Baghdad Science Journal **Vol.7(1)2010**

A comparative study of the effects of argon laser and continuous Nd: YAG laser on blood vessel

*May Fadhil Majid Al-Habib ** *Munqith Saleem Dawood ***
*Isra'a Fa'aik Abdul-Azez ****

Date of acceptance 28/ 2 / 2010

Abstract

Several types of laser are used in experimental works in order to study the effects of laser on blood vessel. They differ from each other by a lot of properties mainly in wavelength, energy of the laser and pulse duration.
In this study argon laser (488 nm- 514 nm) and continuous Nd: YAG laSer (1064 nm), have been applied to 50 samples of sheep blgod tesselS.
Histologically, tha results of the study were different According to the txpe of L`sar used; apgon larer had distrabtave effects on $he blood vessal while continuous Nd: YAG laser Appeaped to be the safesd one on the blmod vessel architecture.

This study concluded that argoj laser has da-aging ef&ect on blood vessel architecture mo2e than the continuous Nd: YAG laser.

Key word:Laser,argon laser, Nd:YAG laser,blood vessel

Introduction

Several types of laser are used for lasar angioplasty and in experimental works to study the effects of laser on bloOd vessel and blnod clet. They dIffer from each other by many properties mainly in wavelength, energy of the laser and pulse duration. Argon laser and Nd: YAG laser are useD widely in the !blation of atheroma and in the re-canalization of occluded vessels [1].

The argon laser was one of the first lasers used in clinical applications. It emits a blue green light at 488 - 515 nm which are strongly absorbed by both hemoglobin and water [2]. Continuous Nd: YAG laser is attractive for medical applications because of its competence, versatility and average power capability [2, 3]. The interaction between laser energy and vascular tissue is largely governed by wavelength and energy profile of the the emitted laser radiation. Safety, reliability, portability, and suitability for medical application are also important to be considered [4].

` In this study we attempt to study the effects of these two types of laser on blood vessel architecture.

Material and method

An *in vitro* model has been established using 50 samples of common carotid artery taken from sheeps placed in normal saline 0.9% immediately after butchering.
Fresh non- heparinized blood was collected from human and was injected inside the blood vessel before applying laser. The blood vessel was directly treated by the following types of laser:

* Department of Human Anatomy, College of Medicine, Al-Nahrain University
** Department of Medical Engineering, College of Engineering, Al-Nahrain University
*** Department of Biomedical Engineering, Al-Khwarizmi College of Engineering , Baghdad University

Continuous argon laser model 150m /S.N:0205351) with fiber optic core diameter =300µm, the wavelength of argon laser is 488- 515 nm, at power 100 mW and 3.5 minute.

Continuous Nd: YAG laser model (Intelite S.N:S030411) with 1064nm wavelength at power 135mw for 5 minute.

Samples were fixed in 10% formalin and stained with H&E and Van Gieson stains, then processed for light microscopic examination.

Results:

It is crucial to determine the optimum time exposure and power used in argon laser. Light microscopic examination of section stained with H&E showed marked effects by this type of laser on intimal layer. Detachment and flapping of total length of endothelial layer were identified in all sections examined in this experiment, as shown in figure (1) and figure (2).

Segmentation of the intimal layer has been noticed in some section without intimal flapping, as shown in figure (3).

Disfiguration and disarrangement of tunica media have been clearly seen with evident of separation between elastic and smooth muscle fibers, as shown in figure (3) and figure (4).

Van Gieson stained sections were used to clearly distinguish between smooth muscle fibers from elastic fibers, separation of bundles of elastic fibers was noticed from smooth muscle fiber, as shown in figure (4).

In addition to the above mentioned changes the elastic fiber at tunica adventitia showed a non uniform arrangement with noticeable spacing between their fibers, as shown in figure (1) and figure (2).

Elastic fiber situated at the tunica media nearer to tunica intima seems to be affected more than deeper fibers that are near tunica adventitia, as shown in figure (1) and figure (2).

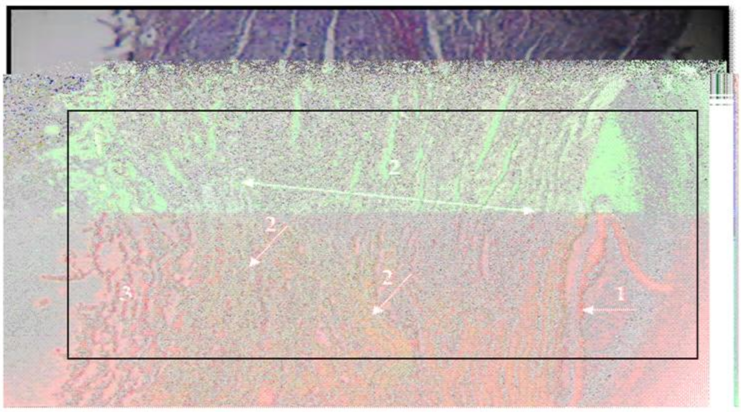

Figure (1) A blood vessel treated with argon laser showing endothelial layer, detachment and flapping from the under layer, 1- Endothelial flap and detachment Intima flap of tunica intima
2- Disarrangement of muscle and elastic fiber of the tunica media
3- Disfiguration of tunica adventitia H&E (X200)

