:   (radiofrequency ablation, RFA)
            (expandable needle)   (cooled-tip needle)
                                                                                      .

                    :   23   (20 ,   3), 14   (
    10   ,   4)   ,
                        .

            10   20   .

                        .

                :   23   14
    (61%),   9   (39%)   ,   14   (100%)
                                                    .   10
                                ,   10
                            .

    3.35± 0.56 cm,   19.9± 6.53 cm^3,   3.58
    ± 0.78 cm, 23.19± 5.27 cm^3 .
                    ,   3.41± 0.59 cm, 26.59± 8.02 cm^3 , 4.04± 0.65
    cm, 33.82± 6.16 cm^3 ($p < 0.05$).
                    :
                    ,   .

                            .   .

                                                    ,   (1-5).
                                    ,
        ,
                        .
            (transcatheter arterial chemoembolization),   .   ,
            (percutaneous ethanol injection theraphy),   ,
   (percutaneous hot saline injection   (5-8).
theraphy)   (radio-frequency ablation)   45   50

[1]
[2]   ,   460
[3]   kHZ
        2002   (ionic agitation)
            .
        2004   4   24   2004   10   11   .   (9-12).

:

15

(expandable needle) , . 1 200W
(cooled- tip needle) . ,

15 (gauge) 10 , 12 .

3.5 cm .

4 cm

. 3 *(clinical patients)*

3 cm 2001 7 2003 7

86

, (charging) 3 cm , 1 37

. 1.1 cm

(8). 3 cm 1.77 cm , 1

3 1

. 23 ,

14 , 63.7

(20). (41- 79), 59.9 (37- 75), 19:4, 12:2 . 37

20:3,

10:4 .

6

. . ,

. fentanyl(Fentanyl , ; ,) 2 ml

10 ml . , 2% lidocane

HCl(Lidocaine ; ,)

(radiofrequency technique)

.

(15 , 3.5 cm) Sequoia 512 (Acuson,

RF 3000 (Boston Scientific, Natick, MA, U.S.A.), Siemens Company, Erlangen, Germany) .

(17 , 2.5 cm)

CC- 1 (Radionics, Burlington, MA, 7- 12 (

U.S.A.) . 50 9.2) , 12

(Watt, W) 30 10W .

3 Light- speed Advantage system (GE

. Medical System, Milwaukee, IL, U.S.A.) CT

1 , . CT

Fig. 1. The shape of lesion induced by radio-frequency ablation.
A. Oval along to axis of electrode.
B. Oval perpendicular to axis of electrode.
C. Spherical shape.

120 mL   2- 3 mL   10   ,

,   ,

30 , 70   180   .

5 mm,   5 mm   .   1 mm

. CT   , VoxelPlusTM(Mevisys,   ,   )   .

CT   (multiplanar reformation,

MPR)   .   Volume =   (a× a× b)/6

,   ,

(Fig. 1).   a   , b

(Fig. 3).

,

.

Volume =   (A× B× C)/6

Wilcoxon

A, B, C   (Fig.   signed ranks test,   paired t- test(, p

2).

(experimental model)

3

cm   .

,

,

.

.

.

.

3.2   6.8   5

12   .

