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REVIEW

Radiofrequency ablation as a treatment tool for liver metastases of colorectal origin

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Abstract

At diagnosis 10–25% of patients with colorectal liver metastases (CRLM) present as resectable disease. Liver resection is the gold standard treatment, resulting in a 5-year overall survival (OS) of 22–58%, local recurrence rates of 1.2–10.4% and a perioperative mortality of less than 5%. Multiple attempts have been made to assess the possible contribution of radiofrequency ablation (RFA) to improve OS and progression-free survival (PFS) in patients with unresectable colorectal liver metastases. The aim of this paper is to review the RFA literature in the setting of colorectal liver metastases: RFA with and without chemotherapy, RFA with and without resection, RFA for solitary unresectable CRLM, surgical and percutaneous imaging-guided RFA, RFA compared with chemotherapy. The reported OS, PFS, local recurrence rates, morbidity and mortality in these different settings are analyzed. This paper reflects on a possible role of RFA in resectable CRLM.

Keywords: *Colorectal liver metastases; unresectable; resectable; radiofrequency ablation.*

Introduction

Up to 50% of patients with colorectal cancer (CRC) develop colorectal liver metastases (CRLM) at some point in the course of their disease. Only 10–25% of these CRLM present as resectable disease at diagnosis. Curative liver resection is currently considered to be the gold standard treatment for resectable CRLM. Hepatectomy has a morbidity of 17–37% and a mortality below 5%[1,2]. Recent reviews showed 5-year OS rates after hepatic resection of 22–58% and a 10-year survival of up to 28%[3,4]. Local recurrence rates after resection vary from 1.2% to 10.4%[3].

For unresectable CRLM recent improvements in systemic chemotherapy have led to an OS of almost 2 years, but 5-year survival after chemotherapy is very rare[3]. In the past decade, several studies have looked at the possible contribution of radiofrequency ablation (RFA) to improve overall survival (OS) and progression-free survival (PFS) in patients with unresectable CRLM.

The aim of this paper is to review the results of trials performed thus far in the setting of unresectable liver metastases and to reflect on a possible role of RFA in resectable disease.

General guidelines

The following guidelines were described and are generally accepted for RFA of CRLM[4,5]:

- The number of lesions should not be considered an absolute contraindication to RFA, but most centers preferentially treat patients with ≤ 5 lesions.
- Best rates of complete ablation are achieved in lesions with a maximum diameter of ≤ 3 cm.
- Tumor location can be a problem in case of:
  - lesions on the liver surface because of thermal injury of adjacent structures (although this risk can be mitigated through pre-ablation

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percutaneous infusion of dextrose fluid into the space between the liver and the adjacent bowel, abdominal wall or diaphragm)
  - lesions adjacent to the hepatic hilum (risk of thermal injury to the biliary tract)
  - lesions adjacent to large hepatic vessels (because of the heat sink phenomenon)
- Intrahepatic bile duct dilatation and untreatable/unmanageable coagulopathy are generally considered a contraindication for RFA. The same applies to the presence of bilioenteric anastomoses, which increases the incidence of hepatic abscess, although there are papers suggesting the combined use of RFA with extended antibiotic prophylaxis in these cases[6]. Tumors located <1 cm from the main biliary duct are at risk for delayed stenosis of the main biliary duct.

RFA for unresectable CRLM compared with chemotherapy

OS and recurrence after RFA

In patients with unresectable CRLM, current systemic chemotherapy can result in a median survival of up to 20.6 months[7]. With regard to the use of RFA in patients with unresectable CRLM, the literature reports on various treatment combinations with RFA in different therapy settings. The results are highly variable with 5-year survival rates from 3.0% to 30.5% and local recurrence rates varying from 5.0% to more than 60% (Tables 1–3). When RFA is performed with an intention to cure in patients with only CRLM, survival and local failure are directly related to the size and number of the lesions and their location, as well as the number of ablations, the chosen approach (open, laparoscopically or percutaneously) and the physician's experience[4]. A literature study by Crocetti et al.[5] and Lencioni et al.[8] showed that nonsurgical patients with ≤5 CRLM, each ≤5 cm in diameter, have a 5-year survival rate of 24–44% after RFA. Best results are obtained with RFA for small (<3–4 cm) solitary lesions, which can result in 40% 5-year survival[4,5]. A meta-analysis by Mulier et al.[9] (3760 patients) found less local recurrence in small lesions (<3 cm). The literature search for this analysis focused on the period 1990–2004, thus also including early experiences with RFA technology and some results from low volume centers[9]. Sørensen et al.[10] found a 3- and 5-year survival of 64% and 44% respectively after RFA for unresectable CRLM. This concurs with the results of a prospective study by Abitabile et al.[11], reporting on 47 patients with CRLM (80% of which were unresectable), in which a 3-year OS rate of 57% was reached. The overall local recurrence rate was 8.8%. All CRLM ≤3 cm (80.2% of lesions) were completely ablated, resulting in a local recurrence rate of 1.6%. Gillams et al.[12] reported a median 3- and 5-year survival

