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Evaluation of breast mass excision by 810 nm diode laser

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Abstract: Breast mass is by far the most important clinical problem that concerns the breast today. This study was carried out to evaluate diode laser as a cutting tool in breast mass excision and as a hemostatic tool for coagulation during surgery. Using 810 nm diode laser with optical fiber 600µm in diameter of conical tip, udder (cow's breast) tissue, and three female patients (mean age of 35.5 y with clinically palpable breast mass) had been used in this study. The patients were followed up regularly postoperatively. In preliminary work on udder tissue, the power needed for cutting and excision was 15W (power density= 5.3 kW/cm^2). The time consumed for excision of a piece of udder tissue, 40×10×3 mm in dimensions was 5 min. The depth range of cutting was 2-3 mm. The speed of cutting was 0.6 cm/s. In the clinical work, the power needed for excision was 15 W (5.3 kW/cm^2 power density). Power used for coagulation was ranging between 10-15W depending on diameter of blood vessel, the overall blood loss during surgery and postoperatively appeared to be less than that in conventional method. The contact laser scalpel produced clear appearance of surgical margin and saved dissection. Hemostatic capability assured clear anatomical visualization and few ligatures. No clinical evidence of infection at the wound site postoperatively. The results showed that the diode laser is effective in minimizing the intra-operative blood loss, postoperative blood loss, and effective in reducing the postoperative pain, swelling and edema. On follow up the patients were presented with relatively better healing progress, no wound infections, and no need for strong pain killer postoperatively.

Introduction

About one out of 16 women will develop breast mass at sometime during her life (Bailey and Love's 2000).

One of the most important discoveries in the twentieth century is the discovery of laser in 1960 (Dixon, 1988). From that time till now the laser is used in different fields of medicine. With the introducing of laser in general surgical practice (Dixon, 1988), and the recent better understanding of photobiology and laser tissue interactions (Parrish and Wilson, 1991), it happened that laser became a useful tool in the hand of a competent surgeon. One aspect at which laser has been useful is for cutting and coagulation purposes (Gregory *et al.*, 1991).

There are many types of laser that can be used in medicine and it depends on wavelength, the kind of the tissue on which the laser applied and the wanted effect (Fuller A. 1987), e.g., the laser in ophthalmic diseases differs from that used in fragmentation of kidney stones (lithotripsy) or that used for excision of tumors. The power needed for these therapies is not the same; it depends on type of application, type of the tissue and even the type of pathology and its treatment (Markolf, 2003).

Maker and Snyder (Baxter *et al* 1999) have found the contact laser scalpel in conjunction with SLTs (surgical laser technologies) CL 60 Nd-YAG laser (1064 nm) provides clear dissection, coagulation and speed in all phases of contact laser mastectomy and breast mass

excision and only the laser is needed as one surgical tool to complete the whole operation.

The present work was done to verify dual action (coagulation and cutting) of diode laser in breast mass excision.

Patients and Methods

Three female patients, average age of 35.5 y (range of 21-55 y) with clinically palpable breast mass, were selected for this study.

Case (1): Fifty five year old female patient presented with left breast mass of 8 months duration, increasing gradually in size, associated with mild pain, no nipple discharge. The patient was menopause since 3 years. On clinical examination, left breast mass at upper outer quadrant region was found. It was 4 - 5 cm in dimensions, freely mobile, no attachment to the skin or underlying tissue, no discharge from the nipple, and no skin changes.

Case (2): Thirty year old female presented with right breast mass of 4 months duration, associated with mild pain, more pain with menstrual period, no history of trauma, no family history of breast cancer, no history of nipple discharge. On clinical examination, right breast mass was detected at the medial upper quadrant of about 7 × 5 cm in dimensions, freely mobile, not fixed to the skin or underlining tissues.

Case (3): Twenty one year old female presented with left breast mass of 3 months duration. The patient was complaining from mild pain, increasing in severity with menstrual cycle, no obvious increase in size during this period. The mass was not associated with nipple discharge. On interrogation there was no history of trauma at the site of the mass. On examination, generally young patient looked well. Bilateral breast examination revealed equal in size, normal skin, no nipple retraction. Examination revealed a mass at lower outer quadrant; it was about 3×5 cm in dimensions, with mild tenderness, freely mobile, no attachment to the skin or the underlying tissues.

The laser system

The laser system was a "Diomed 15" surgical diode laser. It essentially incorporate in (class IV) GaAlAs (Gallium Aluminum Arsenide) diode laser emitting at a wavelength range of 790- 830nm (near infrared) with a power output at laser aperture ranging from 0.5 - 15 W. It can be operated at a continuous or pulsed mode. The aiming beam is a visible diode 635 - 660nm (red beam) with a power of 4 mW (class IIIa diode laser at laser aperture). The accessory used was 600 µm conical tip optical fiber.