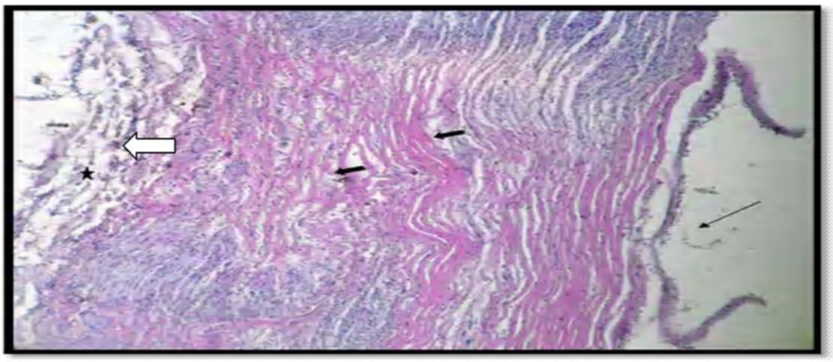

Figure (2) Higher magnification of the selected area from the previous figure shows:

Complete endothelial layer flap detachment from the below layer (←).

Evident separation of tunica muscle fiber (←).

Disfiguration and disarrangement of tunica adventitia (⇐).

Argon laser, H&E (X400).

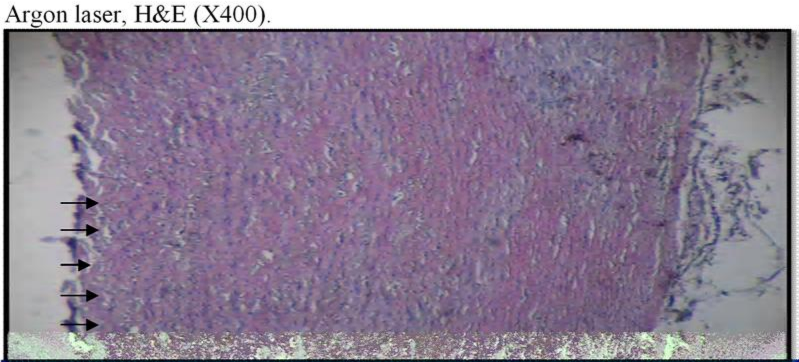

Figure (3) Section in blood vessel shows segmentation & early detachment of endothelial cell layer (arrow).

Argon laser, H&E (X400).

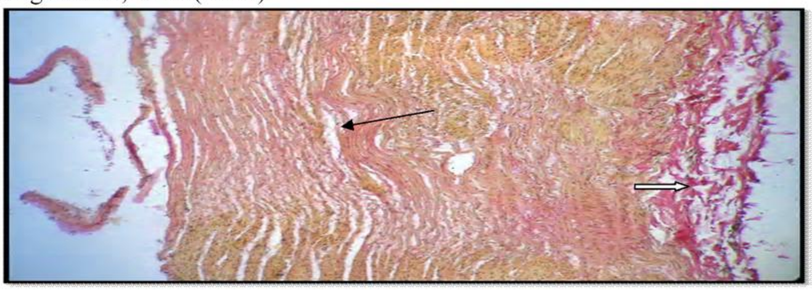

Figure (4) Yellow smooth muscle fibers seem to be intact, elastic lamellae fibers are disarranged with spacing between them. (←)

Notice the disfiguration of elastic fibers in tunica adventitia. (⇒)

Argon laser, Van Geison (X400).

Examination of H&E stained section of the blood vessel cross section treated with continuous Nd: YAG laser showed that the three layers of the vessel are intact with no intimal detachment.

Both elastic fibers and smooth muscle fibers are not affected and look uniformly arranged, as shown in figure (5) and figure (6).

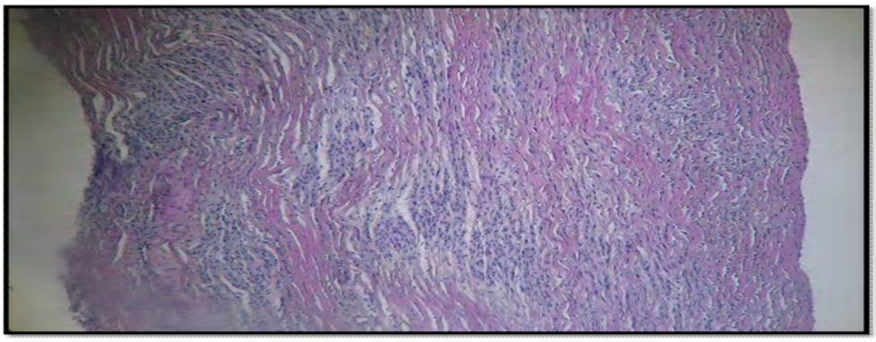

Figure (5) Cross section of the blood vessel shows the three intact layers. Continuous Nd: YAG laser, H&E (X400).

