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A Laboratory Study

A Comparison of Pulsed Radiofrequency and Continuous Radiofrequency on Thermocoagulation of Egg White *in Vitro*

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Background: Clinical studies have demonstrated the efficacy of pulsed radiofrequency (PRF). PRF energy is delivered to neural structures via specifically designed, percutaneously placed needles to treat some chronic pain states. PRF was introduced as a non-destructive alternative to destructive lesioning produced by continuous radiofrequency (CRF) energy. However, there is an ongoing controversy regarding the potential tissue-destructive effects of PRF used for pain management.

Objective: To evaluate the ability of PRF to coagulate egg white at various temperatures used clinically and to compare with CRF.

Methods: A commercially available (TYCO-Radionics Labs) 5 cm, 22G (0.7 mm) SMK needle with 5 mm active tip was inserted into a 10 mL test tube containing raw egg white at 37° C and the tip was heated up to 80° C. The photographic patterns of thermocoagulation of egg white in vitro produced by continuous and pulsed radiofrequency (RF) were compared and the lowest temperature at which PRF produced thermocoagulation was determined.

Results: Pulsed RF produced barely detectable thermocoagulation at 60° C. Above 60°C, the pattern of coagulation produced by PRF resembled that observed with CRF. However, the density and size of the coagulation ball appeared somewhat greater with CRF.

Conclusion: PRF coagulated egg white at temperatures above 60° C in a manner similar to CRF. Monitoring needle tip temperature using the thermode supplied with the needle during PRF and keeping the recorded tip temperature below 60° C may minimize unwanted thermal destruction of tissue.

Key words: Pulsed radiofrequency (PRF), continuous radiofrequency (CRF), chronic pain, heat lesion, coagulation

Pulsed radiofrequency (PRF) energy delivered via specially designed, percutaneously placed needles to neural structures is used to treat some chronic pain states. PRF was introduced as a non-destructive alternative to destructive lesioning produced using continuous radiofrequency (CRF) energy. Clinical studies have demonstrated efficacy of PRF and CRF. Laboratory investigations and theoretical discussions have attempted to explain the mechanism by which non-destructive lesioning with PRF produces pain relief (1-3). Cosman et al (4) presented theoretical and laboratory data showing that in some cases during PRF there are temperature bursts in tissue that extend into the destructive range (45-50C) associated with typical heat lesions produced by CRF. Their evidence demonstrated that PRF produced a "hot spot" at the point of the tip of the needle used to deliver PRF energy. Our objective was to determine the temperature as measured clinically with the needle thermode at which visible coagulation of egg white is produced by PRF and to compare the coagulation patterns produced by PRF and CRF.

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Methods

A commercially available (TYCO-Radionics Labs) 5 cm, 22G (0.7 mm) SMK needle with 5 mm active tip was inserted into a 10 mL test tube containing raw egg white warmed to 35-37°C. A grounding pad was trimmed to fit the long axis of the test tub and inserted into the egg white. CRF or PRF (10 ms pulse duration at 2HZ) was applied through the electrode using a Radionics RF Lesion Generator System (Model RFG-3C Plus). Energy level was set to achieve an electrode tip temperature up to 80° C (CRF) or 42, 60, 65, and 70° C (PRF). Temperature was measured using the thermode supplied as part of the RF needle. Photographs were taken at two minutes after energy delivery was started. High resolution digital photographs were obtained at various time points during continuous and pulsed RF. Approximately 30 photographs were taken and time lapse sequences were generated, which allowed qualitative comparisons of the two techniques.

Results

CRF at or above 60°C produced visible coagulation of egg white (Fig. 1, 80 Continuous). The pattern of coagulation was in a radial direction around the exposed tip, perpendicular to the long axis of the electrode. Coagulation of egg white with PRF energy was not visible at 42°C (Fig. 1, 42° Pulse), and just visible at 60°C (Fig. 1, 60°C Pulsed RF). Coagulation was apparent at the tip as well as along the exposed part of the shank of the electrode. With PRF above 60° C (Fig. 1, 60-65° Pulse, 65° Pulse, 70° Pulse) coagulation was qualitatively similar in size and shape to co-

