multiplied by exposure time(joule/cm2 ).

This power indicates the degree of concentration of the power output.

To define the intensity is the amount of energy present in the volume of laser interaction with tissue or within vessels

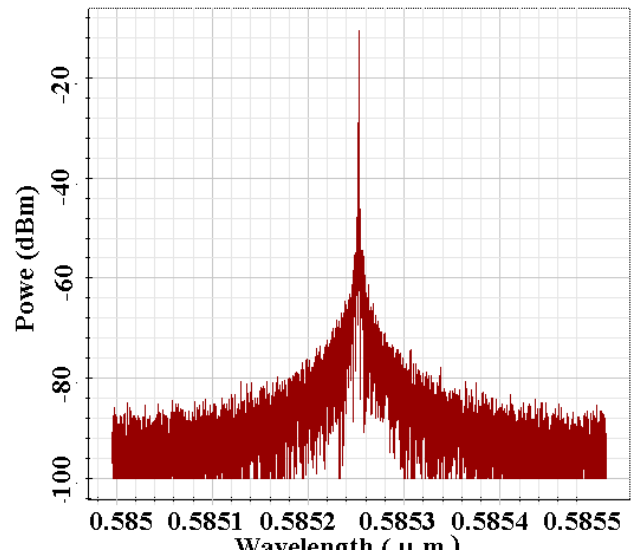
We got the results by using the programming package (Optics System) [18] as shown in figures (7,8,9) that show optical spectral width for a laser with different wavelength for a laser that can used according to clot size and tissue color (wavelength), (in order not to make an interference between the laser and tissue). There is relation between wavelength and spot size (beam radius), as shown in table (3).Also, we found for the same wavelength there are different spot size related with the position of it along the optical axis of the beam as shown in the figure (3& 5). Even the intensity will be less but it helps to cover the clot size.

Table(3)Relation between wavelength & beam radius

sq	Laser wavelength	Spectral width	Figure no.
1	585 nm	0.0004 μm	Fig.(7)
2	595nm	0.0005μm	Fig.(8)
3	1050nm	0.0008μm	Fig.(9)

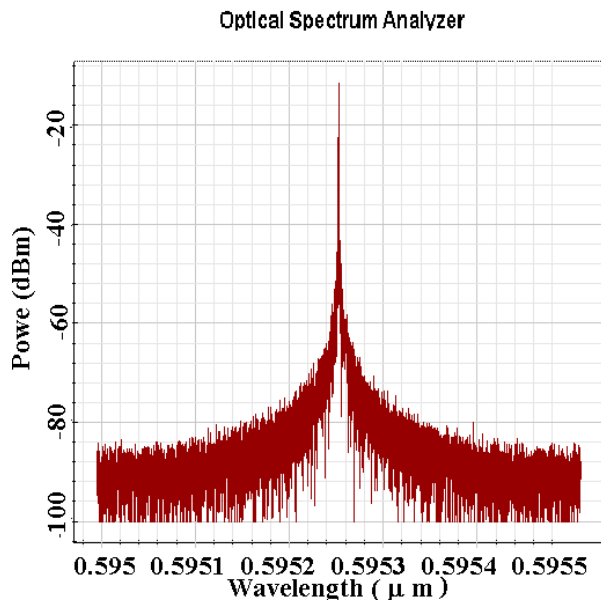
Wavelength 585 nm

Optical Spectrum Analyzer

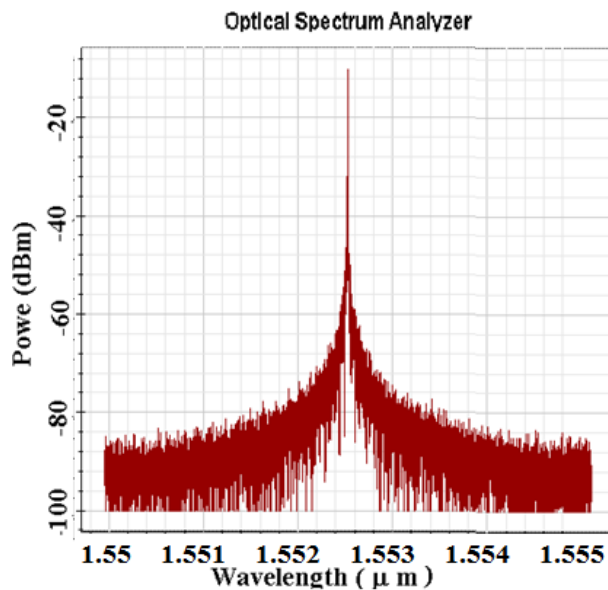


Fig(7) Optical spectrum of Laser wavelength (585nm)

Wavelength 595 nm



Fig(8) Optical spectrum of Laser wavelength (595nm)  
Wavelength 1550



Fig(9) Optical spectrum of Laser wavelength (1550nm)

## V. Conclusion

Using laser technique in treatment of the blood clot is a modern method with a good result.

When using the laser, specifics laser should be careful to choose the and the Fiber optics, which is stable to vessel and blood clot specially the fiber radius Because the fiber size is limited & constant it can't use in any vessel) and spot size of the laser.

Usually, the laser use to dilute the blood clot or break it down into small pieces (it depends on the clot size).

It is possible to use the laser more than once on the same clot (when the clot is big in size).

It is important to choose the wavelength of the laser which should be different than the tissue color to avoid the interface between wavelengths and get successful results.

It is possible to change the spot size according to the blood clot size for the same laser by defocusing the laser.

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