The objective of this study is to analyze the efficacy, side effects, and complications of percutaneous radiofrequency ablation (RFA) performed under ultrasound guidance in 63 patients with 109 colorectal liver metastases. Between January 2002 to December 2004, 63 patients (39 male and 24 female) with 109 hepatic metastases from colorectal cancer were treated with RFA. The mean age of the patients was 65.3 years old (range, 34-89 years), and the mean tumor diameter was 2.9 cm (range, 1.2 to 5.0 cm). Inclusion criteria for the procedure were defined for patients with no more than three metastases and none of which were larger than 5 cm in diameter. The efficacy of RFA was evaluated with biphasic contrast enhanced CT performed one month after the procedure, and then every three months. Complete necrosis was defined as hypoattenuation areas without contrast enhancement in the treated region on the follow-up CT studies. Posttreatment CT showed complete necrosis in 86 of 109 (78.9%) colorectal liver metastases after one session of RFA treatment, and residual tumors were observed in 21.1% (23/109) tumors. Complete necrosis based on tumor size was seen in 100% (24/24) tumors with diameters equal to or smaller than 2 cm, 90.2% (37/41) tumors with diameter between 2.1 and 3.0 cm, 64.3% (18/28) tumors between 3.1 and 4.0 cm, and 43.7% (7/16) tumors between 4.1 and 5.0 cm. The major complications after treatment were abscess (two patients) and biloma (one patient). The length of the follow up period ranged from 4 to 40 months (mean, 22.4 months). During the follow-up period, 13.8% (15/109) metastases showed a local recurrence on the basis of CT findings. RFA appears to be a promising therapeutic modality for the treatment of hepatic metastases from colorectal carcinoma, especially for those tumors no more than 3 cm in greatest diameter, and has a satisfactory success rate in tumors of 3 to 4 cm. The rate of serious complications of RFA is low. Further studies are necessary to determine the long-term efficacy of RFA in colorectal liver metastases.

**Key words:** Liver neoplasms, metastases; Liver neoplasms, therapy; Radiofrequency(RF) ablation
mates, and review the treatment’s techniques, efficacy, and complications.

MATERIALS AND METHODS

Patient selection

From January 2002 to December 2004, 63 patients (39 male and 24 female) with 109 hepatic metastases from colorectal cancer who underwent percutaneous US-guided RFA were evaluated for clinical outcome. The mean age of the patients was 65.3 (range, 34-89 years). Inclusion criteria for the procedure were the patients who were not surgical candidates (61.9%, 39/63) or who refused surgical resection (38.1%, 24/63), and with no more than three metastases and none of which were larger than 5 cm in diameter. This study was approved by our institutional review board, and informed consent was obtained from all patients before the procedure.

All patients had their diagnosis confirmed by US-guided biopsy, performed either prior to or simultaneously with the RFA procedure. Biopsy results revealed colorectal metastases in all cases. Tumor size ranged from 1.2-5.0 cm (mean, 2.9 cm), and they were classified into 4 groups according to their diameters: 24 were < 2 cm; 41 were 2.1-3.0 cm; 28 were 3.1-4.0 cm; and 16 were 4.1-5.0 cm.

Radiofrequency tumor ablation technique

All patients were interviewed before the treatment by one of two experienced interventional radiologists, and were assessed with US and CT before the procedure. Two different RFA devices were used as described previously [9-11]: a Radiofrequency Interstitial Tissue Ablation (RITA) device (Rita Medical Systems, Mountain View, CA, USA), and a Radionics device (Radionics, Burlington, MA, USA). With the RITA device, ablation was performed with an expandable needle electrode (Starburst TM, 2-3 cm; or Starburst XL, 3-5cm). With the Radionics device, treatment was performed with a single (2- or 3-cm active tip) needle electrode. Each tumor had 1-4 ablations per session depending on the tumor size.

The procedure was performed in 57 patients using Meperidine (Demerol) and in 6 patients using conscious sedation (Droperidol, Midazolam and Fentanyl) administered and monitored by anesthesiologists. RFA was performed with real-time US guidance and the RF electrode was advanced into the tumor. For lesions in the right lobe, a subcostal approach was most often used. Grounding was achieved with two grounding pads placed on the skin of bilateral thighs.

