

Improving the Safety and Efficacy of Bimodal Electric Tissue Ablation

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By

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Table of Contents

	Page Number
Title	1
Table of Contents	2
Thesis Abstract	6
Statement of Declaration	8
Acknowledgements	9
Abbreviations	11
1. Introduction	13
2. Radiofrequency Ablation	15
2.1. History of Radiofrequency Ablation	15
2.2. Principles and Mechanisms of Action	15
2.3. Biological Effects of Hyperthermic Therapy	16
2.4. Radiofrequency Ablation Generators	17
2.5. Radio-Imaging in Radiofrequency Ablation	18
2.5.1. Pre-Ablation Imaging	18
2.5.2. Intra-Ablation Imaging	18
2.5.3. Post-Ablation Imaging	19
2.5.3.1. Ultrasonography	19
2.5.3.2. Computed Tomography	20
2.5.3.3. Magnetic Resonance Imaging	20

2.5.3.4. Positron Emission Tomography	21
2.6. Complications After Radiofrequency Ablation	21
2.6.1. Haemorrhagic Complications	21
2.6.2. Abdominal Infections	22
2.6.3. Biliary Tract Injury	23
2.6.4. Hepatic Vascular Injury	24
2.6.5. Liver Failure	25
2.6.6. Visceral Organ Injury	25
2.6.7. Skin Burns	27
2.6.8. Tumour Seeding	27
2.6.9. Miscellaneous	28
2.7. A Systematic Review of Survival and Disease Recurrence after Radiofrequency Ablation for Hepatocellular Carcinoma	29
2.8. A Systematic Review of Survival and Disease Recurrence after Radiofrequency Ablation for Hepatic Metastases	50
3. Electrolysis and Electrochemical Therapy	66
3.1. Animal Experiments	67
3.1.1. Tissue Temperature	67
3.1.2.3 Water Content	67
3.1.3.3 Elemental Concentrations	68
3.1.4.3 Tissue pH	68
3.1.5.3 Gas Productions	68
3.1.6.3 Cellular Histological Changes	68

3.1.7.3 Volume of Tissue Ablation	69
3.1.8.3 Safety	69
3.2. Human Studies	70
3.3. Modifications and Innovations	70
3.4. Problems in Electrochemical Therapy	71
4. Bimodal Electric Tissue Ablation	72
4.1. Early Experimental Results	72
5. Rational for Current Research	76
5.1. Experiment 1: Does Bimodal Electric Tissue Ablation really work by increasing tissue hydration?	76
5.2. Experiment 2: Where is the optimum place to put the anode in Bimodal Electric Tissue Ablation?	77
5.3. Experiment 3: Can Bimodal Electric Tissue Ablation be incorporated into the Cool-Tip RF System?	77
Experiment 1: Bimodal Electric Tissue Ablation – Effect of Reversing the Polarity of the Direct Current on the Size of Ablation.	79
Experiment 2: Bimodal Electric Tissue Ablation – Ablation Size when the Anode is Placed on the Peritoneum and the Liver.	94
Experiment 3: BETA compared to standard Radiofrequency Ablation using the Cool-Tip RF System (Covidien, ValleyLab).	110
6. Area for Future Research	128
7. Conclusions	129
Appendix 1	131
Appendix 2	133
Appendix 3	135

Appendix 4	136
Appendix 5	137
Appendix 6	142
Appendix 7	146
Appendix 8	147
Appendix 9	149
Appendix 10	153
Appendix 11	158
Appendix 12	159
References	160

Thesis Abstract

Introduction:

Bimodal electric tissue ablation (BETA) is a new method of ablation, which combines the process of electrolysis with radiofrequency ablation (RFA) to increase the size of tissue ablations. The cathode of the electrolytic circuit is connected to the radiofrequency (RF) electrode to increase the surrounding tissue hydration. This allows the RFA process to continue for a longer period of time and therefore produce larger ablations. Previous research has shown that BETA could produce larger ablations compared to standard RFA and that it did not produce any significant short or long-term complications. The studies described here aim to increase the knowledge on how BETA works to facilitate its translation into clinical practice to treat liver tumours.

