EFFECTS OF THE ARGON LASER ON ANAESTHETIC GASES AND ENDOTRACHEAL TUBES

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SUMMARY

The effects of argon laser light on endotracheal tubes and gas mixtures have been studied. In recommended use accidental exposure to red rubber and PVC tubes caused minimal damage. Prolonged exposure of PVC tubing and a 2:1 nitrous oxide:oxygen mixture produced a minimal increase in temperature and no detectable increase in the concentration of higher oxides of nitrogen. Transparent endotracheal tubes are recommended if the argon laser is being used in the management of cutaneous lesions of the head and neck.

The effects of the argon laser beam on red rubber and other endotracheal tubes, should accidental exposure occur during surgery, have not been described. Damage to endotracheal tubes caused by carbon dioxide lasers has been described by several authors (Snow et al., 1976; Vourc'h, Tannieres and Freche, 1979).

Argon and carbon dioxide lasers emit electromagnetic radiation at different wavelengths. Radiation from the carbon dioxide laser is emitted in the infra-red region, whereas the argon laser emits principally in the blue/green region of the spectrum at 500 nm. The absorption mechanism in tissues is different for the two wavelengths. In the case of the carbon dioxide laser the radiation is efficiently absorbed by water and the primary effect is vaporization. Radiation absorbed from the argon laser is preferentially absorbed by red tissues, such as haemoglobin, and causes photocoagulation (Di Bartolomeo, 1981).

It is because of the peak absorption by red pigments at this wavelength that port wine stains and pigmentation of the lips in Peutz–Jeghers' syndrome are susceptible to the rays of the argon laser (Goldman, 1980; Ohshiro et al., 1980; Apfelberg et al., 1981; Ohmori and Huang, 1981). Since many of these lesions are in the head and neck region, the possibility of accidental exposure of endotracheal tubes should be considered.

Carbon dioxide lasers use high power outputs and it has been recommended that the endotracheal tube should be protected with a covering of metal foil to reflect the radiation (Wainwright, Moody and Carruth, 1981). Metal endotracheal tubes are being developed for use with these lasers (Wainwright, Moody and Carruth, 1981). The argon laser has a lower power output than the carbon dioxide laser, but in view of the way red materials absorb argon radiation, it would be instructive to examine the effect of the argon laser on red rubber and clear PVC endotracheal tubes, and on anaesthetic gases.

MATERIALS AND METHODS

Equipment

The "Spectra Physics 770 Argon Laser" develops a power output of up to 5.6 W and the duration of each pulse of radiation can be varied from 0.2 to 20 s. The radiation is focused at the end of a fibreoptic waveguide into a spot 1 mm in diameter. Treatment usually involves irradiating the lesion with multiple discrete bursts of radiation of 0.2 s duration at 3 W.

Gas analysis was performed using a direct gas inlet mass spectrometer (AEI Type MS10). This machine was capable of detecting changes of less than 10 p.p.m.

Gas samples were collected in special glass containers as supplied by the mass spectrometer unit at Manchester University. Endotracheal tubes (size 8 mm, walls 2 mm thick) of red rubber (Leyland) and polyvinylchloride (PVC) (Mallinckrodt) were used throughout. Protective yellow anti-laser goggles (Laser-Gard) were worn during all laser experiments.

Methods

The visible effects of exposing the tubes to radiation of varying intensity were observed at the focal

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length of the beam (1.5 cm). The surface temperature of the exposed tube was then measured with a copper-constantan thermocouple of small thermal capacity and fast response time. This was inserted under the surface of the tube which was then exposed to a burst of radiation for 0.5 s at 5.6 W.

In a separate experiment the temperature on the inside surface of the tube was measured during exposure to radiation at the same intensity (5.6 W for 0.5 s) and the increase in temperature of a 2:1 nitrous oxide:oxygen mixture passing through the tube at a flow rate of 6 litre min⁻¹ was measured also. A copper-constantan thermocouple was inserted at the entry point of the gases into the endotracheal tube, and another thermocouple 5 cm distal to the irradiation point.

The duration of exposure to radiation at full and reduced power required to burn a hole through the tube was recorded and the damage resulting from continued exposure for longer periods noted.

Finally, samples of gas were collected in sealed glass containers during irradiation of the tubes and analysed in a mass spectrometer to ascertain whether ionization or oxidation had occurred.