Table 1. Comparison of treatment modalities with/without RFA

Author[Ref.] journal, year	No. of patients	Therapy modality	*N*	OS (%)		DFS (%)		Local recurrence at treatment sites (% patients)
				3 years	5 years	3 years	5 years	
Gleisner[16] Arch Surg, 2008	258	Resection alone	192	72.0	57.4	41.3	41.3	14.8[b]
		RFA ± resection	66	51.2	28.3	8.9	0.0	50.9–62.5[b]
Ruers[18] Ann Surg Oncol, 2007	201	Resection	117	65.0	51.0	35.0	32.0	0.9
		Local ablation	45	40.0	27.0	15.0	11.0	11.0
		Chemotherapy	39	37.5	15.0	–	–	–
Machi[20] Cancer J, 2006	100	RFA after previous liver resection	8	42.0	30.5	23.2	21.7	20.5[b]
		First-line RFA (before chemotherapy)	55					
		Second-line RFA (after chemotherapy)	45					
Elias[21] J Surg Oncol, 2005	63	Resection	99	47.0	–	27.0	–	7.2–9.0 at resection sites[c]
		RFA	154					7.2 at RFA sites[c]
Abdalla[19] Ann Surg, 2004	418	Resection only	190	73.0	58.0	41.1	30.0	2.0
		RFA + resection	101	43.0	–	16.7	–	5.0
		RFA only	57	37.0	–	4.4	–	9.0
		Chemotherapy only	70	13.2	7.7	–	–	–
Leblanc[22] Eur J Surg Oncol, 2008	99	RFA alone	34	75.0[a]	–	–	–	12.0
		RFA + resection	28	68.0[a]	–	–	–	8.0
		Resection alone	37	83.0[a]	–	–	–	6.0

[a]OS at 2 years.
[b]Recurrence anywhere in the liver.
[c]% procedures.

Table 2. RFA for unresectable solitary CRLM versus resection for resectable CRLM

Author[Ref.] journal, year	No. of patients	Lesion size (cm) (range)	Treatment modality	OS (%)		Local failure (% patients)
				3 years	5 years	
Oshowo[17] Br J Surg, 2003	25	3 (1–10)	CT-/MRI-guided percutaneous RFA	52.6	42.3	ns
	20	4 (2–7)	Resection	55.4	34.2	15.0
White[24] J Gastrointest Surg, 2007	22	2 (1–5)	CT-guided percutaneous RFA	24.3	–	45.5
	30	2.5 (1–5)	Resection	81.4	58.6	3.3
Aloia[23] Arch Surg, 2006	30	≤3 (53%) >3 (47%)	Percutaneous/open RFA	57.0	27.0	37.0
	150	≤3 (42%) >3 (58%)	Resection	79.0	71.0	5.0
Hur[25] Eur J Surg Oncol, 2009	25	≤3 (60%) >3 (40%)	Percutaneous/open RFA	77.9	55.4 42.0	28.0
	42	≤3 cm (54.8%) >3 (45.2%)	Resection	81.0	56.1 30.0	9.5

ns, not specified.

Table 3. Percutaneous imaging-guided RFA for unresectable CRLM

Author[Ref.] journal, year	No. of patients	No. of procedures	No. of lesions	Approach	Imaging guidance	Lesion size	OS (%)		Local recurrence (% lesions)
							3 years	5 years	
Veltri[37] Cardiovasc Intervent Radiol, 2008	122	166	199	Percutaneous ($N=177$), surgical ($N=22$)	US (sometimes contrast-enhanced US)	All sizes ≤3 cm >3 cm	38.0 50.0 32.5 ($P=0.006$)	22.0 27.5 12.5	26.3 33.3 66.7 ($P<0.0001$)
Solbiati[38] Radiology, 2001	109	162	172	Percutaneous	CT or US	All sizes ≤3 cm >3 cm	33.0 – –	– – –	29.6 16.5 56.1 (P significant)
Machi[20] Cancer J, 2006	100	146	507	Percutaneous ($N=61$), surgical ($N=85$)	US	All sizes ≤1 cm >1 cm	42.0 Median OS 40.0 months Median OS 22.0 months ($P=0.0026$)	30.5	6.7 – –
Gillams[13] Eur Radiol, 2009	309	617	–	Percutaneous	CT or US	<5 lesions of ≤5 cm, no extrahepatic disease <5 lesions of ≤5 cm >5 lesions and/or >5 cm ($P=0.000$)	49.0 40.0 13.0	24.0 18.0 3.0	– – – –
Jakobs[39] Anticancer Res, 2006	68	–	183	Percutaneous	CT	–	68.0	–	18.0

