Tissue temperature rise during the operation of the Helica T.C. in vitro “soft” and “hard” tissues.

Summary

A safe temperature occurs at a very short distance of less than 2mm from the point of treatment even at the highest operating level of power and longest time of application

TITLE

The rise in temperature in “muscular” and “soft” in vitro tissue over the full range of operating power of the HELICA THERMAL COAGULATOR (TC).

SUMMARY

This paper details the results of tests to measure the temperature rise on in vitro tissue during the application of the Helium Gas Thermal Coagulator manufactured by HELICA INSTRUMENTS LTD, - Research & Development Park, Heriot Watt University, EDINBURGH.

This tissue coagulator supplies a combined fixed rate of low pressure Helium gas supply with a variable low power high frequency alternating current to a Teflon shrouded unipolar electrode. The combination of the helium gas and the alternating current produces a high temperature “flame” when brought close to any conducting object which is used to cauterise and coagulate tissue cells (thermal necrosis) in all forms of surgical procedures. It has been particularly successful in laparascopic techniques where the combined extremely low power and low pressure inert gas supply have benefits of safe operation.

Previous studies have concentrated on the effects of the TC application on both in vivo and in vitro tissue where the depth of necrosis and width of eschar has been measured through the range of standard and non standard operating ranges of power. Both Human and rat tissues have been used in these observations and the published results concluded that operation was safe in all circumstances.

Refer to

1. “Laparascopic use of the Helica Thermal Coagulator: the first report” - Kay Forbes Donaldson and Robert J.S. Hawthorn - 6 March 1995)

2. “Another wave at the old Chestnut - The Helium Beam Coagulator in the treatment of endometriosis” - Dr. G. Cumming and Dr. K Phillips

3. “Assessment of the Helica TC in vivo: Effect of duration of exposure and power setting on tissue injury”. - J. L. Turvil & P Domizio

Range of settings

The TC has a fixed low pressure supply of helium to the shrouded electrode and a variable setting of the alternating current which has three settings selected by a switch on the front control panel The first range “LOW” is from 1W to 8W and is controlled with a rotational variable resistor on the front panel with complete control of the power in the whole of the range. The second and third settings “MEDIUM” and “HIGH” are fixed settings at 16W and 33W respectively and it is not possible to alter the power when these settings are selected.

The gas flow of the Helium gas is not variable and is preset during manufacture to suit the operating characteristics of the TC. It is an integral part of the operation and the TC will not operate at either higher or lower gas flow rates or pressures.

Surgical Operating Range

The power of the TC to coagulate and cauterise is sufficient through the whole of the LOW power range for all laparascopic procedures. The MEDIUM and HIGH settings would be used in open surgical procedures for coagulation.

Why this Paper?

The TC , in use, is very “directional” - it is very easy to ensure that a limited area of tissue is affected even to the depth of a single cell and previous papers examine the physical effect of the TC on in vivo and in vitro tissue. These showed a very limited depth of necrosis not exceeding 1.5mm at the point of the charge and no more than 9.0mm in the lateral spread when the TC was used in the normal operating level of 6w in laparascopic conditions.(1)

These results are consistent with the results in rat tissue (2) where the same settings were used but ulcerations occurred at the higher settings and longer application, up to 10 sec’s, which effectively penetrated in excess of 1.5 mm and created necrosis up to 3mm but with a fulgaration still limited to 1.5mm no matter how high the setting or time applied i.e. the higher settings “burnt” deeper but the tissue necrosis measured from the surface of the remaining tissue never exceeded 1.5 mm.

The depth of necrosis is an indication of the temperature attained during the application at all levels and times and it is safe to presume operating temperature in the tissue outside the visible region of damage did not reach that required for necrosis.

