Original Article

Maintenance treatment of immunotherapy after microwave ablation plus drug-eluting bead bronchial arterial chemoembolization for advanced non-small cell lung cancer: a retrospective single-center cohort study

Sheng Xu[1]^, Zhi-Xin Bie[1], Yuan-Ming Li[1], Jing Qi[2], Jin-Zhao Peng[1,3], Xiao-Guang Li[1,3]^

[1]Department of Minimally Invasive Tumor Therapies Center, Beijing Hospital, National Center of Gerontology, Institute of Geriatric Medicine, Chinese Academy of Medical Sciences, Beijing, China; [2]Department of Neurology, Beijing Chao-Yang Hospital, Capital Medical University, Beijing, China; [3]Graduate School of Peking Union Medical College, Chinese Academy of Medical Sciences, Beijing, China

Contributions: (I) Conception and design: S Xu, XG Li; (II) Administrative support: ZX Bie, YM Li; (III) Provision of study materials or patients: YM Li, S Xu, ZX Bie, J Qi; (IV) Collection and assembly of data: S Xu, JZ Peng, ZX Bie; (V) Data analysis and interpretation: S Xu, ZX Bie, J Qi, JZ Peng, XG Li; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Xiao-Guang Li, MD. Department of Minimally Invasive Tumor Therapies Center, Beijing Hospital, National Center of Gerontology, Institute of Geriatric Medicine, Chinese Academy of Medical Sciences, No. 1 Dahua Road, Dongdan, Beijing 100730, China; Graduate School of Peking Union Medical College, Chinese Academy of Medical Sciences, 9 Dongdansantiao Street, Dongcheng District, Beijing 100730, China. Email: xglee88@126.com.

Background: The combination therapy of immunotherapy and drug-eluting bead bronchial artery chemoembolization (DEB-BACE) or microwave ablation (MWA) has been attempted as an effective and safe approach for advanced non-small cell lung cancer (NSCLC). However, the outcomes of immunotherapy plus multiple interventional techniques for advanced NSCLC remain unclear. This retrospective study thus aimed to investigate the effectiveness and safety of the maintenance treatment of programmed cell death protein 1 (PD-1) blockade after MWA plus DEB-BACE for advanced NSCLC.

Methods: This retrospective cohort study consists of 95 patients with advanced NSCLC who were treated with DEB-BACE between April 2017 and October 2022 and who were allocated to three groups: group A (MWA + DEB-BACE + PD-1 blockade; n=15), group B (MWA + DEB-BACE; n=25), and group C (DEB-BACE alone; n=55). The adverse events (AEs) were compared between the three groups. The outcomes were compared via Kaplan-Meier methods, including median progression-free survival (PFS) and overall survival (OS). Survival analyses were performed via the univariate and multivariate analyses to investigate the prognostic predictors.

Results: The overall incidence of AEs in the groups A–C was 53.3% (8/15), 36.0% (9/25), and 32.7% (18/55), respectively, which did not represent a significant difference (P=0.42). No severe AEs (SAEs) occurred. Group A, compared with group B and group C, had a significantly longer estimated median PFS (33.0 *vs.* 7.0 *vs.* 3.0 months; P<0.001) and OS (33.0 *vs.* 13.0 *vs.* 6.0 months; P=0.002). PD-1 blockade (P=0.006), tumor number (P=0.01), and DEB-BACE/bronchial artery infusion (BAI) chemotherapy cycles (P=0.04) were identified as the predictors of PFS, while the predictors of OS were PD-1 blockade (P<0.001), number of metastases (P<0.001), tumor diameter (P<0.001), and DEB-BACE/BAI cycles (P=0.02).

Conclusions: Compared with that of advanced NSCLC treated with MWA plus DEB-BACE or DEB-

^ ORCID: Sheng Xu, 0000-0003-0757-8289; Xiao-Guang Li, 0000-0002-3345-1313.

BACE alone, the maintenance treatment of immunotherapy after MWA plus DEB-BACE might provide a superior prognosis without increasing the risk of AEs.

Keywords: Lung cancer; drug-eluting beads (DEBs); bronchial artery chemoembolization (BACE); microwave ablation (MWA); immunotherapy

Submitted Dec 31, 2023. Accepted for publication Mar 07, 2024. Published online Apr 08 2024.
doi: 10.21037/qims-23-1876
View this article at: https://dx.doi.org/10.21037/qims-23-1876

Introduction

Lung cancer is one of the leading causes of cancer incidence and mortality worldwide, with the most subtypes of this disease belonging to non-small cell lung cancer (NSCLC) (1). Approximately 75% of patients with NSCLC are diagnosed at an advanced stage (2). Systemic chemotherapy is the standard treatment for advanced NSCLC, but resistance and adverse events (AEs) are the two persisting challenges that limit its application and efficacy. Immune checkpoint inhibitors (ICIs) can prevent immune escape by inhibiting the binding of programmed cell death protein 1 (PD-1)/programmed cell death-ligand 1 (PD-L1), with PD-1 blockade being the predominant type used in clinic (3). In recent years, chemoimmunotherapy has been recommended as the first-line treatment for advanced NSCLC despite its high incidence of AEs (4,5). Compared with systemic chemotherapy, ICIs show milder toxicity but a limited response rate of 0–15%, and monoimmunotherapy is not recommended if a combination with other systemic therapies can be tolerated (4-6).