of 84% and 40% respectively with solitary CRLM ≤4 cm in diameter in 40 patients who were not candidates for resection. Furthermore, these authors reported on 309 patients who were treated with percutaneous RFA[13]. All patients were deemed inoperable for CRLM and were accepted for RFA with 5 or fewer lesions of ≤5 cm, or as many as 9 lesions of ≤4–4.5 cm, or a solitary tumor of ≤7 cm in diameter. Extrahepatic disease was not a contraindication, provided it was stable on treatment. The presence of extrahepatic disease and liver tumor volume (defined by number and size of CRLM) were identified as significant survival factors. For patients with ≤5 CRLM of ≤5 cm the 5-year survival from ablation was 24%, whereas this decreased significantly with higher lesion size or number or if extrahepatic disease was involved[13]. Siperstein et al.[14] prospectively reported on their 10-year experience with RFA for CRLM to assess the factors affecting long-term survival. The inclusion criteria of this study allowed patients who failed chemotherapy, had extrahepatic spread (23.5%),

had up to 12 CRLM and a maximal lesion size of 10 cm. A total of 292 RFA procedures were performed in 234 patients with CRLM. Actual 3- and 5-year OS were 20.2% and 18.4%, respectively[14]. Median OS was improved for ≤ 3 lesions versus >3 lesions. The presence of extrahepatic disease is known to predict poor disease-free survival (DFS) and OS after hepatic resection[4]. The currently available literature on RFA for CRLM in patients with extrahepatic disease varies in opinion[4]. In the study of Siperstein et al.[14] the presence of extrahepatic disease did not adversely affect OS in this series.

From retrospective and non-randomized prospective studies, the results of RFA for unresectable CRLM seem promising, with 5-year survival rates varying from 3% to 30%, depending on lesion size and number, physician's experience with RFA, etc. However, these results should be interpreted with caution, because of their non-randomized nature. On the other hand, for unresectable CRLM 5-year survival is rare after treatment with only systemic chemotherapy[7]. Whether RFA indeed results in superior survival compared with chemotherapy cannot be concluded from these data. This question can only be answered by randomized studies.

In an attempt to create more clarity on the possible benefit of the combination RFA + systemic chemotherapy over chemotherapy only in patients with a limited number of CRLM, the European Organisation for Research and Treatment of Cancer (EORTC) designed the randomized controlled CLOCC trial, in which patients were randomized between chemotherapy alone and chemotherapy plus RFA ($\pm$surgical resection). This study may for the first time provide solid evidence for the benefit of RFA in patients with unresectable CRLM, but definitive results are awaited.