,
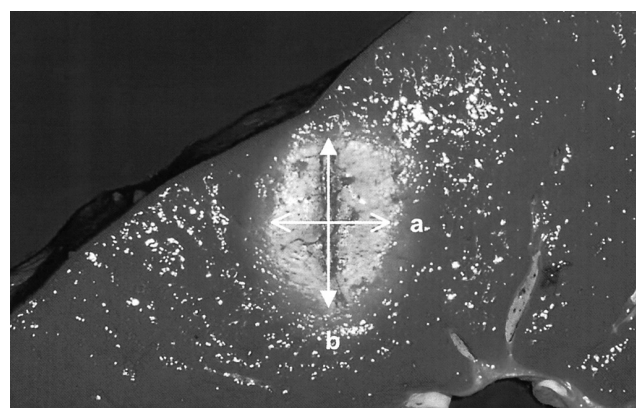
Fig. 3. After RFA in bovine liver, the specimen was immediately cut into 5mm thick slice along the needle axis and evaluated macroscopically by measuring the two longest dimensions with calipers. Volume =   (a× a× b)/6
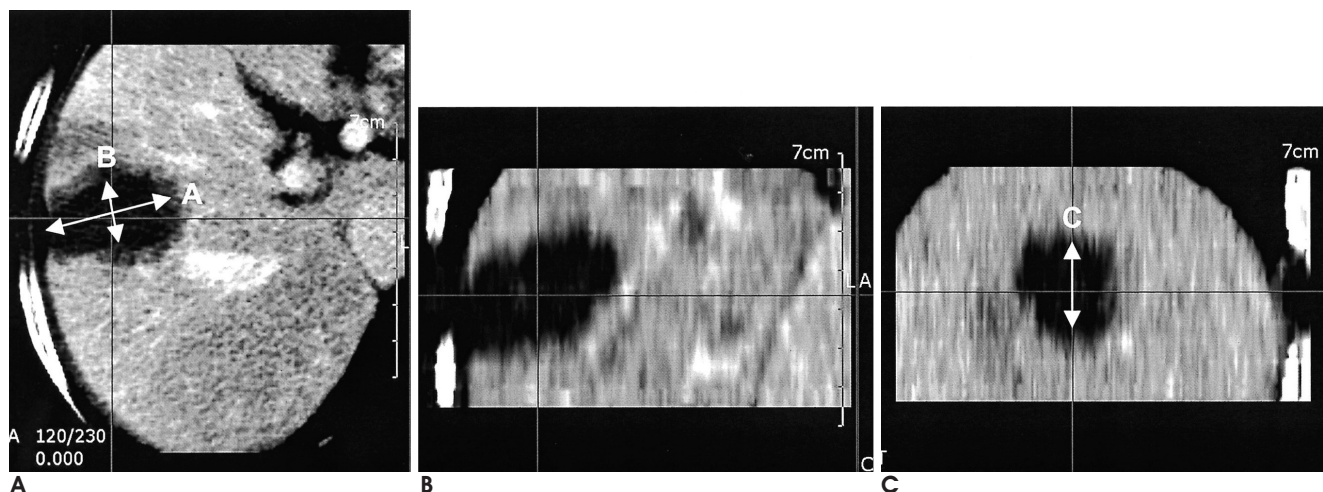
Fig. 2. One day after RFA, CT reformatted MPR (multiplanar reformation) mode, and evaluated by measuring the longest dimensions in each coronal, sagittal and axial images. Volume =   (A× B× C)/6

:

< 0.05)　　　　　　　.　　　　　　　　　　　　　　　　　　　　(Fig. 5).

10　　　　　　　　　,

10

(Fig. 6),

.

,　　　　　　　　　　　23

14　(61%)　　　　　　　　　(Fig. 4),　　　　　　　　　　　　　　,　　　　3.35± 0.56 cm, 19.9± 6.53 cm^3,

9　(39%)　　　　　　　　　　. 9　　　　　　　　　　　　　　　　3.58± 0.78 cm, 23.19±

2　　　　　,　　　　　　　.　　　5.27 cm^3　　　　　　　　　(p= 0.037,

14　　　　　　　　　　　　　　　Table 1).

Fig. 4. Hepatocellular carcinoma in 74-year-old man.
Contrast enhanced CT shows an oval lesion induced RFA by
expandable, perpendicular to axis of the electrode.
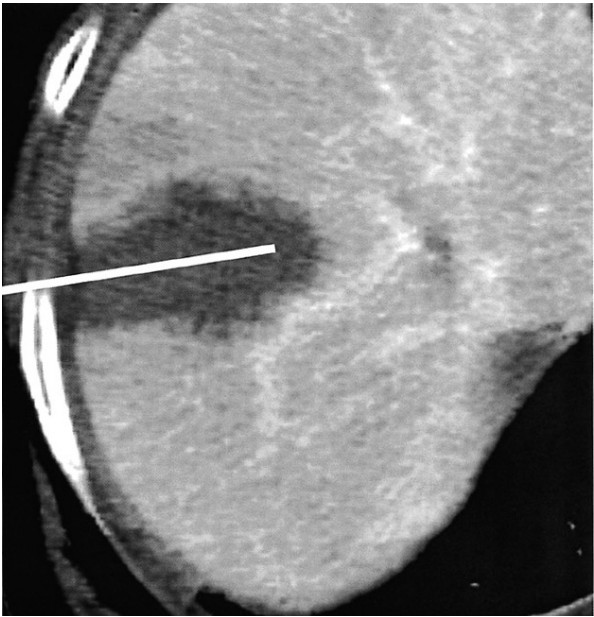
Fig. 5. Hepatocellular carcinoma in 64-year-old man.
Contrast enhanced CT shows an oval lesion induced RFA by
cooled tip, oval along to axis of electrode.

