Stereotactic body radiotherapy versus radiofrequency ablation for hepatocellular carcinoma: a systematic review and meta-analysis

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\textbf{ABSTRACT}

\textbf{Purpose:} To compare the efficacy and safety of stereotactic body radiotherapy (SBRT) with radiofrequency ablation (RFA) for hepatocellular carcinoma (HCC).

\textbf{Materials and methods:} PubMed, MedLine, EMBASE, the Cochrane Library and Web of Science were searched to identify potentially eligible studies comparing the efficacy and safety of SBRT with RFA for HCC from January 1990 to May 2020. Hazard ratios (HRs) or odds ratios (ORs) with 95% confidence intervals (CIs) were used to determine the effect size for overall survival (OS), local control (LC) and complications.

\textbf{Results:} Seven studies including 7928 patients were enrolled in this meta-analysis. The results showed that SBRT was not inferior to RFA based on the pooled HR for OS (HR = 1.09, 95%CI = 0.78–1.52, \(p = .62\)); however, the pooled HR for the LC rate showed the superiority of SBRT (HR = 0.54, 95%CI = 0.35–0.84, \(p = .006\)). Subgroup analysis showed that the pooled HR for the LC rate favored SBRT in patients with tumors sized \(<2\) cm (HR = 0.41, 95%CI = 0.23–0.74, \(p = .003\)), but no significant difference was observed in patients with tumors sized \(\geq 2\) cm (HR = 0.56, 95%CI = 0.25–1.28, \(p = .17\)). In addition, no significant differences in the incidence of late severe complications were observed between the SBRT and RFA groups (OR = 1.01, 95%CI = 0.59–1.73, \(p = .97\)).

\textbf{Conclusions:} Based on the current data, we concluded that SBRT was well tolerated with an OS equivalent to that with RFA; SBRT was superior to RFA in terms of LC of HCC, especially in those with tumors sized \(<2\) cm.

\textbf{Introduction}

The incidence of hepatocellular carcinoma (HCC) is continuously increasing worldwide, with 78,200 patients newly diagnosed per year; yet, the long-term prognosis remains poor [1]. Surgical resection is still the preferred strategy for patients with HCC, but approximately 70% of patients are ineligible for resection at the preliminary diagnosis [2,3]. Radiofrequency ablation (RFA), a minimally invasive curative modality, has been recommended as an alternative to surgical resection in the current guidelines, especially for early HCC [2,3]. However, RFA has its disadvantages: (i) the treatment of subdiaphragmatic tumors is technically challenging [4] and (ii) tumors located adjacent to the macrovasculature are much more likely to be influenced by the heat-sink effect [5].

Stereotactic body radiotherapy (SBRT) is an emerging modality for HCC treatment showing excellent local control (LC) [6–8]. Considering that SBRT is not limited by the anatomic position of the tumor and does not involve a heat-sink effect [9], it can replace RFA as the optimal treatment. However, the results of a recent meta-analysis on this topic were beyond expectations [10]. Two recent retrospective studies [11,12], including one multicenter study, reported results in contrast to the results of the former meta-analysis as they both reported better LC with SBRT. Hence, a systematic review and meta-analysis based on the current evidence are warranted to identify the optimal modality between SBRT and RFA.

\textbf{Material and methods}

This meta-analysis was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. No ethical approval was required because this study was based on published studies.

\textbf{Literature search}

A comprehensive search of the existing published medical literature on the comparison of the clinical efficacy of SBRT...
vs. RFA for HCC was conducted by Lei Wang and Qiao Ke independently. English electronic databases such as PubMed, MedLine, EMBASE, the Cochrane Library and Web of Science were searched for studies published from 1 January 1990 to 31 May 2020. The following keywords were used: ('hepatocellular carcinoma' or 'HCC' or 'liver tumor' or 'liver cancer' or 'liver neoplasm') AND ('stereotactic body radiotherapy' or 'Stereotactic Body Radiation Therapy' or 'SBRT' or 'stereotactic ablative radiotherapy' or 'SABR' or 'stereotactic radiotherapy' or 'SRT' or 'stereotactic radiosurgery' or 'SRS' or 'hyperfraction radiotherapy' or 'HFRT' or 'Cyberknife' or 'Gammaknife' or 'TOMO') AND ('Radiofrequency ablation' or 'RFA'). Any potentially eligible studies were identified manually from the references of the included studies, reviews, letters and comments.