Image-guided microwave ablation (MWA), whose purpose is to induce coagulative necrosis of the tumor and its surrounding margin, is recommended for patients with stage IA NSCLC and contraindications to surgery and radiotherapy (4,7). A phase III trial demonstrated the efficacy of MWA combined with systemic treatment for advanced NSCLC (8). Drug-eluting bead (DEB) microspheres can deliver the chemotherapeutic drugs within 1–2 months and embolize the arteries, which induces higher locoregional drug concentrations than does systemic chemotherapy with negligible systemic toxicity (9). DEBs with bronchial artery chemoembolization (BACE) have been investigated as a salvage or replacement therapy for patients with advanced NSCLC who are resistant or intolerant to systemic chemotherapy (10-15).

Locoregional treatments of ablation or transarterial chemoembolization (TACE) can induce an immunologically favorable tumor microenvironment (16). A retrospective study found that DEB-BACE plus PD-1 blockade might improve the outcomes of those with advanced NSCLC (17). Another study applied MWA plus DEB-BACE in patients with advanced NSCLC and found that postoperative immunotherapy yielded a longer overall survival (OS) (13). We hypothesized that the combination of DEB-BACE and MWA could trigger a more substantial antitumor immunity than could use of a single interventional technique. However, few studies have examined the combination of ICIs and multiple interventional techniques in advanced NSCLC. This retrospective cohort study thus aimed to investigate the effectiveness and safety of the PD-1 blockade after MWA plus DEB-BACE in patients with advanced NSCLC. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1876/rc).

Methods

Patient criteria

All patients with advanced NSCLC who underwent DEB-BACE between April 2017 and October 2022 at Beijing Hospital were enrolled and were subsequently divided into three groups according to whether MWA and/or immunotherapy was performed: group A, MWA + DEB-BACE + PD-1 blockade; group B, MWA + DEB-BACE; and group C: DEB-BACE alone. This retrospective study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the institutional ethics review board of Beijing Hospital. Informed consent for this retrospective analysis was waived. The inclusion criteria were as follows: (I) age of 18–85 years, (II) diagnosis of NSCLC and a tumor stage of III B to IV B, (III) resistance or intolerance to standard treatments, and (IV) Eastern Cooperation Oncology Group (ECOG) performance status (PS) of 0–2. Meanwhile, the

exclusion criteria were as follows: (I) treatment history of immunotherapy, (II) interval between DEB-BACE and ICIs longer than one month, (III) incomplete data, and (IV) follow-up <12 months.

Definitions

Intolerance to standard treatments was considered present when intolerance was due to severe comorbidities, advanced age (≥75 years), or poor ECOG PS score (≥2), whereas resistance to standard treatments was considered present when patients showed resistance to systemic treatments based on radiological reexaminations every 6–8 weeks. The tumor stage was determined based on positron emission tomography or computed tomography (CT) according to the tumor–node–metastasis staging system (eighth edition) (18).

The indications for DEB-BACE or MWA were determined by the multidisciplinary treatment team, with the former being performed for patients who were resistant/intolerant to chemoradiotherapy or molecular targeted therapy and the latter being performed to alleviate the symptoms and decrease the tumor burden.

MWA procedure

CT-guided MWA was performed by several experienced interventional radiologists (S.X., Z.X.B., Y.M.L., J.Z.P., and X.G.L., each with >5 years of experience) and as per the Society of Interventional Radiology guidelines (19), which aims to render inactive as much of the primary tumor tissue as possible. Preoperative evaluation was conducted determine the anesthetic techniques, with local anesthesia being considered for most of the patients, whereas intravenous anesthesia was considered for patients who could not tolerate intraprocedural pain. The MWA instruments included the MTC-3C MWA system (Vison-China Medical Devices R&D Center) or the ECO-100A1 MWA system (ECO Medical Instrument Co., Ltd., China) with a microwave emission frequency of 2,450±50 MHz and an adjustable power of 20–80 W, along with MWA antennas (Vison or ECO) with a length of 15–20 cm and an outside diameter of 16–18 G. A CT scan was immediately performed before the MWA procedure to inform the design of the therapeutic plan and determine the optimal puncture site. MWA antennas were advanced into the tumor, and ablation was performed at a planned power and ablation time, with adjustments being made to the antennas under the guidance of CT as appropriate. The technical endpoints were considered to be reached when the ablation scope contained at least a 5-mm rim of ground-glass opacity encompassing the tumor margins in complete ablation or when the majority of tumor tissue was ablated in palliative ablation. Following this, a CT scan was performed immediately after MWA to evaluate the ablation zone and identify the potential AEs (13).