Imaging assessment after ablation

After RFA all patients underwent immediate follow-up US to evaluate the possibility of bleeding or fluid accumulation. The efficacy of RFA was evaluated by dynamic contrast-enhanced CT performed 1 month after RFA, and then every 3 months. Treated tumors were assessed for residual tumor and size changes. Complete necrosis was defined as hypointense areas without contrast enhancement in the treated region on follow-up CT studies, and all follow-up images were also assessed for the development of new metastatic disease and ancillary peritumoral changes. Residual tumor was defined as viable tumors in an area or areas of tumor after ablation, as determined at the 1-month follow-up study. Recurrent tumor was defined as new tumor growth, after at least one imaging study had demonstrated complete eradication of tumor. Assessment of images was performed in consensus by 2 experienced radiologists.

RESULTS

At the RFA procedure, 49.2% (31/63) patients had one metastasis, while 28.6% (18/63) had two, and 22.2% (14/63) had three metastases respectively. Of the 109 tumors, 32.1% (35/109) were located in the left hepatic lobe and 67.9% (74/109) in the right hepatic lobe. Twenty patients with 33 tumors were treated with the RITA device and 43 patients with 76 tumors were treated with the Radionics device. Of the 20 patients treated with the RITA device, 2 patients were treated with 2-3 cm active electrode, and 18 with 3-5 cm active electrodes. Of the 43 patients treated with the Radionics system, 4 were treated with a 2-cm active tip electrode, and 39 with a 3-cm active tip electrode.

Post-treatment CT showed complete necrosis in 78.9% (86/109) tumors of colorectal metastases after one session of RFA treatment (Figure 1), and residual tumors were observed in 21.1% (23/109) tumors. Complete necrosis based on the tumor size was seen in 100% (24/24) tumors with diameters equal to or smaller than 2 cm, 90.2% (37/41) tumors with diameter between 2.1 and 3.0 cm, 64.3% (18/28) tumors between 3.1 and 4.0 cm, and 43.7% (7/16) tumors between 4.1 and 5.0 cm (Table 1). The mean duration of follow-up was 22.4 months (range, 4-40 months). During the follow up period, 13.8% (15/109) tumors showed a local recurrence on CT studies and
15.9% (10/63) patients developed new liver metastases. Five patients were lost follow up and 14 patients died during the follow-up period. The remaining 44 patients are still alive.

The major complications were found in 3 patients after RFA treatment (4.8%): abscess in 2 patients and biloma in 1 patient. There were 7 minor complications (11.1%): low grade fever in 5 patients, wound pain requiring intravenous analgesics in 1, and mild grounding pad burn injury in 1.

**DISCUSSION**

Hepatocellular carcinoma (HCC) and colorectal cancer metastases are the most common malignant tumors in liver and surgical resection offers the only prospect for cure [2, 3]. However, the number of patients suitable for liver resection is sharply limited by many factors: unresectable location, vascular invasion, multiple tumors, extrahepatic metastases, advanced liver cirrhosis and comorbidities [4, 5]. Local methods for tumor ablation have thus been proposed and among these, RFA is considered a promising alternative to surgery [12].

Radiofrequency thermal ablation works by converting radiofrequency waves into heat through ionic vibration. Alternating current passing from an electrode into the surrounding tissue causes ions to vibrate in an attempt to follow the directional current change. Thus, ionic friction generates heat in the tissue and not in the electrode itself. Increased current leads to more vigorous ionic motion and increased temperature over a period of time, eventually leading to coagulation necrosis and cell death. The purpose of RFA is to achieve local temperatures that are lethal to the targeted tissue. Generally, thermal damage to cells begins at 42°C; once above 60°C, intracellular proteins are denatured, the lipid layer melts, and irreversible cell death occurs [13].

The success rate of RFA in treating colorectal liver metastases depends mainly on tumor size [14-16]. Our results confirmed that better outcomes are achieved for the smaller tumors. We achieved local control in 100% tumors with diameters equal to or smaller than 2 cm and 90.2% in tumors with diameter between 2.1 and 3.0 cm. The total necrosis rate is 64.3% in tumors between 3.1 and 4.0 cm and only 43.7% tumors between 4.1 and 5.0 cm. These findings suggest that larger tumors are sometimes difficult to eradicate completely with RFA. The presence of
residual tumor detected on the follow-up CT scans does not necessarily indicate a poor outcome, because residual tumor can be retreated and there appears to be no higher risk of systemic spread from foci of residual tumor.