A　　　　　　　　　　　　　　　　　　　　　　B
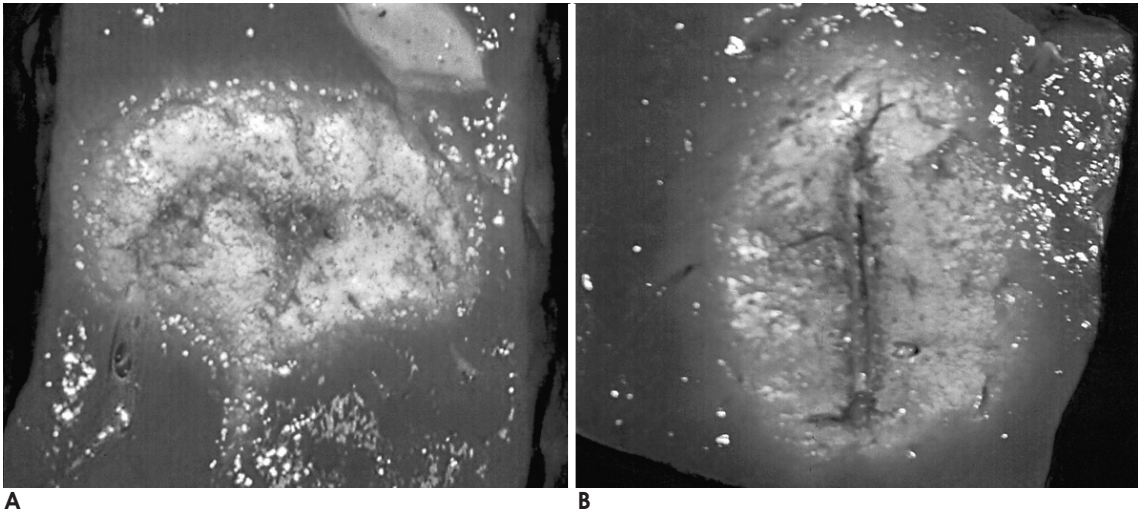
Fig. 6. Photographs show the lesion's shape induced by RFA with expandable needle and cooled-tip needle in bovine liver.
A. The lesion's shape of the RFA with expandable needle was oval perpendicular to the axis of the electrode.
B. The lesion's shape of the RFA with cooled-tip needle was oval along to the axis of the electrode.

3.41± 0.59 cm, 26.59± 8.02 cm³

3.5 cm

4.04± 0.65cm, 33.82± 6.16 cm³

1   17

(*p*= 0.014, Table 2).

,   3 cm   .

.

(8).

,

(5,

12, 25, 26).

(5- 8, 13-

(61%)   (39%)

15).   ,

.

6- 15   47- 95%

,

(5, 16, 17),   6- 10   .

52- 93%   (15- 18).

(18),

(16),

(14),   (19)   ,   (heat sink effect)

.

14- 15

.

.   4   12   (20).

.   ,

10   ,   .

Table 1. Dimensions and Volumes of Lesions Induced by Radio-frequency Ablation with Expandable Needle and Cooled-Tip Needle in Patients with Malignant Hepatic Tumors

	Expandable Needle (Mean ± SD)	Cooled-tip Needle (Mean ± SD)
Diameter (cm)		
Axis 1	3.54± 0.41	4.43± 0.47
Axis 2	3.09± 0.69	2.99± 0.46
Axis 3	3.40± 0.48	3.32± 0.49
Mean	3.35± 0.56	3.58± 0.78
Volume (cm³)	19.90± 6.53*	23.19± 5.27*

* *p* = 0.037

.

.

.

.