Resection of resectable CRLM versus RFA for (un)resectable CRLM

Combined treatment modalities with RFA

In general, new modalities of treatment are reserved for patients who are not eligible for surgery. This implies a bias in patient selection and makes a fair comparison between techniques impossible[15,16]. There are concerns that RFA results in higher recurrence rates than liver resection[15], but comparing the results of different treatment modalities for CRLM is very difficult, as resectable CRLM are treated by liver resection and RFA is reserved for a wider spectrum of patients, in whom resection is contraindicated because of extrahepatic disease, vessel contiguity, comorbidity or an estimated insufficient residual volume of the liver remnant after resection. In other words, patients fulfilling the criteria for liver resection probably have a better prognosis[17]. Multiple papers compare liver resection for resectable lesions with RFA, with or without resection, for unresectable liver lesions (Table 1). Gleisner et al.[16] retrospectively analyzed a large patient cohort (258 patients), including only patients with CRLM who were operated on with curative intent. Also, only RFA treatments performed at the time of open laparotomy were included in the study. OS rates of 72% at 3 years and 57.4% at 5 years were reported for the liver resection-only group, compared with 51.2% and 28.3% respectively in the RFA $\pm$ resection group. DFS at 3 and 5 years was 41.3% for the resection-only group compared with 8.9% and 0% respectively in the RFA $\pm$ resection group[16]. These numbers concur with the other trials reported in Table 1[18–22]. Gleisner et al.[16] reported that the combination of resection and RFA was associated with a significantly increased risk of extrahepatic failure at 1 year compared with patients who were undergoing resection only ($P<0.05$), but propensity score methods revealed differences in baseline tumor and treatment-related factors, resulting in a lack of comparability between resection-only and resection + RFA groups. Furthermore, it should be mentioned that 11 patients underwent RFA alone (14 CRLM), 5 of whom had a solitary lesion ablated that abutted the confluence of the hepatic veins and was deemed unamenable to resection. This could make for a substantial bias[16]. The prospective trial of Ruers et al.[18] and retrospective analysis by Abdalla et al.[19] also included patients with liver-only disease in whom, at laparotomy, resection or local ablation was not feasible for technical reasons and who were subsequently treated systemic chemotherapy only. In the study of Ruers et al.[18] patients treated with chemotherapy ($N=39$) only reached a median OS of 26 months with a 2- and 5-year OS of 51% and 15%, respectively. The patient group undergoing local ablation ($\pm$resection) reached a 2- and 5-year OS survival of 56% and 27%, respectively[18]. Patient groups were too small to show any statistically significant difference between groups. On the other hand, Abdalla et al.[19] found a statistically significant difference in survival for patients treated with RFA as a component of therapy versus chemotherapy only, whether compared as a group ($P=0.002$) or when each subgroup was compared ($P=0.005$). Machi et al.[20] reported on 507 unresectable CRLM in 100 patients, treated with RFA, either after prior liver resection or before or after systemic chemotherapy. They found an OS at 3 and 5 years of 42% and 30.5%, respectively. The authors concluded that RFA can contribute to encouraging long-term survival and appears to confer a survival benefit over systemic chemotherapy alone, particularly when performed as part of the first-line therapy. A prospective study of Elias et al.[21], in which unresectable CRLM was treated with liver resection, RFA and chemotherapy as a combination, came to the same conclusion. Concerning local failure of treatment, defined as recurrence of tumor at the initial treatment sites, resection seems to result in better results than RFA $\pm$ resection (Table 1). Given the bias in patient selection for the different treatment groups, this remains

an impression. All authors agreed that randomized controlled trials (RCTs) are a necessity to assess the possible benefit of these combined modality treatments.

RFA for unresectable solitary CRLM versus resection for solitary CRLM

Table 2 summarizes the trials comparing RFA as a treatment tool for unresectable solitary CRLM with liver resection for resectable solitary CRLM. All of these studies had a retrospective design[17,23–25]. Oshowo et al.[17] reported a comparable 3-year OS for computed tomography (CT)- or magnetic resonance imaging (MRI)-guided percutaneous RFA and liver resection (52.6% vs 55.4%, respectively), whereas the trials of White et al.[23], Aloia et al.[24]and Hur et al.[25]reported a difference in OS and DFS in the advantage of liver resection. After a separate analysis for patients with small ($\leq$3 cm) solitary CRLM, Aloia et al.[24] still reported a significant difference in local failure (i.e. 3% after liver resections vs 31% after RFA ($P = 0.001$)) and 5-year OS (72% vs 18%, respectively ($P = 0.006$)). Hur et al.[25], on the other hand, found similar 5-year survival rates for RFA and liver resection in solitary CRLM of $\leq$3 cm in diameter (55.4% vs 56.1%) and similar local recurrence-free survival rates after 5 years (85.6% vs 95.7%). Abdalla[26] wrote comments on this paper of Hur et al.[25], stating that the relatively comparable outcome after treatment of small lesions should be viewed with optimism but caution, given the small number of patients in this study. In the prospective study on multimodality treatment by Abdalla et al.[19] a sub-analysis showed that survival after treatment of a solitary CRLM by RFA was not comparable with survival after resection of a solitary lesion ($P = 0.025$). However, in these non-randomized studies on RFA for solitary lesions there is a significant selection bias that reserves RFA for lesions located in more difficult situations or for high-risk patients. Again this makes any firm conclusion impossible.

