Chapter 10
Radiofrequency Ablation for Treating Malignant Tumors to the Lungs

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10.1 Introduction

Even if the clinical use of RF ablation in lung tumors started in 2000 [1], the quality of the data available today is limited with inhomogeneous patient populations in early studies mixing primary and metastatic disease. More recently a few prospective studies with larger volume of patient with more homogeneous disease became available. No randomized study versus competitive local treatment such as surgery or stereotaxic body radiation is available. There is only very limited data on other thermal ablation techniques for treating lung lesions such as microwaves, cryoablation [2, 3], and irrevers-

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ible electroporation [4]. The pathological proof of local efficacy of lung RFA has been obtained in an ablation-resection study where nine of the nine treated metastases show 100% necrosis after percutaneous RFA when treating metastases up to 3 cm [5]. Oversizing the ablation zone has been reported in many study as a key for obtaining local control [6, 7]. The following sections are designed to provide an overview on the available clinical data, based on a selective literature review. Studies including mixed populations with primary lung cancer and metastatic disease are excluded.

Major complications are reported in about 2–10% of patients with a case series of 1403 lung tumors who underwent 1000 RFA sessions reporting a major complication rate of 9.8% including 4 deaths with 3 related to pneumonia and 1 to hemorrhage. Frequent major complications were aseptic pleuritis (2.3%), pneumonia (1.8%), lung abscess (1.6%), bleeding requiring blood transfusion (1.6%), pneumothorax requiring pleural sclerosis (2.0%), brachial nerve injury (0.3%), and tumor seeding (0.1%). Previous external beam radiotherapy and age were significant risk factors for pneumonia, emphysema being a risk factor for lung abscess, and pneumothorax requiring pleural sclerosis [8].

Pneumothorax occurs in up to 63% of patients, with roughly 20% of patients requiring chest tube for a short period of time. Pneumothorax should not be considered as a complication unless long-term drainage or more aggressive treatment is needed.

10.1.1 Bronchial Carcinoma

Small-cell lung cancer (SLC) is usually treated with systemic chemotherapy with only few patients being eligible for local treatment as salvage therapy. In contrast early non-small-cell lung cancer (NSCLC) is known to respond well to local therapy, and surgery is often performed in curative intent. In selected patients thermal ablation such as RF ablation is an alternative to surgical resection. This includes patients with a single lung after pneumonectomy, patients with very limited lung capacity, or patients otherwise unfit for surgery. Outcomes are favorable in early stages of disease (Stage Ia/Ib). Ideally tumor size is below 3–3.5 cm. Additional

systemic therapy appears to favorably add to the prognosis. So far it is hard to estimate the clinical value of RF ablation in NSCLC as comparative data are scarce (Table 10.1). RFA for NSCLC is usually performed in nonsurgical patients with severe comorbidities, and it is noteworthy to notice that most of reported deaths in NSCLC RFA series are not related to cancer progression but comorbidities. For Simon et al., Cox regressions showed that an increasing Charlson comorbidity index score was significantly associated with an increased risk of death (HR 1.3, 95% CI 25.5, 58.2) with a score ≥5 (OS = 10.43 months—95% CI 7.61, 19.85), a score of 3–4 (OS = 36.62 months—95% CI 25.54, 58.29), and a score of 1–2 (OS = 55.5 months—95% CI 39.46, 64.02) [9].