Other factors that may affect the success rate of RFA are tumor location and the surrounding tissue [17]. Centrally located tumors are more difficult to treat successfully because of heat loss due to the large amount of vascularity in the hepatic hilum. During RFA, heat loss occurs at the needle tip, mainly through convection by blood circulation. It is easier to completely eradicate peripheral tumors with RFA. Surrounding fibrosis, as seen in liver cirrhosis, is also expected to reduce thermal conduction and heat dissipation, thus improving the efficacy of RFA.

The rate of serious complications with RFA is low [18]. Indeed, a major advantage of RFA is the ability to avoid tract bleeding and tumor seeding by coagulating the tract when the ablating electrode is withdrawn. Large vessel thrombosis, which occurs more frequently after percutaneous ethanol injection (PEI), is rare after RFA. It is probably because large vessels act as a heat sink and prevent thermal injury. Some studies have shown that RFA for colorectal metastases has a low complication rate, and our study identified serious complication in only 3 of 63 patients (4.8%): abscess in 2 patients and biloma in 1. Mild grounding pad burn injury was found in 1 patient, which was completely resolved in one month. To minimize the risk of local burning, the skin must be well prepared and the grounding pad should be smoothly placed without wrinkling.

RFA can be carried out by a percutaneous or laparoscopic approach, or by laparotomy. The percutaneous approach is the least invasive way and the patients are usually discharged soon. More than 95% of our patients were discharged within 24 hours. The lesion can be targeted by various imaging techniques such as US and CT. MR too has been suggested as guidance system, providing a more accurate assessment of the ablated area [19]. However, US is considered as a primary guidance technique because of the easy approach and time-saving. Most of the RFA was finished less than 1 hour in our study.

An important feature of RFA is the ease with which treatments can be repeated. Careful imaging follow-up, particularly looking for interval change with the pretreatment CT scans, will allow early detection of viable or recurrent tumors.

In conclusion, percutaneous US-guided RFA is a safe technique and effective in the treatment of colorectal liver metastases. As a minimally invasive procedure, it is ideal for patients who are not good surgical candidates or who refuse surgery. The success of RFA for colorectal liver metastases is influenced primarily by tumor size. It is a very promising technique that is most successful for tumors smaller than 3cm in diameter, and with satisfactory success rate for the tumors of 3-4 cm in diameter. Long-term follow-up data are still needed regarding local and systemic recurrence and survival after RFA, and will provide additional guidance in the initial selection of patients for this treatment.

REFERENCES

8. de Baère T, Elias D, Dromain C, et al. Radiofrequency ablation of 100 hepatic metastases with a mean follow-up of more than 1 year. AJR Am J Roentgenol 2000; 175: 1619-1625
14. Goldberg SN, Gazelle GS, Solbiati L, Rittman WJ,


超音波導引下經皮熱射頻減除術治療大腸直腸肝轉移癌

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本研究是評估超音波導引下經皮熱射頻減除術治療大腸直腸肝轉移癌的臨床應用、治療效果，以及併發症。從2002年1月到2004年12月，共有63位病人（39位男性與24位女性），109個大腸直腸肝轉移癌，接受超音波導引下經皮熱射頻減除術治療腫瘤。這些病人的平均年齡是65.3歲（37-89歲），平均腫瘤大小是2.9公分（1.2-5.0公分）。本研究的病人其腫瘤數介於1-3個，且每一個腫瘤大小不超過5公分。治療後1個月以動態電腦斷層評估其治療效果，然後每隔3個月追蹤。腫瘤完全壞死的定義是在電腦斷層上被治療的腫瘤呈現低密度且完全沒有顯影。治療後動態電腦斷層攝影顯示78.9%（86/109）的腫瘤完全壞死，而21.1%（23/109）仍有殘存的腫瘤。以腫瘤大小來評估其效果，小於2公分腫瘤的壞死率100%（24/24），2-3公分腫瘤的壞死率是90.2%（37/41），3-4公分腫瘤的壞死率是64.3%（18/28），4-5公分腫瘤的壞死率是43.7%（7/16）。治療後有3位病人有嚴重的併發症，其中2位有肝膿瘻，1位有膽汁郁積。平均的追蹤時間是22.4個月（4-40個月），有13.8%（15/109）的腫瘤在追蹤期有腫瘤復發的情形。經皮熱射頻減除術可以有效的治療大腸直腸肝轉移癌，尤其是小於3公分的腫瘤效果最好，3-4公分的腫瘤的療效也還可以，治療後產生的嚴重併發症的比例也很低。

關鍵詞：肝臟腫瘤，轉移，肝臟腫瘤，治療，熱射頻減除術