RFA as an alternative for resectable CRLM

At present, no evidence from RCTs is available to support the use of RFA as an alternative treatment for resectable CRLM. Nevertheless, some surgeons suggest RFA may replace resection, especially in certain circumstances, such as new hepatic metastases after previous liver resection or limited central disease that would require extended hemihepatectomy[27]. Elias et al.[28] described percutaneous RFA as an alternative to surgery for tumor recurrence after liver resection. Incomplete local RFA treatment was observed in 6 of 47 patients (12.8%). Reported 1- and 2-year survival rates were 88% and 55%, respectively. The authors concluded that percutaneous RFA increases the percentage of curative local treatments for patients with liver recurrence after hepatectomy[28]. Despite the current lack of evidence, a German survey by Birth et al.[29] showed that in 25.9% of hospitals RFA is already being used as a tool for treatment of potentially curative resectable tumors.

RFA approach

For the sake of safety and to minimize local failure, it is mandatory that the lesions should be clearly visualized during RFA treatment. Intraoperative ultrasound (US) is used for surgical (open or laparoscopic) procedures. For percutaneous procedures, US, as well as CT or MRI guidance are an option[4]. Intraprocedural US only provides a rough estimate of the size of ablation, because the boundaries of the hyperechoic area that arise during RFA do not automatically correlate with the actual coagulative damage. In a study by Cha et al.[30] an animal model was used to compare the monitoring of RFA by unenhanced CT with US. CT proved to be an effective way to monitor RFA, because of increased lesion discrimination, reproducible decreased attenuation during ablation, and improved correlation to pathologic size. Both CT and MRI imaging are considered to be more reliable in this regard, although to date no RCTs have been performed to assess the preferred imaging modality[9,31–34].

A review of the literature showed that local tumor recurrence rates varied from 6% to 40% and were related to the size, number and location of the lesions[4]. The indications for a percutaneous approach are a limited number of small tumors, preferably not adjacent to hollow viscera (but this can be overcome by pre-ablation percutaneous infusion of dextrose fluid into the space between the liver and the adjacent bowel), small recurrences after prior liver resection, and patients ineligible for a surgical approach for anatomic and/or clinical reasons. Multiple previous laparotomies or liver resections can be an indication for a percutaneous approach, because of a high probability of extensive adhesions. Furthermore, optimal visualization is mandatory[4]. Recently, Lencioni et al.[8] published an extensive review on percutaneous image-guided RFA for liver tumors. They concluded that the currently available data in the literature suggest that RFA can result in complete tumor eradication in properly selected candidates and provide indirect evidence that this treatment improves survival in nonsurgical patients with limited CRLM. It needs no further explanation that patients should be properly staged before treatment, in order to make adequate patient selection for RFA. The number of lesions should not be considered an absolute contraindication for successful percutaneous RFA if adequate treatment of all lesions can be accomplished. On the other hand, tumor size is a very important predictive factor, but it should be realized that imaging studies tend to underestimate the real size of CRLM. In general, tumor size should not exceed a maximum diameter of 3–4 cm[27]. Subsequent to advances in RFA technique and probes, eradication of up to 97% was described for lesions up to

4 cm[35,36]. Table 3 summarizes the outcome of percutaneous RFA in CRLM. Although CT-guided procedures are generally thought to be more reliable, results for US- and CT-guided percutaneous approaches are fairly similar[20,37–39]. This is probably partly due to the experience of the performing physician within the studies mentioned. The literature review by Mulier et al.[9,27] concluded that authors who treat large numbers of patients had significantly fewer local recurrences. Significant improvement occurs after 40–50 cases, although the plateau phase in the learning curve is reached only at 100 procedures. Nevertheless, as could be expected, larger lesions (>5 cm) still result in worse outcomes[9,13,31].

With regard to length of hospital stay and resulting costs, percutaneous RFA can be performed as a 1-night hospital stay or even a day case, which substantially reduces costs compared with laparoscopic or open RFA.

Morbidity and mortality

An ASCO review of the recent literature shows that RFA has a mortality of 0–2% and the most commonly reported morbidity rate is 6–9%, with a low major complication rate[4]. A review by Stang et al.[40] reported mortality of 0–3.7% and 13–27% major complications for open RFA, whereas this was 0% and 1.8–13% respectively for percutaneous RFA procedures. In other words, RFA in general is considered to have a lower morbidity than major liver resection[15], and for percutaneous RFA these numbers are even better[4,8,15,40]. Furthermore, the literature shows that blood transfusion is rare after RFA and generally hospital stay is shorter[27]. Because of its low morbidity profile, percutaneous RFA can be repeated quite easily in cases of local recurrence, with only very limited clinical consequences for the patient.