Selection criteria

Following were the inclusion criteria: (i) studies including patients with primary or relapsed HCC, (ii) studies in which HCC was diagnosed by clinical imaging or pathological biopsy and (iii) studies including SBRT and RFA groups.

Following were the exclusion criteria: (i) studies including patients with intrahepatic cholangiocarcinoma, mixed liver cancer, or metastatic liver cancer; (ii) studies including patients receiving simultaneous treatments, including transarterial chemoembolization (TACE), (iii) studies with unavailable data on long-term outcomes, (iv) studies based on overlapping cohorts derived from the same center, (v) reviews, comments, letters, case reports and conference abstracts.

Endpoints

Endpoints included overall survival (OS), LC and complications. In this meta-analysis, OS was defined as the time from the start of treatment to death or the last follow-up. LC was defined as the absence of infiel recurrence in patients receiving SBRT or the absence of recurrence within or adjacent to the ablation area for RFA. Early complications were defined as complications occurring within 6 months of treatment or those described as acute complications in the relevant study. Late complications were defined as complications occurring after 6 months of treatment or those described as late complications in the relevant study.

Data extraction

Data on the author’s first name, year of publication, study methods, patient characteristics, interventions and outcomes were extracted and assessed by Lei Wang and Qiao Ke independently using predefined forms. The hazard ratios (HRs) for LC or OS were extracted directly from the original studies or indirectly from Kaplan–Meier curves according to the methods described in detail by Tierney et al. [13] and Parmar et al. [14]. The 1-, 2- and 3-year LC rates or survival rates were extracted from the original studies directly or calculated from Kaplan–Meier curves. In case of a disagreement, a third investigator, Qizhen Huang, intervened to reach a decision.

Quality assessment

The quality of non-randomized studies was assessed using the modified Newcastle-Ottawa Scale (NOS) [15]: ≥7 stars, high quality; 4–6 stars, medium quality; and <4 stars, low quality.

Statistical analysis

The meta-analysis was registered at http://www.crd.york.ac.uk/PROSPERO/ (Review registry 183028) and was performed using RevMan Version 5.3. Heterogeneity was assessed using the χ² test and I² statistics: $p > .10$ and $I^2 < 50\%$ were considered to indicate no heterogeneity. When the hypothesis of homogeneity was rejected, the random-effects model was used to estimate the effect size, and the fixed-effects model was used for studies without significant heterogeneity [16]. Publication bias was not assessed because <10 studies were included in the meta-analysis [17].

Results

Baseline characteristic of the included studies

Initially, 465 studies were identified, of which 14 were excluded due to duplication. After screening the titles and abstracts, 410 studies were excluded. Finally, seven studies [11,12,18–22] were included after the full-text review (Figure 1).

In total, 7928 patients were enrolled in this meta-analysis, including 1170 patients in the SBRT group and 6758 patients in the RFA group. The characteristics and baseline demographic data of the patients in each study are listed in Table 1. The SBRT and RFA procedures in each primary study are depicted briefly in Table 2. The NOS scores for each included study are exhibited in Table 3; two studies [19,20] had a score of 7, four [12,18,21,22] had a score of 8 and one [11] had a score of 9.

Overall survival

OS was compared between SBRT and RFA in five studies [11,12,18–20], including 1092 patients in the SBRT group and 6559 patients in the RFA group. No significant difference was observed in the pooled HR for OS between the SBRT and RFA groups (HR = 1.09, 95%CI = 0.78–1.52, $p = .62$, Figure 2) using a random-effects model ($I^2 = 72\%$, $p = .006$, Figure 2). The 1-, 2- and 3-year OS rates were evaluated in six [11,12,18–20,22], five [11,12,18–20] and four [11,12,18,19] studies, respectively. Similar results were found in terms of the pooled ORs for 1-, 2- and 3-year OS between the SBRT and RFA groups (1-year OS: OR = 0.83, 95%CI = 0.63–1.10, $p = .19$; 2-year OS: OR = 0.88, 95%CI = 0.54–1.43, $p = .61$; and 3-year OS: OR = 0.85, 95%CI = 0.45–1.59, $p = .61$; Table 4).
Local control

LC rates were compared between the SBRT and RFA groups in three included studies [18,21,22], including 203 patients in the SBRT group and 867 patients in the RFA group. Using a fixed-effects model ($I^2=5\%$, $p=.35$, Figure 3), the pooled HR for the LC rate was in favor of SBRT (HR = 0.54, 95%CI 0.35–0.84, $p=.006$, Figure 3). Subgroup analysis showed that compared to those in the RFA group, the pooled ORs for 1-, 2- and 3-year LC in the SBRT group were 2.78 (95%CI 1.95–3.95, $p<.001$, Table 4), 2.00 (95%CI 1.50–2.66, $p<.001$, Table 4) and 1.97 (95%CI 1.51–2.57, $p<.001$, Table 4), respectively.

