The Future of Radiofrequency Ablation is Looking BETA

Short and Long Term Studies of Bimodal Electric Tissue Ablation (BETA) in a Porcine Model

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Thesis Abstract

Introduction

Radiofrequency ablation (RFA) is a popular method of treating unresectable liver tumours by the use of a high frequency, alternating electrical current that heats and destroys tumour cells. The size of the ablation is limited by localised charring of adjacent tissue that prevents further conduction of the radiofrequency current. In the clinical setting, this results in increased rates of local recurrence in tumours that are greater than 3 cm in diameter as multiple, overlapping ablations need to be performed to treat the one tumour.

To overcome this problem, a modified form of RFA called Bimodal Electric Tissue Ablation (BETA) has been created. BETA adds a direct electrical current to the alternating radiofrequency current, thus establishing its bimodal character. When direct currents are used in biological tissues, water is transferred from anode to cathode by a process called electro-osmosis. By attaching the cathode to the radiofrequency electrode, water is attracted to the area thus preventing tissue desiccation and charring.

The BETA circuit has been constructed and tested using a porcine model. The aims of the studies are to confirm that larger ablations can be produced with the BETA system and that it is safe to use in an animal model. Three studies have been performed to test these aims in porcine liver.

Methods

The first study was designed to compare sizes of the ablation produced between standard RFA and the BETA circuit. This was followed by a long-term study to assess associated changes to liver function and pathological changes within the liver as well as identifying

any other treatment related morbidity. The third study assessed the difference in ablation size and safety aspects when the positive electrode of the direct current circuitry was moved from small surface area under the skin to a large surface area on the skin.

Results

Ablations with significantly larger diameters are created with the BETA circuit using a multi-tine needle (49.55 mm versus 27.78 mm, $p<0.001$). This finding was confirmed in the third experiment using a straight needle (25 mm versus 15.33 mm, $p<0.001$). Ablations produced by the BETA circuit induce coagulative necrosis within the treated liver and the injury heals by fibrosis in a manner similar to other thermal therapies. Significant rises in some serum liver enzymes are seen within 24 hours of treatment but these return to normal within 4 days. An electrolytic type injury can be produced at the site of the positive electrode. By increasing the surface area of this electrode, the risk of tissue damage is decreased but ablations are significantly smaller (18 mm versus 25 mm, $p<0.001$).

Conclusions

The BETA circuit consistently produces significantly larger ablations than RFA. The treatment appears safe but positioning of the positive electrode of the direct current requires careful consideration. Injuries produced behave like other thermal therapies with coagulative necrosis followed by fibrotic healing. As larger ablations are consistently produced, it is hypothesised that with further refinements, tumours greater than 3 cm in diameter could be treated with lower rates of recurrence.

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Statement

I declare that this thesis contains no material which has been accepted for the award of any other degree in any university and that to the best of my knowledge and belief, contains no material previously written by another person, except where due reference is made in the text. I consent to this thesis being made available for photocopying and loan if applicable and if accepted for the award of the degree.

Christopher Dobbins

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Preface

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Dobbins, C., Brennan, C., Wemyss-Holden, S. Cockburn, J., Maddern, G.J. Bimodal Electric Tissue Ablation – Long Term Study of Morbidity and Pathological Change. *Journal of Surgical Research*. Accepted for publication 10/9/2007.

Dobbins, C., Brennan, C., Wemyss-Holden, S., Cockburn, J., Maddern, G.J. Bimodal Electric Tissue Ablation – Positive Electrode Studies. *ANZ Journal of Surgery*. Accepted for publication 15/10/2007.

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