Preliminary work

An in vitro preliminary work was done to prefix parameters for cutting and excision. It was done on a piece of udder tissue, 0.5 kg weight, 20×10×5cm in dimensions using powers of 5, 10 and 15 W. During this work the power setting was changed to a higher wattage because tissue response to cutting was judged to be inadequate at lower setting. An incision of 9 cm in length, 3 – 4 mm in depth, 15 W power, and in CW mode was done in 15 s, i.e., 0.6 cm/s. A complete excision of a piece of this tissue, about 40×10×3 mm in dimensions using power of 15W, was done in 5 min duration. All the amount of the udder tissue was fixed on the table by needles at its margin, cutting and dissection of the measured parts (40×10×3 mm) done by perpendicularly placing the end of the optical fiber.

Clinical work

Under general anesthesia with endotracheal intubation, after painting the site of surgery with 10% of povidone iodine solution as antiseptic, surgical drape applied, curved skin incision was done at the site of the mass using an ordinary metallic scalpel. Using prefix dose parameters obtained from preliminary work, hemostasis was secured by the laser at power ranging between 10–15 W in non-contact way, using 600µm diameter optical fiber. The mass and edges of skin were fixed by silk as a stay-suture, for traction and counter traction to avoid using metallic tools that reflect the laser beam. Dissection started at about 2–3 mm from the margin of the mass, any bleeding have been secured by contact laser fiber tip at the site of bleeding, at power of 10–15 W depending on diameter of bleeder. Complete dissection of the mass from the breast tissue was finished in 30–45 min depending on size of the mass. This is approximately the same time needed in conventional method. After complete removal of the mass and securing hemostasis, (redivac drain was left in the case No. 1 only). Skin incision and underling tissues were closed by ordinary sutures, and then dressing applied. Safety precautions were applied using goggles

for the patient, surgeon, nurse, anesthetist and assistant anesthetist. Postoperatively there was no evidence of haematoma, or edema, few milliliter of blood in the drain, mild pain (there was no need for strong pain killer). Skin sutures were removed on the seventh post-operative day. Follow-up continued for 6 weeks, there were no complications.

Results

Preliminary work

Results were studied and revealed that power needed for cutting and excision was 15 W. During this work the setting was changed to higher wattage because the tissue response was judged to be inadequate at lower setting. The time consumed for excision of a piece of udder tissue (40×10×3 mm in dimensions) was 5 min. The depth range was 2 - 3 mm for each trial. The speed of cutting was 0.6 cm/s.

Clinical work

The collected results of these cases indicate that laser excision of breast mass provides the control and familiarity of a hand- held instrument, but with distinctive advantages over conventional surgical technique. The precision of the contact laser scalpel produces clear control of surgical margins and safe dissections of the major vein and vessels. The hemostatic capability assures clear anatomic visualization, and few ligatures. Overall blood loss and drainage appeared to be less than in the conventional scalpel /electrocautery method. The procedure required time approximately the same as for the conventional method, but with earlier mobility and less pain. Simple analgesia was required postoperatively as shown in Table (1).

Table (1). Results of laser breast mass excision.

Case no.	Intraoperative blood loss	Postoperative blood loss	Postoperative pain	Infection
1	Minimal blood loss	Few c.c. in redivac drain	Mild	No infection
2	Minimal blood loss	No drain inserted	Mild	No infection
3	Minimal blood loss	No drain inserted	Mild	No infection

When laser energy is absorbed by a chromophore (The main absorbing components in tissue including, hemoglobin in blood, melanin in skin, hair, moles, and water present in all biologic tissue), heat is dissipated in the target. Depending on the exposure time, tissue vaporization, or coagulation, or both will take place. In this study, the most important laser tissue interaction mechanisms are photothermal vaporization and coagulation. Vaporization could be useful in cutting and debulking (reduced size). Cutting occurs when highly localized tissue vaporization is performed by focusing laser beam, using very small spot size of 0.1 - 0.5 mm. This focused beam can incise the tissue to a depth of several mm depending on the laser power and the speed of incision. At temperature equals 100^{o}C, the strong absorption of infrared radiation by water leads to boiling of the tissue water, cell rupture and dehydration and tissue shrinkage. Continuing the exposure past the boiling point of the cell water does not cause a further rise in temperature initially, because the applied energy is consumed as evaporative heat in changing the material from the liquid to the vapor phase. Once all the water has been vaporized, the temperature starts to climb again. Beyond about 150^{o}C carbonization

occurs, and increased energy absorption by the charred surface promotes a relatively sharp rise in temperature. Temperatures higher than 400 ^{o}C are associated with vaporization, burning, and excavation. Also vaporization is useful in debulking; a large tissue area can be vaporized using defocused laser beam using higher power to maintain power density, and cutting with this broader beam, results in less precision but better homeostasis for vascular areas. This process is useful in treating skin or mucous membrane diseases by removing tissue in few cell layers (Markolf, 2003). Water, and thus soft tissue, vaporizes at 100^{o}C. When the laser hits soft tissue, rapid heating causes the water in the tissue to flash into steam, ablating the tissue (Evrard *et al*, 1993; Fleischer and Sivak, 1984). When tissue heating by laser is continued for several seconds the coagulation of cell protein occurs when the temperature reaches 60˚C. Protein denaturation is visibly manifested by a whitish discoloration. This temperature is sufficient to cause capillary and small blood vessel sealing, so homeostasis is also obtained (Markolf, 2003).