Reflections and conclusions

The efficacy and reliability of RFA depends mainly on the diameter of the targeted lesions, the applied approach (surgical or percutaneous RFA) and the distance between the targeted lesion and large vessels (because of the heat sink phenomenon). Obviously, larger CRLM require overlapping treatment zones, i.e. multiple RFA sessions, which makes the result less reliable[9]. RFA for lesions greater than 5 cm in diameter is even questionable[9,31]. The RFA approach might progressively become a less interesting discussion point. Intraoperative ultrasound can be best performed in a surgical approach (and in particular open RFA) and the liver can be fully mobilized, which provides the optimal conditions for adequate placement of the RFA probe[31], but basically the indication for each approach is a matter of patient selection. In the case of grossly resectable disease with a few unresectable lesions, there is a preference for open RFA. On the other hand, for patients with unresectable CRLM, who are not fit for major surgery because of extensive comorbidity, a minimally invasive approach should be used. Furthermore, the experience of the physician performing RFA appears to be an important factor influencing outcome[9,27], the use of CT or MRI guidance improves the accuracy of the treatment[31] and newer generation probes seem to result in lower local recurrence[27]. Therefore, in some highly specialized centers, a percutaneous approach does seem to produce equivalent results to those achieved by liver resection in well-selected patients[9].

For unresectable CRLM, currently available prospective and retrospective data[18,19] strongly suggest a benefit of any combined modality treatment with RFA over a chemotherapy-only approach. The final results of the CLOCC trial are awaited.

In the current literature, there is a lack of evidence for the use of RFA as an alternative to surgery in patients with resectable CRLM. The results for series on RFA for small solitary lesions are contradictory (Table 2)[26]. Nevertheless, one can assume that RFA for small solitary lesions would result in a different (better) outcome if patient selection is shifted from unresectable to resectable CRLM, implying more favorable tumor biology, better localization etc. Furthermore, this would result in a more parenchymal sparing policy, in which extended liver resections could be avoided for small, but centrally located lesions, thus leaving in place a far larger liver remnant[3,27]. This would leave more room for retreatment of future local recurrences or newly developed CRLM at other sites of the liver.

Because most papers currently available in the literature compare RFA treatment for unresectable CRLM with liver resection for resectable CRLM, interpretation of the results in any direction remains very difficult and dangerous. The only real solution to this persistent deadlock is the design of an RCT for carefully chosen, resectable, small ($\leq$3 cm), solitary CRLM to be treated with RFA versus resection. Several authors have expressed their sincere concerns about the dangers of conducting such a trial, as it might encourage inappropriate use of RFA by the occasional practitioner of thermal tumor ablation[41]. But one could also turn this argument around in favor of an RCT: the reality of clinical practice is indeed already catching up, as can be concluded from the survey of Birth et al.[29]. Physicians are already autonomously interpreting the available data and, despite the lack of real evidence, deciding for themselves to treat selected resectable patients with RFA. If an RCT is not performed soon, determining what is really good clinical practice will become impossible.

References

[1] House M, Ito H, Gönen M. Survival after hepatic resection for metastatic colorectal cancer: trends in outcome for 1,600 patients during 2 decades at a single institution. J Am Coll

Surg 2010; 210: 744–5. doi:10.1016/j.jamcollsurg.2009.12.040. PMid:20421043.

[2] Nordlinger B, Sorbye H, Glimelius B. Perioperative chemotherapy with FOLFOX4 and surgery versus surgery alone for resectable liver metastases from colorectal cancer (EORTC Intergroup trial 40983): a randomized controlled trial. Lancet 2008; 371: 1007–16. doi:10.1016/S0140-6736(08)60455-9. PMid:18358928.

[3] Mulier S, Ruers T, Jamart J. Radiorequency ablation versus resection for resectable colorectal liver metastases: time for a randomized trial? An update. Dig Surg 2008; 25: 445–60. doi:10.1159/000184736. PMid:19212117.

[4] Wong SL, Mangu PB, Choti MA. American Society of Clinical Oncology 2009 clinical evidence review on radiofrequency ablation of hepatic metastases from colorectal cancer. J Clin Oncol 2010; 28: 493–508. doi:10.1200/JCO.2009.23.4450. PMid: 19841322.

[5] Crocetti L, de Baere T, Lencioni R. Quality improvement guidelines for RFA of liver tumours. Cardiovasc Intervent Radiol 2010; 33: 11–17. doi:10.1007/s00270-009-9736-y. PMid:19924474.

[6] Thomas K, Bream P, Berlin J. Use of percutaneous drainage to treat hepatic abscess after radiofrequency ablation of metastatic pancreatic adenocarcinoma. Am Surg 2004; 70: 496–9. PMid:15212401.

