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Studies in laser safety of new high-output systems: 2. TEA CO2 laser impacts

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2. TEA CO_2 laser impacts

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The new TEA (transversely excited atmospheric pressure) CO_2 laser can produce ionization of air. No information is as yet available of the effect of this new high-power output laser on man. Repeated impacts of 30 mJ pulses with 100 kW, which produced ionization of air, caused non-specific superficial coagulation necrosis which healed promptly.

Impacts of high intensity laser beams on living tissue continue to be of great interest.[1–3] The CO_2 laser has been used with outputs of 300 W on skin, liver, bone and kidney of dogs.[4] Powers of 85 to 100 W have been used in investigative laser surgery for man. A special type of high intensity CO_2 laser is the TEA CO_2 laser, a transversely excited atmospheric pressure CO_2 laser. This is used extensively in research and industrial applications. This laser can produce ionization of air. Smith and Gerger,[5] with 200 ns pulses from a TEA CO_2 laser, determined that the minimum threshold intensity for atmospheric air was 3×10^9 W cm^{-2} for a spot diameter of 100 μm. It is necessary, then, to know of its reaction in human tissue. Initial exposures of man to new laser systems are usually done on the skin of the flexor surface of the forearm.

In these experiments on the skin, the TEA laser had a helical electrode structure, operating in the lowest order of transverse gaussian mode. There were, also, several

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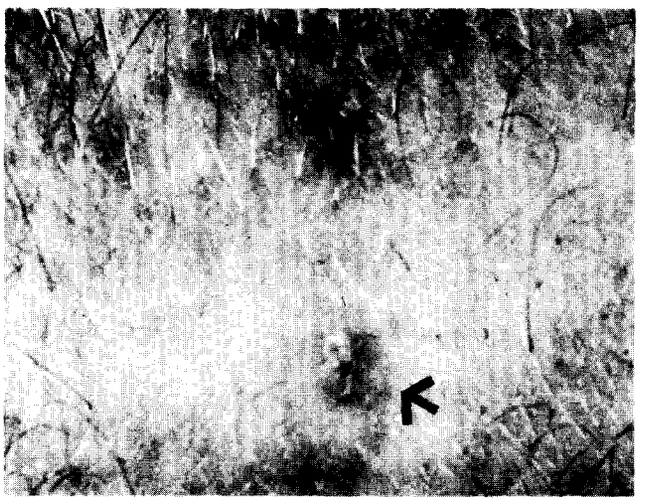

Fig.1 TEA CO_2 30 mJ pulse, 100 kW impact on forearm after 24 hours, showing reddened papule with superficial crusting

Fig. 2 Biopsy of TEA CO_2 lesion showing superficial crusting, flattened epidermis, sharply circumscribed polymorphonuclear and lymphocytic infiltrate. Hematoxylin-eosin X200

longitudinal modes. In a previous report by Yablonovith [6] the details of this laser and its pulses were described.

Pulses of 30 mJ (100 kW) and with a diameter of approximately 100 μm (0.5–0.25 s exposures) were given in four separate areas to the flexor surface of the left forearm of a Caucasian volunteer. Immediate prickling and burning were followed in several hours by erythema and in 24 hours by spreading erythema, edema and superficial crusting (Fig.1). A biopsy of one of the 24-hour reactions was obtained. The other areas were left as controls.

Biopsy studies (Fig.2) showed a sharply limited zone of epidermal destruction with a sharply circumscribed zone of coagulation necrosis of the underlying dermis for a very shallow depth, and an accumulation of neutrophils and lymphocytes within the zone of coagulation. The impact zone and the inflammatory response was, then, sharply demarcated and relatively shallow. This non-specific inflammatory reaction does not differ from that observed from impacts of a CO_2 laser on skin.[2]

The control areas healed within a week without any residual scarring. These healed areas were not excised. No scars could be observed over a period of six months.

Although this TEA CO_2 laser produced ionization of air with a focused beam, the reactions in the skin of man at the focal point showed only a moderate degree of non-specific thermal coagulation necrosis. These reactions were not similar in their initial changes or subsequent follow-up observations to those produced by x-ray reactions.

These few and preliminary experiments on a single volunteer indicate that it is safe to conduct additional studies of this type on man's skin. Some additional studies which are needed are on comparative power densities of impacts of the CO_2 and the TEA CO_2 laser, the effects of chronic exposure, air pollution studies from material processing, and, finally, biomedical applications.

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