Discussion

The surgical laser technology has been utilized to refine the breast tumor excision and mastectomy procedures (Baxter *et al*, 1999). In performing breast tumor excision or mastectomy for breast cancer, only one surgical tool is needed to perform the entire procedure. Laser scalpel provides excellent precision, coagulation and speed in all phases of the procedure. Some surgeon may prefer to use the metallic scalpel technique to make the initial skin incision. Using the metallic scalpel produces bleeding and risks contamination of healthy tissue. Cancer cells can be unknowingly dissected via the scalpel and subsequently spread; contributing to local recurrence. The heat and sterilization effect of electrocautery mitigates these problems, but generates others. Electrocautery stimulates nerves, therefore making surgical precision and control extremely difficult. The contact laser technique combines the advantages of both the scalpel and electrocautery by producing a precise flap in a bloodless field with no electrical charring. Anatomical visualization is excellent (Fujimaki and Nakayama, 1986) and, in the process, the contact laser scalpel seals off nerve endings, it is believed that this element contributes to the conspicuous absence of pain experienced by the patients postoperatively. Advantages of the laser technique are particularly evident during vein dissection where meticulous precision is critical (Schroder *et al*, 1987). Dissection of the axillary vein is extremely difficult to perform using electrocautery without risking tissue damage to contiguous structures (Abster and Joffe, 1985). The hundreds of nerves in this region create uncontrollable tissue spasm when electrocautery is employed. The conventional process using scissors, scalpel, hemostats and sutures, is time consuming Hemostats damaging tissue and sutures remaining in the body, can impair recovery time. In laser mastectomy, the surgeon dissects lymph nodes from vessels and nerves. The axillary vein is freed from surrounding tissue with precision, hemostatic control, no tissue stimulation and less assistance. Lymphatic and nerves are sealed. In removing the breast tissue from the pectoralis major and minor muscles, a clean dissection, leaving the muscle tissue absolutely untouched by directing the laser scalpel toward the breast tissue being removed, so produces no muscle damage. Small vessels are coagulated prior to the transection, precipitating a fast muscle dissection. Larger vessels, up to 1.5 mm, are coagulated with the side of the laser scalpel. Nerve and muscle stimulation is particularly critical in this phase of the surgery. Electrocautery causes tremendous stimulation and contributes to muscle soreness post-operatively (Guyn, 1997). The laser scalpel produces no muscle or nerve stimulation (Taugho, 2000). This lack of muscle stimulation has contributed to the good post-operative results (Baxter *et al*, 1999).

Conclusions

The results showed that the diode laser is effective in minimizing the intra-operative blood loss, and in reducing the postoperative pain, swelling and edema. On follow up the patients presented with relatively better healing progress, no wound infections, and no need for strong pain killer postoperatively. Although the time needed for excision is the same as in the conventional method, probable with more skillness and experience time will be shorter. Diode laser used

for the breast mass excision in the hope that it can be used as a single tool for mastectomy in cases of malignant breast mass.

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الخلاصة

تعتبر عقدة الثدي من اكثر المشاكل السريرية المهمة عند النساء حيث ان أمرأة واحدة من كل ست عشرة أمرأة تصاب بهذا المرض خلال فترة حياتها . أجريت هذه الدراسة لتقييم جهاز ليزر الدايود كأداة للقطع وكأداة أيقاف النزف الدموي عند أستئصال عقدة الثدي. تم اجراء الدراسة على مرحلتين أولا على الضرع للحصول على قيم جرعة الليزر للقطع والأستئصال والثانية على ثلاث نساء (معدل العمر 35.5 سنة) لأستئصال عقدة الثدي المتحسسة سريرياً. أن القدرة التي تم أستخدامها في القطع كانت 15 واط (كثافة القدرة تساوي 5.3 كيلو واط /سم2) بينما كانت القدرة المستخدمة لأيقاف النزف الدموي من الاوعية التي لاتتجاوز قطرها 1.5 ملم تتراوح بين 10– 15 واط . أظهرت النتائج ان الفقدان الدموي خلال العملية وبعدها كان اقل مما هو عليه بالطرق التقليدية وكذلك آلم العملية وبعدها كان اقل مما هو عليه بالطرق التقليدية مع قلة وذمة العملية. عند متابعة المرضى سريرياً بعد العملية لم تظهر علامات التهاب و خلاجات الجرح ولم تكن هنالك حاجة لمُسكن ألم ذو فعالية عالية. كما أن التئام الجرح كان قد تقدم بصورة جيدة .