Temperature Measurements

The previous experiments were undertaken in vivo with the same tissue being reused in vitro and it was not possible to measure the temperature attained in the tissue to confirm the implication in the visible effects of fulgaration. This study was undertaken on animal tissue to allow the measurement of the rise in temperature in tissue wvoer the full operating range of the TC (effectively 1W - 33W) and also over a variable time of operation. The range of operation in both powers settings and time was chosen to match previous studies i.e. 2W, 4W, 6W, 8W - representing the LOW setting, 16W and 33W at the MEDIUM and HIGH settings respectively. The time selected again matched the previous experiments at 1, 3, 5 and 10 seconds.

Tissue types.

Two types of tissue were selected from animal tissue one “muscular” to represent “hard” tissue and another “soft” tissue in this case liver.

Measurement techniques

The tissue was separated into individual cubes of approximately 2.5mm dimensions and each piece used for one application. A short probe attached to a digital thermometer was inserted into the flesh approximately 2-3mm from the surface parallel to the surface where the TC was applied.

The temperature was stabilised by waiting till the reading had settled, then the application of power made at the preset level for a determined period. The resulting rise in temperature was immediate and continued to rise even after the power was removed. The highest stable temperature attained was recorded. This final temperature could take up to 1 min from the cessation of the treatment but the rise was logarithmic with a steep rise initially and a decreasing rate of increase with time e.g. the last 30 secs or so could result in 1 degree of change.

The difference in the starting temperature and the final temperature could only be due to the effect of the TC and indicated the power reaching the temperature probe with the conditions applied.

The results of the experiment are shown in APPENDICES 1 & 2

The results are not as consistent as would be expected. Precise control of the values applied by the TC is very easy but the position of the temperature probe in the tissue, especially the “soft” tissue is not easy and it is not possible to be as precise as required. Additionally the effect of the TC ‘s operation on tissue is dependent on the condition of the tissue and in particular the moisture content. Obviously it is not possible to control the moisture of the tissue and these along with the previous point lead to some inter sample variation which can only be attributed to sampling error at this point. It would take a very large sample over a large amount of tissue types to estimate this error sufficiently accurately to gain a detailed picture.

The results of the experiment are clearly in line with the previous results. The lowest settings gave the lowest rises in temperature and the MEDIUM settings the highest The maximum rise in temperature could reasonably be expected at the HIGH setting but at this level the tissue acts as a resistance to the flow of power and the effect is to dissipate the energy over a larger area and to cause ulceration which reduces the temperature rise at the depth measured.

The general rise in temperature up to the MEDIUM setting and the fall of at HIGH is consistent with the previous observations of necrosis and while no measurements of the eschar and depth of necrosis could be taken accurately,a visual assessment confirms the previous results.

RESULTS

The graphs in App 1 shows an increasing rise in temperatures as the power and time of treatment is extended at the test depth of 2 - 3 mm. Necrosis requires a temperature of 82 C - a rise of approximately 50 C over body temperature and this is obviously attained in the region of the treatment. The observed effects are consistent with the necrosis measurements and depth of fulgaration indicated in previous reports with the maximum eschar recorded at 9mm and depth and maximum fulgaration measured at 1.5mm with 3mm necrosis caused by the resulting ulcer, but the results also show that a safe temperature is possible at a very short distance of less than 2mm from both the point of treatment even at the highest level of power and time.

Helica Thermal Coagulator

Measurements of Temperature rise experienced in "soft" tissue.

1 - In virto animal tissue
2 - Probe inserted at approximately 2 - 3 mm below surface of tissue, imediately under region of treatment.
3 - Digital thermometer attached to probe.
4 - Temperatures recorded when stabilised.