[7] Wolpin B, Mayer. Systemic treatment of colorectal cancer. Gastroenterology 2008; 134: 1296–310. doi:10.1053/j.gastro.2008.02.098. PMid:18471507.

[8] Lencioni R, Crocetti L, Pina MC. Percutaneous image-guided radiofrequency ablation of liver tumors. Abdom Imaging 2009; 34: 547–56. doi:10.1007/s00261-008-9479-2. PMid:19030918.

[9] Mulier S, Ni Y, Jamart J. Local recurrence after hepatic radiofrequency coagulation: multivariate meta-analysis and review of contributing factors. Ann Surg 2005; 242: 158–71. doi:10.1097/01.sla.0000171032.99149.fe. PMid:16041205.

[10] Sørensen S, Mortensen F, Nielsen D. Radiofrequency ablation of colorectal liver metastases: long-term survival. Acta Radiol 2007; 48: 253–8.

[11] Abitabile P, Hartl U, Lange J. Radiofrequency ablation permits an effective treatment fro colorectal liver metastases. Eur J Surg Oncol 2007; 33: 67–71. PMid:17174059.

[12] Gillams A, Lees W. Five-year survival following radiofrequency ablation of small, solitary, hepatic colorectal metastases. J Vasc Interv Radiol 2008; 19: 712–7. doi:10.1016/j.jvir.2008.01.016. PMid:18440460.

[13] Gillams A, Lees W. Five-year survival in 309 patients with colorectal liver metastases treated with radiofrequency ablation. Eur Radiol 2009; 19: 1206–13. doi:10.1007/s00330-008-1258-5. PMid:19137310.

[14] Siperstein A, Berber E, Ballem N. Survival after radiofrequency ablation of colorectal liver metastases: 10 years experience. Ann Surg 2007; 246: 559–65. doi:10.1097/SLA.0b013e318155a7b6. PMid:17893492.

[15] Gurusamy K, Ramamoorthy R, Imber C. Surgical resection versus non-surgical treatment for hepatic node positive patients with colorectal liver metastases. Cochrane Database System Rev 2010; CD006797; doi: 10.1002/14651858.CD006797.pub2.

[16] Gleisner A, Choti M, Pawlik T. Colorectal liver metastases: recurrence and survival following hepatic resection radiofrequency ablation and combined resection-radiofrequency ablation. Arch Surg 2008; 143: 1204–12. PMid:19075173.

[17] Oshowo A, Gillams A, Harisson E. Comparison of resection and radiofrequency ablation for treatment of solitary colorectal liver metastases. Br J Surg 2003; 90: 1240–3. doi:10.1002/bjs.4264. PMid:14515293.

[18] Ruers T, Joosten J, Wiering B. Comparison between local ablative therapy and chemotherapy for non-resectable colorectal liver metastases: a prospective study. Ann Surg Oncol 2007; 14: 1161–9. doi:10.1245/s10434-006-9312-5. PMid:17195903.

[19] Abdalla E, Vauthey J, Ellis L. Recurrence and outcomes following hepatic resection, radiofrequency ablation and combined resection/ablation for colorectal liver metastases. Ann Surg 2004; 239: 818–27. doi:10.1097/01.sla.0000128305.90650.71. PMid:15166961.

[20] Machi J, Oishi AJ, Sumida K. Long-term outcome of radiofrequency ablation for unresectable liver metastases from colorectal cancer: evaluation of prognostic factors and effectiveness in first- and second-line management. Cancer J 2006; 12: 318–26. doi:10.1097/00130404-200607000-00011. PMid:16925977.

[21] Elias D, Baton O, Sideris L. Hepatectomy plus intraoperative radiofrequency ablation and chemotherapy to treat technically unresectable multiple colorectal liver metastases. J Surg Oncol 2005; 90: 36–42. doi:10.1002/jso.20237. PMid:15786433.

[22] Leblanc F, Fonck M, Evrard S. Comparison of hepatic recurrences after resection or intraoperative radiofrequency ablation indicated by size and topographical characteristics of the metastases. Eur J Surg Oncol 2008; 34: 185–90. PMid:17998155.

[23] Aloia T, Vauthey J, Loyer E. Solitary colorectal liver metastases: resection determines outcome. Arch Surg 2006; 141: 460–6; discussion 466–7. PMid:16702517.

