It is Possible to Cause Damage to a Laser Fibre during Delivery of Tumescent Anaesthesia for Endovenous Laser Ablation (EVLA)

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Submitted 26 March 2008; accepted 10 June 2008

Abstract
Aims: To establish a possible mechanism of damage to a laser fibre significant enough to cause a retained segment within a patient.

Methods: A 21 G needle was used to pierce a VARILASE™ 810 nm Laser Fibre inserted within a 4F sheath. A tiny pin source of light from the aiming beam emerged from the needle hole in the sheath. Using laser protection protocol, the generator was fired for one minute at 14 Watts (W) continuous wave. The sheath and fibre were then examined. In a control experiment, we were unable manually to break a fibre where the coating had been damaged prior to the laser being fired.

Results: The aiming beam was noted to be concentrated at the side of the catheter at the point of needle damage rather than at the fibre tip. When the fibre was removed from the sheath the distal length, from the point of damage to the tip, was retained within the sheath. Longer firing with the sheath surrounded by a wet towel or a pork loin resulted in complete severance of the sheath and fibre.

Conclusion: There are no firm manufacturer’s guidelines on whether Tumescent Anaesthesia should be delivered before or after the laser fibre has been inserted into the patient. Some units performing EVLA prefer to do this with the laser fibre in situ as it is easier to image on ultrasound than the sheath alone. The results of this in-vitro experiment would suggest it is possible to cause sufficient needle damage to fracture a laser fibre when fired. In the interests of safety we would recommend administration of tumescent anaesthesia should always be carried out before introduction of the laser fibre.

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Introduction
Endovenous laser ablation (EVLA) is becoming an increasingly popular treatment for truncal vein reflux in superficial venous disease. It provides a minimally invasive alternative
to traditional vein stripping with much lower pain and morbidity for the patient.\textsuperscript{1} It has the added advantages of being a local anaesthetic technique and can be performed relatively quickly, typically the whole procedure taking around thirty to forty five minutes depending on case complexity. This makes it ideal to perform as a ‘walk in- walk out’ treatment.

The technique must be performed under ultrasound control with or without the presence of a sonographer/vascular technologist. Higher resolution ultrasound systems are preferable, although expensive, to ensure the equipment used has sufficient image quality to resolve introduction cannulae and laser fibres when tissues are distorted by the presence of tumescent anaesthesia.

In our unit we prefer to deliver tumescent anaesthesia around the introduction cannula before introduction of the laser fibre as we perceived that there was potential risk of damaging the fibre inadvertently with a needle tip. However we know that in many centres delivery of tumescent anaesthesia is performed with the fibre already in situ as distortion of anatomy occurs when the tumescent fluid (and often air micro-bubbles) is introduced. This distortion can make ultrasound imaging and therefore accurate fibre placement more difficult. However with high resolution ultrasound equipment and technologists with experience in intra-operative catheter techniques these technical difficulties can be overcome. There are no current manufacturer guidelines as to whether delivery of tumescent anaesthesia can cause damage to a laser fibre. Indeed many units are taught to deliver tumescence with the laser fibre as we perceived that there was potential risk of damaging the fibre inadvertently with a needle tip. However we now know that in many centres delivery of tumescent anaesthesia is performed with the fibre already in situ as distortion of anatomy occurs when the tumescent fluid (and often air micro-bubbles) is introduced. This distortion can make ultrasound imaging and therefore accurate fibre placement more difficult.

A case report\textsuperscript{2} describing a 28 cm retained segment of laser fibre following Endo Venous Laser Ablation (EVLA) was presented at the Society of Vascular Technology 15th Annual General Meeting in Edinburgh in November 2006. The manufacturer and laser safety authority had been notified of this case. No proven explanation had been provided as to how this incident and damage process had occurred. The procedure technique employed in this case described delivery of tumescent anaesthesia with the laser fibre in situ. In question and answer session it was suggested that damage to the laser fibre, with the needle tip delivering tumescent anaesthesia, may have caused this damage to the laser fibre. In our experience, even with high resolution ultrasound and experienced operators, it is very common for the needle delivering tumescent anaesthesia to touch the introduction cannula in situ in the vein. When this was suggested to the distributor of the laser equipment they felt it was unlikely to have caused such catastrophic failure of the fibre. Our unit decided to test the hypothesis by a series of \textit{ex vivo} experiments to see if a needle tip could cause sufficient damage to a laser fibre to cause it to fracture during delivery of laser energy.

Materials and Methods

A VARILASE \textsuperscript{TM} 810 nm Laser generator and fibres (identical system to that used in case report\textsuperscript{1}) were used in these experiments. The experiments were conducted in a laser approved room and full laser protection protocol was used at all times. In pre-experiment testing it was impossible to break an undamaged laser fibre by bending even with quite considerable force.