First sample

	Power Setting											
	1/10 Low		3/10 Low		6/10 Low		10/10 Low		Medium		High	
Time in secs	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C
1	16.6	17.4	16.6	18.7	16.7	20	17.8	20.1	20.4	24.1	19.3	20.5
3	16.4	19.6	16.5	20.4	16.4	20	17.2	23.1	18.2	25.9	16.9	20.1
5	16.9	19.5	16.8	24.8	16.8	23.2	18.2	26.2	17.9	26.5	16.7	20.3
10	16.2	23.6	16.4	23.3	17.5	32.8	17.8	26.3	18.2	25.5	17.2	22.8

Second sample

	Power Setting											
	1/10 Low		3/10 Low		6/10 Low		10/10 Low		Medium		High	
Time in secs	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C
1	17.1	20	17.4	19.2	17.2	19.9	16.5	18.4	17.4	20.8	19.8	22.4
3	17	20.7	17.4	22.4	17.3	24.4	16.4	19.5	17.6	24.8	18.3	26.3
5	16.9	21	17.5	24.8	17.3	24.2	16.2	31.2	17.6	30.2	16.9	27.3
10	17.7	25.4	17.4	25.3	17.5	26.3	17.4	26.4	17.7	39.2	17.6	32.3

Mean Temperature rise from both samples C

	Setting					
	1/10 Low	3/10 Low	6/10 Low	10/10 Low	Medium	High
Time in secs						
1 Sec	1.85	1.95	3	2.1	3.55	1.9
3 Secs	3.45	4.45	5.35	4.5	7.45	5.6
5 Secs	3.35	7.65	6.65	11.5	10.6	7
10 Secs	7.55	7.4	12.05	8.75	14.4	10.15

Helica Thermal Coagulator

Measurements of Temperature rise experienced in "muscular" tissue.

1 - In virto animal tissue
2 - Probe inserted at approximately 2 - 3 mm below surface of tissue, imediately under region of treatment.
3 - Digital thermometer attached to probe.
4 - Temperatures recorded when stabilised.

First sample

	Power Setting											
	1/10 Low		3/10 Low		6/10 Low		10/10 Low		Medium		High	
Time in secs	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C
1	15.7	16.5	16.9	17.5	18.3	19.4	17.6	19.4	17	18.8	18.9	19.8
3	16.4	17.6	17.4	18.4	16.1	17.8	18.2	20	17.9	20.8	18.5	21.8
5	16.8	18.2	17.3	18.8	16.8	19.6	17.7	20.9	17.9	21.6	19.1	23.8
10	16.3	18.1	17.7	21.7	17.2	20.4	18.9	22.4	17.9	29.2	17.7	24.4