Materials & Methods

The first study tested whether BETA really acts by increasing the hydration of tissues around the RF electrode. This was achieved by reversing the polarity of the electrolytic circuit, which theoretically would produce smaller ablations compared to standard RFA. The second study assessed where would be the best location (skin, parietal peritoneum or liver) for the anode of the electrolytic circuit during a BETA process. The third experiment determined whether the principle of BETA could be incorporated into the Cool-Tip RF system, which uses internally-cooled electrodes (ICEs).

Results

The duration of ablation when the polarity of the electrolytic circuit was reversed (called reversed polarity bimodal electric ablation, or RP-BEA) were significantly shorter compared to standard RFA and BETA (48s vs. 148s and 84s respectively, $p=0.004$). Consequently the size of ablations in RP-BEA was significantly smaller compared to RFA and BETA (9.1mm vs. 13.4mm and 11.6mm, $p=0.001$). The second experiment showed that the size of ablations were significantly larger when the anode of the electrolytic circuit was placed on the peritoneum or the liver, compared to when it was placed on the skin (19.7mm and 17.9mm

vs. 12.4mm, $p < 0.001$). Lastly, the third experiment showed that the principle of BETA could be incorporated into the Cool-Tip RF system to produce significantly larger ablations compared to standard RFA alone (23.1mm vs. 20.1mm, $p < 0.001$).

Discussion

The results from this study confirmed the theory that BETA increases ablation size due to the effects of increased tissue hydration around the RF electrode. The increased hydration delays tissue desiccation during an ablation, thus allowing the process to continue for longer periods of time, therefore producing larger ablations. The efficacy of BETA depends on good electrical conductivity between the cathode and the anode of the DC circuit. Results from the second study showed that BETA works best when the anode of the electrolytic circuit was placed deep to the skin as the stratum corneum consisted of a layer of anucleated cells which have high electrical resistivity. Lastly, BETA could be incorporated into the Cool-Tip RF system (Covidien, ValleyLab), which is one of the popular RFA generators in the market. This means that BETA could be readily incorporated into existing RF generators, therefore facilitating its translation into the clinical settings.

Statement of Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any University or other tertiary institution to Dr. Leong Ung TIONG and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. The author acknowledges that copyright of published works contained within this thesis (as listed below) resides with the copyright holder(s) of those works. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue, the Australasian Digital Theses Program (ADTP) and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

1. Tiong LU, Finnie JW, Field JBF, Maddern GJ. Bimodal Electric Tissue Ablation (BETA) – Effect of Reversing the Polarity of the Direct Current on the Size of Ablation (*published online in the Journal of Surgical Research - 08 February 2011 (10.1016/j.jss.2011.01.013)*)
2. Tiong LU, Finnie JW, Field JBF, Maddern GJ. Bimodal Electric Tissue Ablation (BETA): A study on Ablation Size when the Anode is placed on the Peritoneum and the Liver (*published online in the Journal of Surgical Research - 28 February 2011 (10.1016/j.jss.2011.01.061)*)
3. Tiong LU, Maddern GJ. A Systematic Review of Survival and Disease Recurrence after Radiofrequency Ablation for Hepatocellular Carcinoma (*published in the British Journal of Surgery, September 2011; Vol 98 (9): 1210-1224*)
4. Tiong LU, Field JBF, Maddern GJ. Bimodal Electric Tissue Ablation (BETA) compared to the Cool-Tip RFA System. (*accepted for publication by the Australian and New Zealand Journal of Surgery*)

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Abbreviations:

AC – alternating current

AFP – alpha-fetoprotein

ASA - American Society of Anaesthesiologists

BETA – bimodal electric tissue ablation

CLM – colorectal liver metastasis

CT – computed tomography

DC – direct current

ECT – electrochemical therapy

FDG – Fludeoxyglucose

HAI – hepatic artery infusion

HCC – hepatocellular carcinoma

HIFU – high intensity focused ultrasound

ICE – internally cooled electrode

IVC – inferior vena cava

LITT – laser interstitial thermal therapy

MCT – microwave coagulation therapy

MRI – magnetic resonance imaging

PAI – percutaneous acetic acid injection

PE – perfused electrode

PEI – percutaneous ethanol injection

PET – positron emission tomography

RCT – randomized controlled trials

RF – radiofrequency

RFA – radiofrequency ablation

RNA – ribonucleic acid

RP-BEA – reversed polarity bimodal electric ablation

TACE – trans-arterial chemo-embolization

US - ultrasonography