Experiment 1

An undamaged laser fibre was connected to the laser generator and the aiming beam allowed to project along the fibre to emerge at its tip. A 21 G needle was allowed to pierce the laser fibre to cause minor damage to its outer coating - see Fig. 1a. Minimal force was required to do this. A tiny point of red light could be seen emerging from the point of damage with the naked eye but was very difficult to appreciate on photographic image. At this stage the fibre was intact and could not be broken with manipulation. The laser fibre was covered and surrounded in dampened surgical drapes to protect adjacent structures. The laser was then fired for 1 minute at 14 W continuous wave.

Experiment 2

An undamaged laser fibre was placed inside its introduction sheath and locked into position. The fibre was connected to the laser generator and the aiming beam projected along the fibre to its tip. A 21 G needle was inserted into the sheath and allowed to pierce the fibre. A tiny pin source of red light was noted to be projecting from the hole in the sheath. The laser was fired for 1 minute at 14 W continuous wave with the fibre and sheath surrounded in dampened surgical drapes.

Experiment 3

An Endo Venous Laser Ablation (EVLA) was performed using a pork loin phantom to simulate human tissue. A skewer was inserted into the meat to create a track. Then a length of plastic tubing (the outer packaging for the guide wire from the laser kit) was fitted to the end of the skewer and pushed back along the track. The laser sheath and fibre were damaged with a 21 G needle as previously described. The sheath and fibre were then carefully inserted into the length of tubing within the meat. The tubing was carefully removed to prevent any manual damage to the fibre and the sheath and fibre were left in situ in the meat. A simulated EVLA treatment was performed at 14 W continuous wave, withdrawing the sheath at a rate of 1 cm every six seconds.

Results

In the first experiment, a strong source of light was noted projecting from the side of the fibre at the point of needle damage - see Fig. 1b. The fibre was also distorted at this point but remained intact. The fibre was then picked up. It was found to be very brittle at the damage point and merely handling the fibre caused it to fracture completely - see Fig. 1c.

In the second experiment with the fibre within its sheath, the aiming beam projected strongly from the puncture site after 1 minute - Fig. 2a. The proximal end of the laser fibre was withdrawn from the sheath and the
fibre was noted to be broken at the point of needle damage. The distal portion of the fibre was retained within the sheath and could not manually be removed. The sheath was cut open to deliver the retained portion of fibre. This experiment was repeated, this time leaving the laser fibre in situ for a further 1 minute of 14 W continuous wave firing. After 2 minutes of laser energy the sheath was completely burnt through at the point of needle damage as well as the fibre being broken - Fig. 2b.

This observation was reproduced in the third experiment with the laser sheath and fibre embedded within a pork loin and on butterfly dissection (Fig. 3a) the retained distal end of the sheath and fibre tip and also the burn track from the continued laser treatment by the proximal end of the broken fibre, can clearly be seen.

**Discussion**

The experiments described suggest a plausible mechanism for the clinical mishap presented\(^2\) and subsequently published\(^3\) by the Liverpool group. The original authors stated during their presentation that they inserted the laser fibre into the sheath within the vein before the administration of tumescent fluid around the vessel. However in their publication, they state that the fibre was not inserted until the tumescence had been completed and suggested manual force under firing as the mechanism for fracture of the fibre. The proposed mechanism suggested in our experiments
and the conclusion drawn by the Liverpool unit have important safety considerations that cannot be ignored. Both mechanisms demonstrate how readily damage can be caused to a laser fibre.

Our experiments show that light energy is concentrated at a point of damage to the protective coating of the fibre. It is logical to surmise that heat build up at that point rather than at the fibre tip leads to melting and disruption of the sheath and fracture of the fibre as demonstrated. An intense foreign body reaction would be expected from a significant length of retained fibre leading to a requirement for its removal; an unsatisfactory scenario.1 This study demonstrates the ease with which damage may be caused to some laser fibres, especially if they are of a type with a plastic coating. However, it is possible that some laser fibres may be more resistant to damage if the optical core is made exclusively from glass. The authors continue to investigate this point.

We are aware that some clinicians have been advised to insert the laser fibre prior to tumescence on the grounds that it is highly echogenic and therefore easier to see on ultrasound than the relatively hypoechoic fibre sheath. However in the light of our experiments we would suggest this is potentially dangerous practice. We would propose the insertion of a guide wire into the sheath as a marker if clinicians are experiencing difficulty with visualisation.

Conclusion

It is possible easily to damage an endovenous laser fibre within its sheath with the tip of a hypodermic needle. We recommend therefore that tumescence must be carried out before such a fibre is inserted to prevent serious complications such as retention of the device.

Acknowledgements

Grateful thanks are given to Charmaine Harrison, Craig Smith and Catharine McGuinness, clinic members who all made minor, but important, contributions to the preparation of the manuscript.

References