Table 2. Dimensions and Volumes of Lesions Induced by Radio-frequency Ablation with Expandable Needle and Cooled-Tip Needle in Bovine Liver Model

	Expandable Needle (Mean± SD)	Cooled-tip Needle (Mean± SD)
Diameter (cm)		
Short axis	3.1 ± 0.37	3.64± 0.28
Long axis	4.02± 0.48	4.84± 0.37
Mean	3.41± 0.59	4.04± 0.65
Volume (cm³)	26.59± 8.02*	33.82± 6.16*

* *p* = 0.014

.

de Baere

(20)   ,

(20)   ,

.

al. Treatment of hepatocellular carcinoma with transcatheter arterial embolization. *Cancer* 1994; 73:1341-1345

2. Takayasu K, Moriyama N, Muramatsu Y, Suzuki M, Yamada T, Kishi K, et al. Hepatic arterial embolization for hepatocellular carcinoma. Comparison of CT scans and resected specimens. *Radiology* 1984;150:661-665

3. Livraghi T, Bolondi L, Lazzaroni S, Marin G, Morabito A, Rapaccini A, et al. Percutaneous ethanol injection in the treatment of hepatocellular carcinoma in cirrhosis: a study in 207 patients. *Cancer* 1992; 69:925-929

4. Honda N, Guo Q, Uchida H, Ohishi H, Hiasa Y. Percutaneous hot saline injection therapy for hepatic tumors: an alternative to percutaneous ethanol injection therapy. *Radiology* 1994; 190:53-57

5. Livraghi T, Goldberg SN, Lazzaroni S, Meloni F, Solbiati L, Gazelle GS. Small hepatocellular carcinoma: treatment with radio-frequency ablation versus ethanol injection. *Radiology* 1999; 210:655-661

6. 　　　　　，　　　　，　　　　，　　　　，　　　　，　　　　．
　　　　　　　　：　　　　　　　．
　2000;42:743-749

7. Jiao L, Hansen P, Havlik R, Mitry RR, Pignatelli M, Habib N. Clinical short-term results of radiofrequency ablation in primary and secondary liver tumors. *Am J Surg* 1999;177:303-306

8. McGhana JP, Dodd GD 3d. Radiofrequency ablation of the liver: current status. *AJR Am J Roentgenol* 2001;176:3-16

9. Matthewson K, Coleridge-Smith P, O`Sulivan JP, Northfield TC, Bown SG. Biological effects of intrahepatic neodymium: yttrium-aluminum-garnet laser photocoagulation in rats. *Gastroenterology* 1987;93:550-557

10. Roberts DW, Coughlin C, Wong TZ, Fratkin JD, Douple EB, Strohbehn JW. Interstitial hyperthermia and iridium brachtherapy in treatment of malignant glioma. A phase I clinical trial. *J Neurosurg* 1986;64:581-587

11. Rossi S, Fornari F, Pathies C, Buscarini L. Thermal lesions induced by 480KHz localized current field in guinea pig and in pig livers. *Tumori* 1990;76:54-57

12. McGahan JP, Browning PD, Brock JM, Tesluk H. Hepatic ablation using radiofrequency electrocautery. *Invest Radiol* 1990;25:267-270

13. Curley SA, Izzo F, Delrio P, et al. Radiofrequency ablation of unresectable primary and metastatic hepatic malignancies: results in 123 patients. *Ann Surg* 1999;230:1-8

14. Livraghi T, Goldberg SN, Lazzaroni S, Meloni F, Ierace T, Solbiati L, et al. Hepatocellular carcinoma: radio-frequency ablation of medium and large lesions. *Radiology* 2000; 214:761-768

15. Solbiati L, Goldberg SN, Ierace T, Livraghi T, Meloni F, Dellanoce M, et al. Hepatic metastases: percutaneous radio-frequency ablation with cooled-tip electrodes. *Radiology* 1997;205:367-373

16. Rossi S, Buscarini E, Garbagnati F, Di Stasi M, Quaretti P, Rago M, et al. Percutaneous treatment of small heaptic tumors by an expandible RF needle electrode. *AJR Am J Roentgenol* 1998;170:1015-1022

17. Lencioni R, Goletti O, Armillotta N, Paolicchi a, Moretti M, Cioni F, et al. Radio-frequency thermal ablation of liver metastases with a cooled-tip electrode needle: results of a pilot clinical trial. *Eur Radiol* 1998; 8:1205-1211

18. Goldberg SN, Goldberg SN, Gazelle GS, Dawson SL, Rittman WJ, Mueller PR, Roenthal DI. Tissue ablation with radiofrequency using multiprobe arrays. *Acad Radiol* 1995;2:670-674

19. Lorentzen T. A cooled needle electrode for radiofrequency tissue ablation: thermodynamic aspects of improved performance compared with conventional needle design. *Acad Radiol* 1996;3:556-563