10.1.2 Metastatic Lung Disease

The acceptance of resecting of lung metastases dates back to 1997, when an international registry reported actuarial 5-, 10-, and 15-year survival rates of 36%, 26%, and 22%, respectively [10]. Despite several reports evidence for surgical metastasectomy remains weak and is discussed controversial [11]. Overall survival after RF ablation of lung metastases appears to be very similar to s surgical metastasectomy. A systematic review of lung metastasectomy in colorectal lung metastases looked at 2925 patients with a 5-year overall survival in between 27 and 68% [12]. RF ablation is typically limited to no more than 5–6 lesions, ideally less than 3, with a maximum diameter of 3–3.5 cm. An obvious advantage of RF ablation over surgery is its potential to easily preform repeated ablations during the course of disease. OS rate after RFA of lung metastases is within the range of the best results obtained by surgical resection with very similar predictive factors of OS than RFA. Indeed complete resection, location of primary disease, DFI, number of metastases, and positive lymph nodes at pathology have been reported as predictive factors in meta-analysis of lung metastasectomies [10, 12]. The size of metastases, number of metastases, extrapulmonary disease, and DFI have been reported as predictive as predictive factors in lung radiofrequency ablation [13, 14] (Table 10.2).

Table 10.1 Summary of studies on RF ablation in NSCLC

Author	Patients/ lesions	Ablations [*n*]	Tumor stage	Lesion size [mm]	Follow-up [months]	Overall survival 1 year [%]	3 year [%]	5 year [%]	Median survival [months]	Local recurrence/ progression [%]	Major complications [%]
Fernando (2005) [15]	18/21		I–IV	28 (12–45)	14 (3–25)	80			n.r.	38	1 death
Beland (2010) [16]	79/79		I–IV	26 (10–55)	17 (1–72)				n.a.	38	
Hiraki (2011) [17]	50/52	52	I	21 (7–60)	37 (2–88)	94	74		67	31	6
Ambrogi (2011) [18]	57/59	80	I	26 (11–50)	46 (12–82)	83	40	25	33	41	5
Lanuti (2012) [19]	45/?	55	I	23 (7–45)	32 (2–75)		67	31	44	38	n.a.
Kodama (2012) [20]	44/51	55	I–IV	17 (6–40)	29 (1–98)	98	73	56		11	5.5
Simon (2012) [9]	82	–	IA–IB	–	–	77	50	20	36.6	–	–
Palussiere (2015) [21]	87/97	–	I–IIA	21 (10–54)	31 (17–51)	91.9	77.5	58.1		21.1	3.4

10.2 Study Results

Table 10.2 Summary of studies on RF ablation in lung metastases from cancer of different origins

Author	Patients/ lesions	Ablations [*n*]	Entity	Lesion size [mm]	Follow-up [months]	Overall survival 1 year [%]	3 year [%]	5 year [%]	Median survival [months]	Local recurrence/ progression [%]	Major complications [%]
Yan (2006) [22]	55/n.a.	70	CRC	21±11	24 (6–40)	85	46	n.a.	33 (4–40)	38	17
Yamakado (2007) [23]	71/155	n.a.	CRC	24±13	19 (4–42)	84	46	n.a.	31	47	20
Hamada (2012) [24]	84/141	n.a.	CRC	23±14	27 (14–93)	91	45	21	34.9	28	2.2
Soga (2009) [25]	15/26	n.a.	RCC	22±14	25 (1–70)	100	100	100	n.r.	13	7
	24/109	n.a.		25±15	29 (1–70)	90	52	52	n.r.	46	
Palussiere (2011) [26]	29/47	n.a.	Sarcoma	9 (4–40)	50 (28–72)	92	65	n.a.	n.a.	11	59
Chua (2010) [27]	148	188	Mixed	40	29 (2–103)		60	45	51	4	
Gillams (2013) [13]	122/398	256	CRC	17 (5–40)	18 (6–102)		57		41	19	4
Matsui (2015) [28]	84/172	113	CRC		37.5	95	65	52		14	1.8
De Baere (2015) [3]	40/60	48 cryo	Mixed	14 (3–32)	Min 12					6	6
De Baere (2015) [14]	566/1037	642	Mixed 188 CRC	15 (4–70)	36 (20–53)	92	68	52	62	11	–

The relatively high major complication rate is almost completely based on cases requiring chest tube due to pneumothorax after ablation

n.a. not available, *n.r.* not reached, *RCC* renal cell carcinoma

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