The efficacies of SBRT and RFA for HCC were compared according to tumor size in two studies [18,21]. In the subgroup of tumors sized ≤ 2 cm, including 76 patients in the SBRT group and 180 patients in the RFA group. The pooled HR showed that no significant difference was observed in the rate of LC between two groups (HR = 0.56, 95%CI 0.25–1.28, $p=.17$, Figure 4(A)), using a fixed-effects model ($I^2=0$, $p=.44$, Figure 4(A)). However, in the subgroup of tumors sized > 2 cm, including 101 patients in the SBRT group and 164 patients in the RFA group. The pooled HR for LC was in favor of SBRT (HR = 0.41, 95%CI 0.23–0.74, $p=.03$, Figure 4(B)), using a fixed-effects model ($I^2=0$, $p=.51$, Figure 4(B)).

Complications

Early complications were evaluated in four studies [11,12,18,21]. The incidence of early severe complications (grade ≥ 3) ranged from 0 to 5% in the SBRT group and from 0 to 11.0% in the RFA group (Table 5). A meta-analysis
Table 1. Characteristics of the clinical trials included in the meta-analysis.

| Study            | Design          | Treatment  | Population | Patients before | Age (years) | Gender | Etiology | Follow-up (Month) | LC (1/2/3years) | OS (1/2/3years) | OS p-value | OS p-value |
|------------------|-----------------|------------|------------|----------------|-------------|--------|-----------|------------------|----------------|----------------|------------|------------|
| Shiozawa 2015 [22] | Single center RFA | Single HCC | 35 / 38     | 75.1 (81.0)  | /            | /      | /         | /                | /              | /              | /          | /          |
| Wahl 2015  [22]   | Single center RFA | Single HCC | 29 / 30     | 35.8 (40.8)  | /            | /      | /         | /                | /              | /              | /          | /          |
| Rajyaguru 2018 [19] | Multi-center RFA | T1-2N0 HCC | 296 / 275   | 38.6 (41.0)  | /            | /      | /         | /                | /              | /              | /          | /          |
| Parikh 2018 [19]  | Multi-center RFA | T1-2N0 HCC | 32 / 32     | 27.0 (27.0)  | /            | /      | /         | /                | /              | /              | /          | /          |
| Kim 2020 [11]     | Multi-center RFA | Localized HCC | 638 / 521  | 65.0 (65.0)  | /            | /      | /         | /                | /              | /              | /          | /          |
| Hara 2020 [11]    | Multi-center RFA | Localized HCC | 1568 / 313  | 67.3 (67.3)  | /            | /      | /         | /                | /              | /              | /          | /          |

HCC: hepatocellular carcinoma; SBRT: stereotactic body radiotherapy; RFA: radiofrequency ablation; LC: local control; OS: overall survival; HBV: hepatitis B virus; HCV: hepatitis C virus; NBNC: non-HBV/HCV; PSM: propensity score matching; NA: not available.

Discussion

As a minimally invasive treatment, RFA is the first-line strategy for early HCC [2,3], but it has always been challenged by SBRT [2,3,23]. In this meta-analysis, seven studies with 7928 patients were identified to evaluate the clinical efficacy of SBRT versus RFA. The results showed that the OS with SBRT was comparable to that with RFA, but the LC rate with SBRT was superior to that with RFA; in addition, compared to RFA, SBRT decreased the incidence of early toxicities without increasing the incidence of late toxicities. Hence, SBRT is safe and efficient and should be considered as an alternative treatment for HCC.

RFA is not only a minimally invasive curative treatment but also a cost-effective treatment strategy for small HCCs [20,24]. RFA is recommended for single tumors sized <5 cm or in patients than four tumors among which the largest has a size of <3 cm. The short-term efficacy of RFA was confirmed to be non-inferior to that of radical resection [2,3]. In addition, intraoperative RFA combined with hepatectomy has been used for multiple tumors [25]. However, the clinical application of RFA has been restricted by its inherent defects as previously mentioned.