**RESULTS**

**Red Rubber Tube**

When the tube was irradiated continuously at maximum power (5.6 W), the red rubber absorbed radiation and a hole was burned in the tube which eventually caught fire (fig. 1).

When the tube was irradiated at maximum power with a 0.5-s pulse, the temperature of the red rubber tube increased by 190-210 °C at the surface and 10 °C inside the tube. The effects of different periods of exposure of the red rubber tube to radiation at 5.6 W are shown in the figure 2.

Bursts of radiation for 0.2 s at 5.6 W, with a pause between pulses to allow the tube to return to the ambient temperature, caused slight indentation of the tube after 20 pulses. Continuous exposure for 5 s produced flames and slight surface damage, after 10 s the rubber melted and after 20 s a hole formed.

With continuous radiation at 3 W, the tube started to melt after 15 s, but no hole was burnt after 20 s.

With exposure at maximum power (5.6 W) for 20 with nitrous oxide and oxygen passing through the tube, the gas ignited and burnt fiercely once the laser beam had pierced the tube. Flames shot from the end of the tube and were difficult to extinguish, although there was no explosion.

**PVC Tube**

The laser beam passed through the PVC tube and with only slight surface damage was detectable after 20 s exposure to maximum power (5.6 W) (fig. 3). However, when the black lettering on the PVC tube was hit by the beam, the surface blackened, so absorbing more radiation. The tube melted rapidly and a hole formed.

Experiments performed on the PVC tubing to measure temperature changes were impossible, as the radiation passed through the tube, heating the thermocouple itself. The probe was replaced adjacent to the point of exposure and the surface temperature was increased by 10°C with repeated bursts of 0.5 s at 3 W, with 0.5-s pauses between bursts. Continuous exposure at 3 W for 20 s increased tube temperature to 80°C.

The nitrous oxide-oxygen mixture passing through the tube was warmed by only 2°C after a 10-s burst of radiation at maximum power (5.6 W).

Exposure of the PVC tube to maximum power radiation for 20 s produced only a dimple on the surface. However, when placed on a green surgical towel, the laser beam was reflected, burning a hole through the tube in 10 s (fig. 4).

Using the mass spectrometer, the gas samples were analysed. A mass spectrum was obtained for the samples, with particular reference to the following three peaks in the mass spectrum: the 32 peak for oxygen, the 44 peak for nitrous oxide and the 46 peak for nitrogen dioxide and nitric oxide (assuming that any nitric oxide present would be oxidized to nitrogen dioxide). A standard sample taken with no exposures of the tube revealed trace amounts at the 46 nitrogen dioxide peak of a few parts per million. Analysis of samples taken from the red rubber tube and the PVC tubes under irradiation revealed no changes in the constituents of the sample. Similarly, a sample taken from a red rubber tube after a window hole had been cut in it so that gas was being directly irradiated, showed no changes.

**DISCUSSION**

The results presented indicate that, if the argon laser is used with bursts of between 0.2 and 0.5 s at 3 W, accidental exposure of either red rubber or PVC endotracheal tubes would cause minimal damage. However, a clear PVC tube would seem to be preferable if greater levels of irradiation are being used. Green towels should not be placed underneath PVC tubes, as they reflect the beam back onto the tube.
FIG. 1. Effects of continuous irradiation at 5.6 W on a red rubber endotracheal tube.

FIG. 2. Effects of different periods of exposure of the red rubber tube to radiation at 5.6 W with 0.5-s pulses.

FIG. 3. Change in PVC tube after 20 s exposure to radiation of 5.6 W.

FIG. 4. Reflection of the laser beam, by a green surgical towel, back onto the PVC tube, produced a hole in 10 s.
(fig. 4). Prolonged exposure of PVC tubing and gas mixtures inside produced minimal increases in temperature, no explosions and no detectable increase in concentration of higher oxides of nitrogen in the gas mixture. These findings confirm the basic concept that, as long as the laser beam passes uninterrupted, the substance through which it passes undergoes no change. It is only when the beam is interrupted that its energy is converted into heat.

The use of explosive or inflammable anaesthetic agents, such as cyclopropane or ether in conjunction with the argon laser, is clearly contraindicated.

At the time of writing, no intra-oral operations have been conducted with the argon laser, and therefore the opportunity for prolonged exposure of the endotracheal tube has not occurred. However, use of the argon laser is increasing and has been suggested for use in ENT surgery (Di Bartolomeo, 1981). Haemangiomas of the cheek also seem to be suitable targets for argon laser treatment.

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REFERENCES


