Lecture 1

Basic of RFA

Hyunchul Rhim, MD

In our institution, we treat the patient with hepatocellular carcinoma according to the protocol which was decided through the tumor board meeting of our liver cancer center (Figure). Our basic policy for non-surgical treatment of HCC is consistent with the recently revised BCLC guideline. We treat the patient with upto 3 nodules smaller than 3cm by RFA alone. If the tumor is not clearly seen despites applying CE-US, Fusion imaging, and artificial ascites, we refer this patient to single session combined treatment (RFA immediatey after TACE). For the intermediate sized (3-5 cm) tumors, we are doing dual session combined treatment (RFA 3-4 days after TACE) or RFA using multiple electrodes. We are waiting the mid-term results with two different methods.

RFA can be performed percutaneously, laparoscopically, or at laparotomy. Whenever possible, the percutaneous approach should be performed because it has several advantages over laparoscopy and open laparotomy. RFA performed percutaneously is the least invasive procedure, can be performed on an outpatient basis, provides minimal morbidity, is relatively inexpensive when compared with other approaches, and can be performed using no more than local anesthesia with conscious sedation. In our hospital, we are treating the most patient in patient basis (3 days stay) under local and IV sedation using lidocaine, Pethidine, and Fentanyl. In more than 90% cases, RFA is performed percutaneously under US-guidance. During the whole procedure, we monitor the patient' s vital signs and perform 4 phase dynamic liver CT immediately after ablation to assess the therapeutic response. If there is no complication or residual tumor to be treated, the patient discharge at the next day of ablation. At one month, we assess the therapeutic efficacy by dynamic liver CT, and then we follow-up the patient at every 3-4 month with same imaging study and tumor markers.

Although there is no robust data with randomized controlled trial comparing to the results of surgery, the 5 year survival data in large series is reported to 40-60% which is quite promising. Furthermore, there are many evidences to support the safety of RFA in the literatures. The reported mortality and major complication rate is less than 0.5% and 2~5%, respectively, which is the definite benefit over the surgery. However, the local tumor progression (3~24%) is still main problem of RFA to be overcome by the further refinement of device and more sophisticated case selection.

The keys to successful ablation are the following three. First, we need to make a plan well with a balance between safe and complete ablation. Best planning is the first step for a successful outcome after RFA of hepatic tumors. Planning includes the following: (i) to assess the feasibility of procedure based on inclusion/exclusion criteria (proper patient selection); (ii) decision of type of approach (i.e. percutaneously, laparoscopically, open), electrodes, guiding modalities and number of ablations; and (iii) to decide whether to apply overlapping ablations or a special technical tip (e.g. artificial ascites) for safe and complete ablation. The feasibility assessment for RFA begins

with a review of good-quality abdominal CT or magnetic resonance imaging. These preoperative imaging studies are used to determine the number and size of tumors and their relationship to surrounding structures including blood vessels or vital organs. An operator should perform planning ultrasonography (US) if a US-guided procedure is considered. An operator should assess three-dimensional (3-D) configuration and size of the tumor, whether there is a safe electrode path to the tumor, whether there is any organ close to the expected RFA zones and whether there is any large vessel close to the tumor.

Safe ablation is the second key to a successful loco-regional treatment. Minimal invasiveness is a clear advantage of image-guided ablation over the surgical treatment. Safe ablation can be supported by careful patient selection, close patient monitoring during the ablation and appropriate management of complication after the ablation. As careful patient selection cannot guarantee safe ablation, early detection during and immediately after ablation is more important for managing the major complications appropriately. To minimize the mortality resulting from the major complication, an interventional radiologist should be aware of the broad spectrum of complications encountered after RFA of hepatic tumors (e.g. bleeding, massive infarction, extensive abscess with sepsis and thermal injury of the colon). The frequency of major complications may be correlated with both the experience and aggressiveness of an operator. If an operator has more aggressive posture for achieving complete ablation with enough ablative margin, the rate of major complication will be increased even when treating technically feasible tumors.

Complete ablation is the last key to a successful local treatment. The ablative margin surrounding the index tumor is an established prognostic factor for local tumor control. Local tumor progression can develop at the margin of an ablation zone if the ablative margin is inadequate compared to acceptable ablative margins. So that there is enough ablative margin, three factors should be considered prior to or during the ablation: (i) the tumor size with 3-D configuration; (ii) the configuration and size of the RFA zone made by a specific electrode; and (iii) the direction of the RF electrode path related to the tumor configuration. We believe that a complete ablation depends on achieving a symmetrical ablative margin rather than simply increasing the volume of the ablation zone.

In summary, RFA is the most popular method in image-guided tumor ablation. Before starting RFA procedure as a beginner, it is important to understand the basic mechanism of thermal ablation and RF devices and the broad spectrum of complication encountered after ablation. Many clinical studies have supported the growing evidence of a clear survival benefit, excellent results for local tumor control and improved quality of life. The keys to successful ablation were 1) best planning, 2) safe ablation and 3) complete ablation. Finally, multimodality approach is the smartest way to manage the patient suffering with malignant tumors.

Basic of RFA

Hyunchul Rhim, MD

Currently chemotherapy, surgery, and radiation therapy have been three mainstays of cancer treatment. However, new interventional oncology (IO) techniques are developing and coming into wider use. Image-guided tumor ablation is the most popular technique for unresectable malignant tumor involving the liver, kidney, and lung. There are many energy sources for tumor ablation. Among them, radiofrequency is the most commonly using energy source worldwide. Radiofrequency thermal ablation (RFA) is receiving increasing attention as an alternative to standard surgical therapies for the treatment of liver neoplasms. Benefits over surgical resection include the anticipated reduction in morbidity and mortality, low cost, suitability for real time image guidance, the ability to perform ablative procedures on outpatients, and the potential application in a wider spectrum of patients, including nonsurgical candidates.

The primary goal of thermal ablation is to treat an entire tumor by heating to destroy the malignant cells in a minimally invasive way without damaging adjacent vital structures. Hence, it is important to understand how heat interacts with tissue to induce cell death. Increasing the temperature only several degrees to 50℃ to 520℃ markedly shortens the time necessary to induce cytotoxicity (4 to 6 minutes). Between 60℃ to 1,00℃, there is near instantaneous induction of protein coagulation. Temperatures greater than 1,050℃ result in tissue boiling, vaporization, and carbonization. These processes usually retard optimal ablation because of a resultant decrease in energy transmission. Thus, a key point for ablative therapies is achieving and maintaining a 50℃ to 100℃ temperature range throughout the entire target volume.

RF energy is delivered to the tumor by means of an RF electrode, a thin (usually 21- to 14-gauge) needle that is electrically insulated along all but the distal shaft. When connected to the appropriate generator, RF current flows from the exposed, noninsulated portion of the electrode. As these current flows to electrical ground, it results in frictional heating by means of ion agitation, which induces cellular death through coagulation necrosis. For monopolar systems, the ground is usually a pad placed on the patient's back or thigh, whereas in bipolar systems, a second electrode serves as the ground. The RF system is basically composed of an alternating electric current generator, ground pads, and electrodes that make up the components of an electric circuit. The electrode design and generator algorithms are variable, but two main type of electrode are straight type internally cooled electrode and multitined expandible electrodes. There are insufficient data and experience to claim that any specific device and equipment is superior or inferior because superior results may be often due to technique or tumor biology. Recently two RF devices made in Korea were introduced in the market.