As a modality of high-dose-rate external beam radiotherapy, SBRT typically exhibits a strong biological effect with an excellent LC rate (87~100%) [6-8]. SBRT was also confirmed to be equivalent to proton or carbon ion therapies by a systematic review [10]. Consequently, SBRT has been conducted prevalently in clinical settings as an alternative to difficult resection or RFA [2], as a second-line treatment after failed TACE [2,23], as a downstaging strategy for large HCCs [17], as a bridging therapy for liver transplantation [26,27], and as a palliative option for advanced HCC or distant metastasis [2,23]. However, SBRT has three drawbacks: (i) it is necessary to extend the clinical target volume and planning target volume beyond the tumor itself to avoid missing the target; an extended target volume results in more damage to normal tissues, especially in those with background cirrhosis [28]; (ii) repeat SBRT may not be feasible for intrahepatic recurrent tumors; and (iii) more fractions are generally needed.

A previous meta-analysis found that the efficacy of SBRT was equivalent to that of RFA in terms of LC but was inferior to that of RFA in terms of OS [10]. This may be because SBRT is often performed in cases involving difficulties in RFA, failed TACE, large tumors, or relapsed HCC; these
| Study            | Treatment | Doses and fractions | Technique and/or device | Breathing control | Dose limitation of OAR |
|------------------|-----------|---------------------|-------------------------|-------------------|-----------------------|
| Shiozawa 2015    | SBRT      | Total dose was 60 Gy, and divided into 3 to 5 fractions | Cyberknife (Accuracy Incorporated, Sunnyvale, CA, United States) | real time respiratory tracking | The irradiation range of the hepatic parenchyma surrounding the tumor was ≥ 17 Gy and the irradiated site was ≤ 20% of the whole liver |
|                  | SBRT      | Initial power output was 40W/60W, and increased by 10W/N/min to a maximum of 60/100W, energy was delivered 1 to 3 times | US guided, Cool tip RF System (Covidian, Boulder, CO, United States) or a CelonPower System (Olympus Medical Systems, Tokyo, Japan) | NA | NA |
| Wahl 2016        | SBRT      | Median doses of 30 or 50 Gy with a range of 27 to 60 Gy, and divided into either three (44%) or five (35%) fractions, delivered two to three times per week, median biologically equivalent dose for all patients was 100 Gy assuming an a/b ratio of 10. | Three-dimensional conformal techniques | Active breathing control or four-dimensional CT simulations | Dose limits to 0.5 cc of the duodenum, stomach, and heart were 24, 22.5, and 30 Gy for three fractions, with a limit of less than 30 cm³ of the chest wall receiving ≥ 30 Gy. For five-fraction plans, the limits were 30, 27.5, 52.5, and 35 Gy, respectively |
| Rajyaguru 2018   | SBRT      | Dose: <30 Gy (n = 25, 9%), 30–39 Gy (n = 35, 13%), 40–49 Gy (n = 115, 42%), ≥50 Gy (n = 60, 22%), Unknown NA missing (n = 40, 16%). Fractions: 1–2 (n = 26, 9%), 3–5 (n = 216, 80%), ≥6 (n = 17, 6%), Unknown NA missing (n = 11, 4%). | Three-dimensional conformal techniques | NA | NA |
| Wahl 2016        | SBRT      | Median doses of 30 or 50 Gy with a range of 27 to 60 Gy, and divided into either three (44%) or five (35%) fractions, delivered two to three times per week, median biologically equivalent dose for all patients was 100 Gy assuming an a/b ratio of 10. | CyberKnife (CyberKnife; Accuray, Sunnyvale, CA) (n = 55; 31.9%), Tomotherapy (Hi-Art TomoTherapy; Accuray, Madison, WI) (n = 60; 57.1%), volumetric modulated arc therapy (Elekta VMAT; Elekta, Stockholm, Sweden) (n = 33; 31.4%), and CyberKnife (CyberKnife M6; Accuray, Sunnyvale, CA) (n = 6; 57.1%), and 3-dimensional conformal radiotherapy in (n = 6; 57.1%). | US guidance, cooled-tip needle (Cool tip RF ablation system, Valleylab, Boulder, Co, USA) | NA |
| Parikh 2018      | SBRT      | NA | NA | NA | NA |
| Kim 2019         | SBRT      | Sixty-five patients (61.9%) received a total of 60 Gy in 4 fractions (Fx) (125.0 Gy of equivalent dose in 2.0 Gy fraction [EQD2]) and 22 patients (21.0%) received 52 Gy/4Fx (EQD2 100.0 Gy). Other dose-fractionation schedules (from the phase I dose-escalation cohort) included a total of 36 Gy/4Fx (n = 6; 5.7%), 45 Gy/3Fx (n = 6, 5.7%), 44 Gy/4Fx (n = 4; 3.9%), 40 Gy/5Fx (n = 1; 0.9%), and 40 Gy/5Fx (n = 1; 0.9%). | Tomotherapy (Hi-Art TomoTherapy, Accuray, Madison, WI) (n = 60; 57.1%), volumetric modulated arc therapy (Elekta VMAT; Elekta, Stockholm, Sweden) (n = 33; 31.4%), CyberKnife (CyberKnife M6; Accuray, Sunnyvale, CA) (n = 6; 57.1%), and 3-dimensional conformal radiotherapy in (n = 6; 57.1%). | Vae-LokTM (CIVCO, Coralville, IA) and an abdominal compression device | NA |
| Kim 2020         | SBRT      | The median equivalent dose in 2.0-Gy fractions (n/f) of 10 was 72.0 (IQR, 66.6–88.0) Gy, and the median biologically effective dose was 86.4 (IQR, 78.8–105.6) Gy | CyberKnife (CyberKnife; Accuray, Sunnyvale, CA) (n = 158; 31.9%), Tomotherapy (Hi-Art TomoTherapy; Accuray, Madison, WI) (n = 124; 25.0%), volumetric modulated arc therapy (Elekta VMAT; Elekta, Stockholm, Sweden) (n = 113; 22.8%), and 3-dimensional conformal radiotherapy (n = 101; 20.4%). | Ultrasound guidance, Cool-tip Needle, COVIDIEN | NA |

