集束型水冷微波消融天线的热场特性

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摘要 单一发射极的水冷却微波天线对于直径<3 cm的肿瘤已有很好的治疗效果,但是对于体积较大的肿瘤治疗效果并不理想。本研究基于一种新型集束型微波天线,讨论在不同功率和时间下,有效消融区域的形态、温度分布等特性。采用不同微波功率和时间对离体牛肝进行消融,记录测温点的温度上升曲线,并测量消融尺寸。结果表明:15 min内,40 W最大消融面积为25.627±2.400 cm^2,最大消融体积为81.655±3.500 cm^3,消融区域横纵比0.660±0.020。15 min内,60 W最大消融面积为49.803±2.900 cm^2,最大消融体积为244.965±4.000 cm^3,消融区域横纵比0.777±0.010。当肿瘤横径<5.3 cm,纵径<6.9 cm时,建议使用40 W的加热功率。当消融肿瘤体积较大,肿瘤形状为类圆形时,建议使用60 W的加热功率。进行消融手术尽量使用小功率、长时间的治疗方式,可使临床医生准确控制消融范围,避免消融其他器官组织。

关键词 微波消融;温度场;离体;微波天线

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Thermal Field of Water-cooled Microwave Ablation Antenna with Three Antennas

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Abstract The single antenna of water-cooled microwave antenna for treating tumor cells with a diameter less than 3 cm has satisfactory therapeutic effect, but it is not ideal for large tumor cells. Based on a new type of microwave antenna with three antennas, this paper discusses its characteristics under different power and time, including the effective ablation area and temperature distribution. Bovine liver was ablated *in vitro* under different microwave power and time, the temperature rising curve was recorded at the measuring points, and the ablation size was measured. The results show that within 15 min, the maximum ablation area under 40 W was 25.627±2.400 cm^2, the maximum ablation volume was 81.655±3.500 cm^3, and the aspect ratio of the ablation area was within 0.660±0.020. Within 15 min, the maximum ablation area under 60 W was 49.803±2.900 cm^2, the maximum ablation volume was 244.965±4.000 cm^3, and the aspect ratio of the ablation area was 0.777±0.010. When the tumor diameter <5.3 cm, and the longitudinal diameter <6.9 cm, 40 Wis recommended for use. When the tumors are larger and with a quasi-circular shape, 60 W is recommended for use. Low-power and prolonged treatment helps clinicians to accurately control the ablation range, avoiding ablation of other organs and tissues.

Keywords microwave ablation; thermal field; *in vitro*; microwave antenna

50

[1]

[2~6]

20

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[7~9]

60℃

[10~12]

[13]

3

60℃

1　材料与方法

1.1　材料

3　　16.5 cm

1 cm

1　　1.5 cm

图1　集束型水冷式消融天线

Fig. 1　Water-cooled microwave ablation antenna with three antennas

2450±50 MHz

0~100 W

BT09-100　　Agilent　34970A

80 cm^2　　6.5 cm

1/2　　2

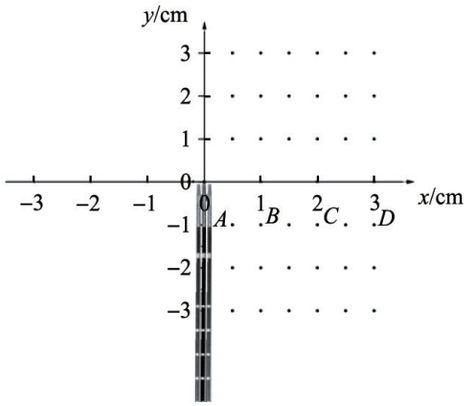

图2　测温点布置

Fig. 2　Temperature measuring point layout

1.2　实验方法

1

37℃

2

x=0　y=0

0　−1　　2

3

4　　40 r/min

5　　2450 MHz　　40 W　60 W　　5　10　15 min

6　　3 s

60℃

表1 功率为40、60 W的数据统计

Table 1 Data under power of 40 and 60 W

/W	/min	/℃	/cm^2	/cm^3	/cm	/cm
40	5	90.812±2.300	9.051±1.500	17.917±1.700	2.902±0.200	3.830±0.400
	10	99.184±2.100	19.043±2.300	50.936±2.000	3.794±0.400	5.835±0.300
	15	106.094±2.600	25.627±2.400	81.655±3.500	4.612±0.300	6.719±0.400
60	5	100.047±2.400	25.372±1.700	80.345±3.000	5.343±0.200	6.908±0.400
	10	108.863±2.300	42.216±2.600	185.716±3.500	6.319±0.400	8.102±0.300
	15	110.219±2.700	49.803±2.900	244.965±4.000	7.228±0.100	8.720±0.400

1

90℃

110℃

60 W

40 W 60 W

5.3 cm 6.9 cm 80.3 cm^3

80.3 cm^3

40 W

60 W

3 结论

15 min

40 W 25.627±2.400 cm^2

81.655±3.500 cm^3 15 min 60 W 49.803±

2.900 cm^2 244.965±4.000 cm^3

60 W

40 W 60 W

5.3 cm 6.9 cm 80.3 cm^3

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