[24] White R, Avital I, D'Angelica M. Rates and patterns of recurrence for percutaneous radiofrequency ablation and open wedge resection for solitary colorectal liver metastases. J Gastrointest Surg 2007; 11: 256–63. doi:10.1007/s11605-007-0100-8. PMid: 17458595.

[25] Hur H, Ko Y, Min B. Comparative study of resection and radiofrequency ablation in the treatment of solitary colorectal liver metastases. Am J Surg 2009; 197: 728–36. doi:10.1016/j.amjsurg.2008.04.013. PMid:18789428.

[26] Abdalla E. Commentary: Radiofrequency ablation for colorectal liver metastases: do not blame the biology when it is the technology. Am J Surg 2009; 197: 737–9. doi:10.1016/j.amjsurg.2008.06.029. PMid:18789420.

[27] Mulier S, Ni Y, Ruers T. Radiofrequency ablation versus resection for resectable colorectal liver metastases: time for a randomized trial? Ann Surg Oncol 2008; 15: 144–57. doi:10.1245/s10434-007-9478-5. PMid:17906898.

[28] Elias D, de Baere T, Smayra T. Percutaneous radiofrequency thermoablation as an alternative to surgery for treatment of liver tumor recurrence after hepatectomy. Br J Surg 2002; 89: 752–6. doi:10.1046/j.1365-2168.2002.02081.x. PMid:12027986.

[29] Birth M, Hildebrand P, Dahmen G. Aktueller Stand der Radiofrequenzablation von lebertumoren: eine deutschlandweite Umfrage. Chirurg 2004; 75: 417–23. doi:10.1007/s00104-003-0801-9. PMid:15085282.

[30] Cha C, Lee F, Gurney J. CT versus sonography for monitoring radiofrequency ablation in a porcine liver. Am J Roentgenol 2000; 175: 705–11.

[31] Joosten J, Ruers T. Local radiofrequency ablation techniques for liver metastases of colorectal cancer. Crit Rev Oncol Hematol 2007; 62: 153–63. doi:10.1016/j.critrevonc.2006.12.001. PMid: 17317204.

[32] Meloni M, Goldberg N, Livraghi T. Hepatocellular carcinoma treated with radiofrequency ablation: comparison of pulse inversion contrast-enhanced harmonic sonography, contrast-enhanced power Doppler sonography, and helical CT. Am J Roentgenol 2001; 177: 375–80.

[33] Mahnken A, Buecker A, Spuentrup E. MR-guided radiofrequecy ablation of hepatic malignancies at 1.5T: initial results. J Magn Reson Imaging 2004; 19: 342–8. doi:10.1002/jmri.20004. PMid:14994303.

[34] Lencioni R, Crocetti L, Cioni D. Percutaneous radiofrequency ablation of hepatic colorectal metastases: technique, indications, results and new promises. Invest Radiol 2004; 39: 689–97. doi:10.1097/00004424-200411000-00007. PMid:15486530.

[35] de Baere T, Elias D, Dromain C. Radiofrequency ablation of 100 hepatic metastases with a mean follow-up of more than 1 year. Am J Roentgenol 2000; 175: 1619–25.

[36] Helmberger T, Holzknecht N, Schöpf U. Radiofrequency ablation of liver metastases. Technique and initial results. Radiologe 2001; 41: 69–76. doi:10.1007/s001170050929. PMid:11220100.

[37] Veltri A, Sacchetto P, Tosetti I. Radiofrequency ablation of colorectal liver metastases: small size favourably predicts technique effectiveness and survival. Cardiovasc Intervent Radiol 2008; 31: 948–56. doi:10.1007/s00270-008-9362-0. PMid: 18506519.

[38] Solbiati L, Ierace T, Tonolini M. Radiofrequency thermal ablation of hepatic metastases. Eur J Ultrasound 2001; 13: 149–58. doi:10.1016/S0929-8266(01)00127-6. PMid:11369526.

[39] Jakobs T, Hoffmann R, Helmberger T. Radiofrequency ablation of colorectal liver metastases: mid-term results in 68 patients. Anticancer Res 2006; 26: 671–80. PMid:16739337.

[40] Stang A, Fischbach R, Teichman W. A systematic review on the clinical benefit and role of radiofrequency ablation as treatment of colorectal liver metastases. Eur J Cancer 2009; 45: 1748–56. doi:10.1016/j.ejca.2009.03.012. PMid:19356924.

[41] Curley A. Radiofrequency ablation versus resection for resectable colorectal liver metastases: time for a randomized trial? Ann Surg Oncol 2007; 15: 11–13. doi:10.1245/s10434-007-9668-1. PMid:17955298.