**SBRT:** stereotactic body radiotherapy; **RFA:** radiofrequency ablation.
patients often show worse LC and poor prognosis. However, since 2019, two studies [11,12], including one international multicenter study [11], have reported results in favor of SBRT using a propensity score matching (PSM) design. Hence, the current meta-analysis of updated data was warranted to help in clinical decision-making. In this meta-analysis, seven studies [11,12,18–22] were eligible for the final synthesis. The results showed that the pooled HR for the LC rate was in favor of SBRT; significantly increases were also observed in the 1-, 2- and 3-year LC rates with SBRT. Furthermore, SBRT was found to be superior to RFA for tumors sized >2 cm but not for tumors sized ≤2 cm. Hence, we strongly recommend SBRT as the first-line treatment for unresectable HCC, especially in those with tumors sized >2 cm.

Excellent LC with SBRT was confirmed in this meta-analysis, but SBRT did not confer a long-term survival benefit. The reasons for this might be as follows: (i) patients in the SBRT group often had unfavorable factors, including advanced stage, larger tumor size and failure of initial treatment, which would affect the result regardless of PSM; (ii)
Figure 4. Subgroup analysis of local control between groups of SBRT and RFA stratified by tumor size. A, Tumor ≤ 2 cm. B, Tumor >2cm.

Table 5. Treatment-related complications in included studies.

| Study         | Treatment | Patients | Related complications                                                                 | p Value |
|---------------|-----------|----------|---------------------------------------------------------------------------------------|---------|
| Shiozawa 2015 | SBRT      | 35       | No early toxicity; G3 late toxicity: 11.4% (4/35 ascites, 2 of them liver-related deaths) | NA      |
|               | RFA       | 38       | No early toxicity; No late toxicity                                                   |         |
| Wahl 2016     | SBRT      | 63       | G3 acute toxicity: 5% (1 radiation induced liver disease, 1 GI bleeding, and 1 worsening ascites) | .31     |
|               | RFA       | 161      | G3 acute toxicity: 11% (1 pneumothorax, 2 sepsis, 2 duodenal and colonic perforation, 3 bleeding, and 2 deaths) | .66     |
| Rajyaguru 2018 | SBRT    | 275      | NA                                                                                   | NA      |
|               | RFA       | 521      | NA                                                                                   |         |
| Parikh 2018   | SBRT      | 32       | NA                                                                                   | NA      |
|               | RFA       | 32       | NA                                                                                   |         |
| Kim 2019      | SBRT      | 95       | No early toxicity; No late toxicity                                                  | .850    |
|               | RFA       | 95       | G3/G4 acute toxicity: 3.7%, No late toxicity                                         |         |
| Hara 2019     | SBRT      | 106      | One-year ≥ G3 toxicity: 8.2%                                                         | .230    |
|               | RFA       | 106      | One-year ≥ G3 toxicity: 10.2%                                                        |         |
| Kim 2020      | SBRT      | 313      | G3/G4 acute toxicity: 1.6%, any-grade late toxicities: 5.8%                          | .268    |
|               | RFA       | 313      | G3/G4 acute toxicity: 2.6%, any-grade late toxicities: 5.3%                          |         |