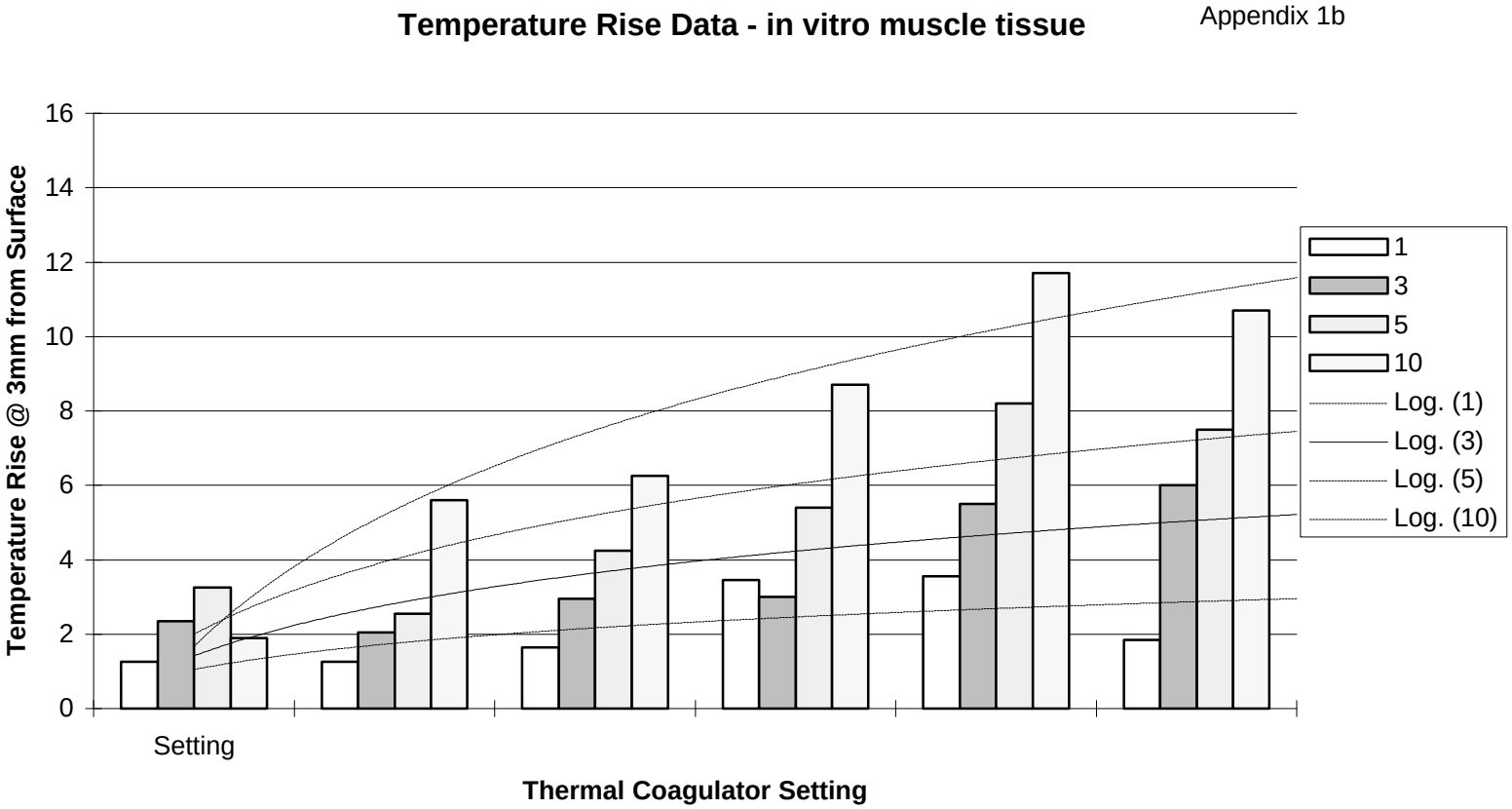
Second Sample

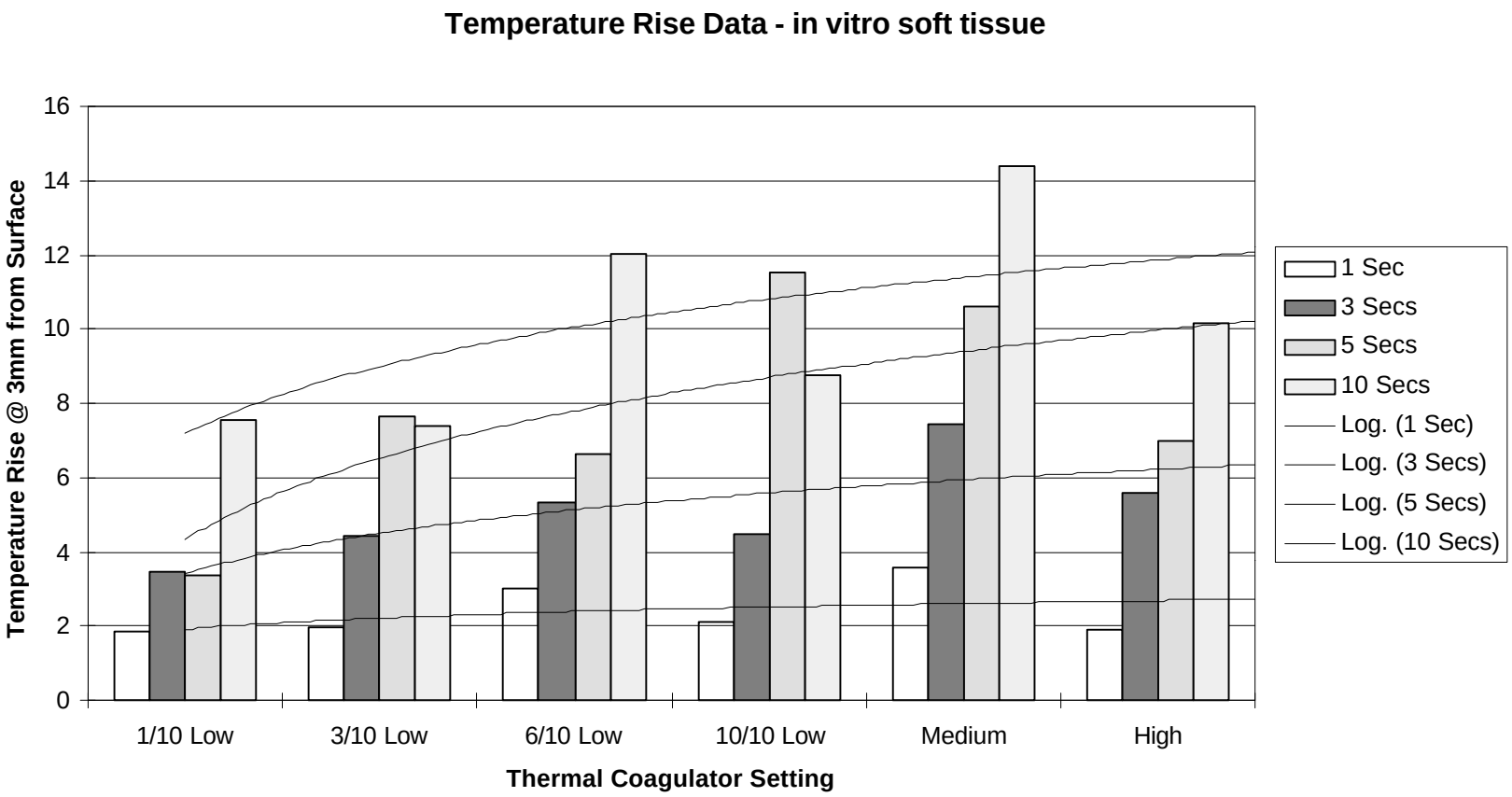
	Power Setting											
	1/10 Low		3/10 Low		6/10 Low		10/10 Low		Medium		High	
Time in secs	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C	Start Temp C	Finish Temp C
1	17.4	19.1	18.5	20.4	18.3	20.5	17.5	22.6	17.4	22.7	17.3	20.1
3	17.4	20.9	17.7	20.8	18	22.2	18	22.2	17.9	26	17.3	26
5	17.8	22.9	18	21.6	18.8	24.5	18.3	25.9	18.9	31.6	17.8	28.1
10	17.3	19.3	18	25.2	19.7	29	17.8	31.7	19	31.1	18.4	33.1

Mean Temperature rise from both samples C

	Setting					
	1/10 Low	3/10 Low	6/10 Low	10/10 Low	Medium	High
Time in secs						
1	1.25	1.25	1.65	3.45	3.55	1.85
3	2.35	2.05	2.95	3	5.5	6
5	3.25	2.55	4.25	5.4	8.2	7.5
10	1.9	5.6	6.25	8.7	11.7	10.7

Appendix 1b


Temperature Rise Data - in vitro muscle tissue
Temperature Rise @ 3mm from Surface
16
14
12
10
8
6
4
2
0
Setting
Thermal Coagulator Setting
1
3
5
10
Log. (1)
Log. (3)
Log. (5)
Log. (10)


Temperature Rise Data - in vitro soft tissue
Temperature Rise @ 3mm from Surface
16
14
12
10
8
6
4
2
0
1/10 Low
3/10 Low
6/10 Low
10/10 Low
Medium
High
Thermal Coagulator Setting
1 Sec
3 Secs
5 Secs
10 Secs
Log. (1 Sec)
Log. (3 Secs)
Log. (5 Secs)
Log. (10 Secs)