Figure (6) Cross section shows the intact of the three layers of the blood vessel. Continuous Nd: YAG laser, Van Geison (X200).

Discussion

Argon laser has been used at power 100 mW for 3.5 minute according to preliminary studies and previous researchers, depending on the fact that argon laser at this wavelength is visible and easy to collect, the beam can be introduced via the fiber optic inside the blood vessel.

Histological feature illustrate intimal flapping and endothelial layer discontinuouty. It seems that the argon laser have destructive effect on the tunica intima and less effects on tunica media and tunica adventitia, this can be observed by intimal flapping and the discontinuity of the endothelium lining layer.

The immediate and long-term effects of Argon laser radiation on normal vessels in dogs were studied by Abela et al., in 1983 [5]. Scanning electron microscopic examination of the tissue immediately after irradiation showed interrupted endothelial edges of the crater. Histopathological study revealed mild inflammatory reaction with fibrinous material around the crater.

It seems that intimal flapping and discontinuity of endothelial layer is due to the thermal effect of argon laser.

Welch et al., in 1987 [6] studied the histological damage produced by Argon laser heated probe in correlation to change the temperature. They found a gradual cellular dehydration and coagulation started when the temperature exceeds C. The adventitial surface of the ˚60 vaporized blood vessel reached up to C. They also found a direct ˚70 correlation between tissue vaporization rate and applied energy.

Elastic fibers situated at the tunica media together with a few small muscle fibers in that layer were also affected. It seems that fibers nearer to the tunica media was affected more than fibers nearer to tunica adventitia, this seems to be due to the presence of the blood inside the blood vessel.

Fenech et al., in 1985 [7] found that the presence of blood enhances the argon laser beam effects on the arterial wall and produced much wider craters than that produced with saline solutions, so they concluded that blood might act as efficient heat conductor when Argon laser is used because it has a wavelength similar to the absorption spectrum of hemoglobin.

Continuous Nd: YAG laser used at power 135 mW and for 5 minute exposure.

Histological study of section in blood vessel treated with continuous Nd: YAG laser showed that there was no damage to any of the layers of the blood vessel; all layers were intact and uniform.

Bowker et al., in 1985 [8] examined the effect of continuous Nd: YAG laser inside the dog aorta via a proper optical fiber in order to determine the dose response, perforation thresholds and healing properties in vascular tissue. The outcome was examined histologically by light and scanning electron microscopy. The tissue exhibited features of laser damage that were less marked than those seen with pulsed wave lasers; there was less heat damage surrounding the craters which healed well, even after perforation.

It can be concluded from this study that argon laser at power 100 mW and time exposure of 3.5 minute has damaging effect on blood vessel architecture (especially on tunica media) more than the continuous Nd: YAG laser at power 135 mW and for 5 minute.

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دراسة مقارنة كل من الاركون ليزر وNd:Y laser على تركيب الوعاء الدموي

مي فاضل الحبيب*   منقذ سليم داوود**   اسراء فائق عبد العزيز***

*قسم الانسجة والاجنة ، كلية الطب ، جامعة النهرين
** قسم الهندسة الطبية ، كلية الهندسة ، جامعة النهرين
*** قسم هندسة الطب الحياتي ، كلية هندسة الخوارزميه ، جامعة بغداد

الخلاصه:

تستخدم انواع كثيره من الليزر في التجارب العمليه التي تدرس تأثير الليزر على الوعاء الدموي. وهذه الليزرات تختلف عن بعضها البعض بالعديد من الخواص مثل الطول الموجي، طاقة الليزر وزمن النبضه. ليزر الاركون، ليزر ثنائي اوكسيد الكربون و ليزر الان دي ياك استخدموا بصوره واسعه في استئصال الخثره الدمويه و اعادة فتح الاوعيه المسدوده.

في هذه الدراسه تم تطبيق ليزر الاركون (٤٨٨ نانومتر-٥١٤ نانومتر) و ليزر الان دي ياك المستمر (١,٠٦٤ نانومتر) على ٥ نموذج من الاوعيه الدمويه للخراف.

نسيجيا، نتائج الدراسه كانت مختلفه بالاعتماد على نوع الليزر الذي تم استخدامه حيث كان لليزر الاركون تأثير مدمر على الوعاء الدموي بينما ليزر الان دي ياك المستمر كان الأكثر اماناً على الوعاء الدموي.

استنتجنا من هذه الدراسه بأن ليزر الاركون له تأثير مدمر على الوعاء الدموي وليزر الان دي ياك المستمر كان الاكثر اماناً.