SBRT: stereotactic body radiotherapy; RFA: radiofrequency ablation; GI: gastrointestinal; NA: not available.

Figure 5. Forest plot of the incidence of early and late toxicity between groups of SBRT and RFA. A, early toxicity. B, late toxicity.
recurrence was the bottleneck of HCC prognosis [29]; and (iii) treatment after recurrence would affect the long-term outcome [30]. Consequently, we speculate that SBRT would result in more favorable outcomes if it is applied as the first-line treatment; a well-designed multicenter randomized controlled trial is needed to verify this hypothesis.

SBRT is conducted in fewer fractions, and the dose to the target edge drops rapidly [31]. Early toxicities related to SBRT, including radiation-induced liver disease, have rarely been reported, especially with advances in breathing-motion management strategies such as mechanical abdominal compression [32], four-dimensional computed tomography [33,34], respiration gating systems [35,36], real-time target tracking and continuous patient position adjustment with robotic treatment couches [37,38]. As a noninvasive modality, SBRT can be used to avoid the adverse events caused by RFA, including hemorrhage, pneumothorax and biliary fistula. In this meta-analysis, no significant differences in the incidence of late severe toxicity were observed between the SBRT and RFA groups, but the pooled OR for the incidence of early severe toxicity was in favor of SBRT.

However, the accessibility of SBRT is not similar to that of RFA, especially in China, where SBRT is generally conducted in highly-volume radiotherapy centers. Quality of life (QoL) is an important posttreatment endpoint for evaluating different treatment modalities for HCC mainly because long-term survival is generally poor in this population. Klein et al. [39] reported that liver SBRT was well tolerated and did not worsen the overall QoL, although it could lead to temporary appetite loss and fatigue. However, the QoL has not been compared between SBRT and other modalities, especially RFA. In reality, cost-effectiveness is also a concern in patients when they make decisions regarding treatment. Previous studies have found that if equal survival was assumed, SBRT was less cost-effective than RFA either for inoperable colorectal liver metastases or for inoperable localized HCC [24]. Hence, more factors, in addition to efficacy and safety, should be taken into consideration when making treatment decisions.

There were several limitations to this meta-analysis. First, all the included studies were retrospective, and selection and recall bias were difficult to avoid. Second, the population in each included study was slightly different, which would result in apparent heterogeneity, even though we conducted subgroup analyses. Third, considering that patients receiving SBRT often have unfavorable prognostic factors in real-world settings, confounding factors were difficult to eliminate, although PSM was performed in five included studies [11,12,18–20]. Fourth, LC included the absence of local progression and recurrence; however, only data on recurrence were reported in one of the included studies, which would lower the credibility of this meta-analysis. Fifth, the procedure of SBRT was not standardized, which might have resulted in treatment bias. Lastly, conference abstracts were excluded from this meta-analysis due to the inability to assess literature quality, which would have increased the publication bias. Hence, a well-designed randomized controlled trial is needed with unified dosage and fractionation regimens for SBRT and preset response criteria for treatment.

Conclusions

Based on the current data, we concluded that SBRT can be used as an alternative to RFA, especially for tumors sized >2 cm, tumors adjacent to the macrovasculature, tumors difficult to treat with RFA and cases involving TACE failure; however, SBRT does not exhibit a survival advantage. This conclusion needs to be validated in future prospective randomized controlled trials.

Acknowledgements

The authors thank Editage (www.editage.cn) for English language editing.

Disclosure statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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