

A comparison of different power levels used by laser systems in the IVF laboratory

Summary

Modern high power laser systems designed for use in the IVF laboratory can be shown to deliver less energy to an embryo during procedures than lower power systems.

Introduction

Over recent years lasers have been used increasingly in the in vitro fertilization (IVF) laboratory. The procedures for which lasers are now routinely used include laser assisted hatching or thinning, blastomere biopsy, trophoctoderm biopsy and polar body biopsy.

All laser systems for IVF work on the same principle, that being to deliver a tightly focused laser beam for a short duration that heats and disintegrates zona pellucida (ZP). All commonly available laser systems use lasers that operate in the same part of the light spectrum, near infrared, 1480nm wavelength. All have the ability to vary the duration of the laser pulse and this directly affects the amount of ZP that will be removed. Different models of laser system available today employ different powers of laser, ranging from ~100mW up to 400mW, and some systems even offer variable power.

Uncertainty exists for embryologists as to how much energy they are delivering to the embryo during laser procedures and how much energy could be harmful to the embryo. Laser systems can provide software overlays to assist the user in performing safe operations, but there is a lack of quantifiable data relating cell damage to short duration laser energy and temperature.

The amount of energy delivered in a single laser pulse is simply the product of laser power and the pulse duration. For example, a laser of 400mW fired for a duration of 200µs (which would make a hole in ZP of several µm) delivers 80µJ. If this energy were distributed through a small droplet of media (10 µl), then it would cause an increase in temperature of about 0.002°C. As the droplet would be losing heat to the surrounding environment then even delivering hundreds of pulses could not cause a noticeable increase in the droplet temperature.

However, laser energy is not delivered uniformly across the droplet, but tightly focused, and this is what makes the laser useable for disintegrating ZP. A certain amount of the energy delivered will raise the temperature of the ZP to the point where it disintegrates. There will also be surplus energy delivered into the area of focus and transferred to the surrounding area. This surplus energy has the potential to damage surrounding cells. It is therefore desirable to minimise the amount of energy and so reduce this potential for damage. It is the aim of this paper to demonstrate that the choice of laser power has a significant effect on the amount of energy that is delivered when dissolving ZP.

Method

Thawed mouse embryos were placed in microdroplets and overlaid with oil. A Saturn 5 Active™ laser system was fitted to an inverted microscope with an Integra Ti™ micromanipulation workstation using a metal heated insert calibrated to heat the dish contents to 37°C. The Saturn 5 Active™ was modified to have three pre-set power levels of 175mW, 300mW and 400mW (calibrated using a laser power meter). Each embryo was held with a holding pipette against the bottom of the dish and the laser was used with various pulse durations at each of the

three power levels on different sections of the ZP. Each power/pulse combination was repeated several times. The directional ability of the Saturn 5 Active™ meant that it was easy to ensure that a fresh area of ZP could be targeted for each laser pulse. The diameters of the holes created were measured using the software supplied with Saturn 5 Active (measurements previously calibrated with a stage micrometer). The power level, pulse duration, and the average resulting hole diameter were recorded for each laser pulse.

Results

The energy that was needed to be delivered to make an 8µm hole at 400mW was 76µJ. At 300mW the energy was 102µJ. At 175mW the energy needed was 147µJ, almost twice the amount as at 400mW. At all diameters of hole, the lower power laser needed to deliver more energy than the higher power.

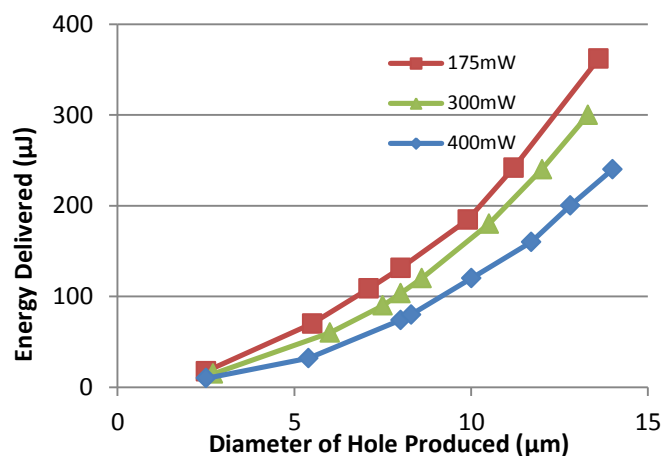


Fig. 1 Energy vs Hole Diameter

Conclusions

Less energy is required to dissolve ZP with a 400mW laser compared with lower power lasers.

An embryologist should look to minimise the surplus energy delivered to reduce the potential for damage.

By using Saturn 5™ or Saturn 5 Active™ laser systems, (the highest power lasers currently available), the embryologist can improve the safety of laser procedures compared with lower power systems.

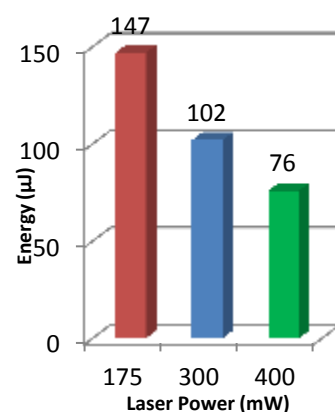


Fig. 2 Energy delivered to produce 8 µm hole

Discussion

Our tests used mouse embryos to compare the energy required to produce holes at different laser powers. The comparison is valid, but absolute values are likely to be different in human embryos. The uncertainties of the effects of short duration laser heating should be acknowledged. Further research in this area would be beneficial, but until that takes place, it is logical to minimise the risk of damage.