20. de Baere T, Denys A, Wood BJ, Lassau N, Kardache M, Vilgrain V,

1. Taniguchi K, Nakata K, Kato Y, Sato Y, Hamasaki K, Tsuruta S, et

(12　)

50W　　　　　　　　　150W

　　　　　　　12

(charring)，　　(boiling)，

(safty margin)

　　　　　　　　　　，　　　　　3 cm

(21- 23).

et al. Radiofrequency liver ablation: experimental comparative study of water-cooled versus expandible systems. *AJR Am J Roentgenol* 2001;176:187-192

21. McGahan JP, Gu WZ, Brock JM, Tesluk H, Jones CD. Hepatic ablation using bipolar radiofrequency electrocautery. *Acad Radiol* 1996;3:418-422

22.   ,   ,   ,   ,   ,   .   .
1999;41:1127-1132

23. McGahan JP, Brock JM, Tesluk H, Gu WZ, Schneider P, Browning PD. Hepatic ablation with use of radiofrequency electrocautery in the animal model. *J Vasc Interv Radiol* 1992;3:291-297

Radio-frequency Ablation in Patients with Malignant Hepatic Tumor and Experimental Model: Comparison of Expandable Needle and Water-Cooled Needle[1]

Yong Ju Moon, M.D., Yong Yeon Jeong, M.D., Jeong Kim, M.D., Nam Yeol Yim, M.D., Eun Ha Kim, M.D.[2], Kwon Ha Yoon, M.D.[2], Seog Wan Ko, M.D.[3], Heoung Keun Kang, M.D.

[1]Department of Diagnostic Radiology, Chonnam National University Medical School and [2]Wonkwang University Medical School and [3]Chonbuk National University Medical School

Purpose: The purpose of this study was to compare the shape and volume of the radio-frequency induced lesions produced by two commercially available radio-frequency ablation (RFA) systems, the expandable and cooled-tip needles, in clinical patients and an experimental model.

Materials and Methods: A twelve-array anchor expandable needle electrode and a single cooled-tip needle electrode were used to treat hepatic tumors with a single session in 23 patients (20 hepatocellular carcinomas and 3 hepatic metastases) and fourteen patients (10 hepatocellular carcinomas and 4 hepatic metastases), respectively. Twenty RFA induced lesions were created with each system in 10 explanted bovine livers. The shape of the RFA induced lesions were divided into oval lesions along or perpendicular to the axis of the electrode and spherical lesions, and we then calculated the volumes of the RFA induced lesions.

Results: Fourteen (61%) lesions of the 23 patients treated with the expandable system were oval perpendicular to the axis of the electrode and nine (39%) of the lesions were spherical. All the lesions (100%) of the 14 patients treated with the cooled-tip needle were oval along the axis of the electrode. In the ex vivo bovine livers, the shape of the all RFA induced lesions was oval perpendicular to the axis of the electrode for the expandable needle, and oval along the axis of the electrode for the cooled-tip needle. The mean diameter and volume of the RFA induced lesions in the patients were 3.35 ± 0.56 cm and 19.9 ± 6.53 cm^3, respectively, for the expandable needle and 3.58 ± 0.78 cm and 23.19 ± 5.27 cm^3, respectively, for the cooled-tip needle. In the ex vivo model, the mean diameter and volume of RFA induced lesions were 3.41 ± 0.59 cm and 26.59 ± 8.02 cm^3, respectively, for the expandable needle, and 4.04 ± 0.65 cm and 33.82 ± 6.16 cm^3, respectively, for the cooled-tip needle ($p < 0.05$).

Conclusion: These results indicate that the shape of RFA induced lesions with the expandable needle were oval perpendicular to the axis of the electrode but those with the cooled-tip needle were oval along the axis of the electrode in both the clinical and experimental models. The cooled-tip needle induced significantly larger lesions than the expandable needle in the clinical patients and the experimental model. We need to consider these characteristic findings for RFA when we are performing such procedures.

Index words : Liver neoplasms, therapy
Radiofrequency (RF) ablation

Address reprint requests to : Yong Yeon Jeong, M.D., Department of Diagnostic Radiology, Chonnam National University Medical School
8 Hak-dong, Dong-gu, Gwangju 501-757, Korea.
Tel. 82-62-220-5748   Fax. 82-62-226-4380