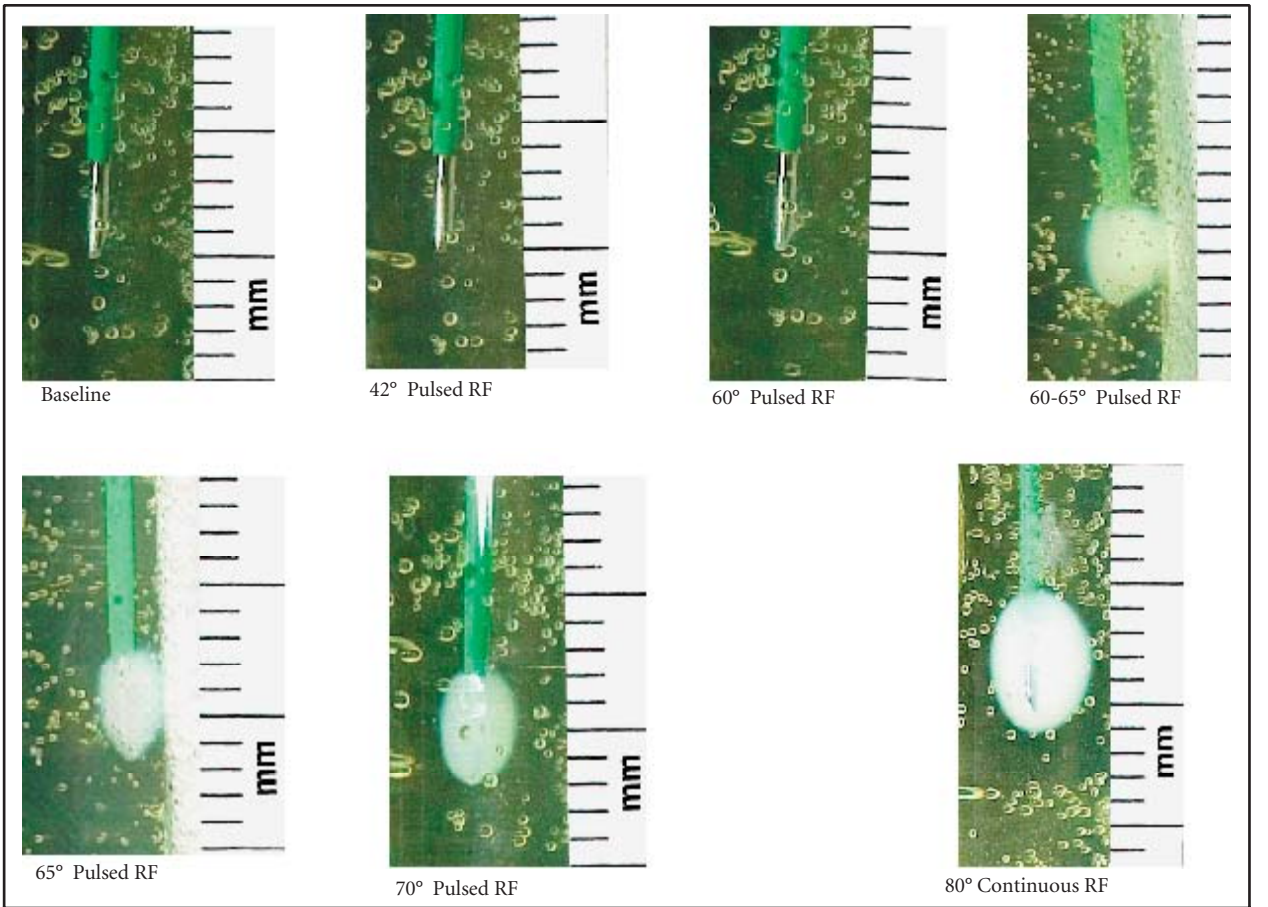

Fig. 1. *Photographs of the tip of a 5 cm, 22G (0.7 mm) SMK needle with 5 mm exposed tip two minutes after application of continuous or pulsed radiofrequency energy for two minutes. Coagulation of egg white in which the needle and ground electrode are submerged was barely visible at 60 ^{0} C PRF. Above 60 ^{0}C PRF produced a coagulation pattern similar to CRF, although the density and size of the coagulation ball appeared somewhat greater with CRF.*

agulation produced by CRF. However, the density of the coagulation ball at the needle tip appeared somewhat greater with CRF than PRF at all temperatures tested.

Discussion

Our results show that within two minutes after the start of PRF, coagulation of egg white was visible at the needle tip and along the exposed portion of the needle shaft if the temperature as measured clinically was $\geq$ 60° C. When the temperature achieved with PRF was between 60-65° C, the egg white was coagulated in a radial direction around the exposed tip, perpendicular to the long axis of the electrode, similar to the coagulation pattern produced by CRF. According to Cosman et al (4), egg white turns an increasingly dense white color above about 55-60°C, using 70V (peak), 20 ms pulses at 2Hz. A white color first begins to form at the tip's point within a few seconds. We were not able to confirm that coagulation starts at the needle tip, possibly because our observation times and observation method were less refined than those used by Cosman et al (4).

Conclusion

Monitoring needle tip temperature using the thermode supplied with the needle during PRF and keeping the temperature below 60° C may minimize unwanted thermal destruction of tissue. Based on our observations of egg white coagulation, temperatures above 60° C are required to produce tissue destruction typical of coagulation necrosis. However, use of lower temperatures does not exclude tissue injury at the ultrastructural level. In summary, as assessed by coagulation of egg white in the laboratory, thermocoagulation and presumably tissue injury are a function of the set temperature with continuous as well as pulsed radiofrequency techniques.

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