DEB-BACE procedure

Digital subtraction angiography-guided DEB-BACE was performed after MWA by several experienced interventional radiologists (S.X., Z.X.B., Y.M.L., J.Z.P., and X.G.L., each with >5 years of experience). For the DEB-BACE procedure, the Seldinger technique was performed in the femoral artery. A 5-French pigtail catheter (Impress Pigtail Flush; Merit Medical, USA) was used to detect the origins of the tumor-feeding arteries, including the bronchial arteries and nonbronchial systemic arteries (NBSAs), which was followed by selection of the arteries with a 5-French cobra (Impress CB 1; Merit Medical, USA) or left gastric artery catheter (Radifocus, Terumo, Japan). The superselection was performed via a 1.98-French microcatheter (PARKWAY SOFT; Asahi Masters, Japan) to avoid ectopic embolization. CalliSpheres (100–300 or 300–500 μm; Jiangsu Hengrui Pharmaceuticals Co., Ltd., China) were mixed with gemcitabine (600–800 mg) at a temperature of 23–28 ℃ for half an hour, which was followed by the addition of the equal volume of contrast agent to the microspheres, which was used for the chemoembolization of tumor-feeding arteries via the microcatheter. The technical endpoint was the complete stagnation of the contrast agent in the tumor-feeding arteries. After the first cycle of DEB-BACE, repeat DEB-BACE/bronchial artery infusion (BAI) chemotherapy was performed as appropriate, with DEB-BACE being considered for patients who still exhibited abundant tumor staining during angiography and BAI being considered for those patients without these findings. The chemotherapeutic drugs during BAI consisted of paclitaxel (100–200 mg) for patients who were resistant to platinum-based chemotherapy, whereas gemcitabine (600–800 mg) plus nedaplatin (80–100 mg) was used for patients without resistance (13). For patients in groups A and B, DEB-BACE was performed within 4–6 weeks after MWA.

Immunotherapy protocol

PD-1 blockade was performed for patients with high PD-L1 expression. For patients in group A, camrelizumab (200 mg; Hengrui), sintilimab (200 mg; Innovent Biologics, China), or toripalimab (240 mg; Junshi Biosciences, China) was administered synchronously or within 1 month after administration of DEB-BACE. The PD-1 blockade was examined every 3–4 weeks and was terminated when progression or severe immunotherapy-related AEs (irAEs) occurred.

Management of AEs

The AEs of DEB-BACE, MWA, or PD-1 blockade were evaluated as per the National Cancer Institute Common Terminology Criteria for Adverse Events version 5.0 (20). A repeated CT scan was performed 24 hours after MWA to investigate the delayed complications. Chest tube placement was completed for moderate and severe pneumothorax or pleural effusion, which was removed after these conditions disappeared. Symptomatic treatments or antimyelosuppression were administered for grade 2 MWA- or DEB-BACE-related AEs or above. Moreover, steroid therapy was administered for grade 3 irAEs or above.

Further management

For patients who had distant metastases, radiotherapy was performed as demanded. For patients who developed progression or were intolerant AEs, the best supportive care or anlotinib (Fukewei, Chia Tai Tianqing Pharmaceutical Holdings Co., China) was considered at a dose of 12 mg/d on a treatment schedule of 1 week on and 1 week off, which was terminated if patients became intolerant to anlotinib-related AEs.

Assessments

Radiological reexaminations of CT were performed every 3 months. The response was evaluated, with agreement being obtained by at least two experienced radiologists (S.X., J.Z.P., and X.G.L., each with >10 years of experience), which was classified as complete response, partial response, stable disease, or progressive disease (PD) according to Response Evaluation Criteria in Solid Tumors version 1.1 (21). The disease control rate (DCR) was defined as the percentage of patients with a response to treatment outside of PD. Progression-free survival (PFS) was identified as the period from MWA/DEB-BACE to disease progression or death, and OS was considered to be the period from MWA/DEB-BACE to death or the last follow-up (October 31, 2023). The censoring date was the last clinical assessment date for patients who neither died nor experienced PD.

Statistical analyses

All statistical analyses were performed with SPSS 25.0 (IBM Corp., USA). Demographic characteristics, AEs, and prognostic data in the three groups were evaluated and compared. One-way analysis of variance (ANOVA) was used for numerical variables, and the chi-squared test was used for categorical variables. The detailed outcomes in the three groups were evaluated and compared via Kaplan-Meier method. There were 18 possible predictors of PFS and OS that were explored by univariate and multivariate analyses. The log-rank test was used for univariate analyses, and variables with a P value <0.05 in univariate analyses were entered into stepwise Cox proportional hazards analyses. Variables with a P value <0.05 in the multivariate analysis were identified as the final predictors.

Results

Demographic characteristics

There were 95 patients with advanced NSCLC enrolled in this study (group A: n=15; group B: n=25; group C: n=55; *Figure 1*). Of these, 57 (60.0%) patients developed resistance to standard treatments, including 6 (6.3%) who received surgery combined with tyrosine kinase inhibitors (TKIs) or chemotherapy, 13 (13.7%) who received chemoradiotherapy, 18 (18.9%) who received TKIs, and 20 (21.1%) who received monochemotherapy. The detailed characteristics are shown in *Table 1*. There were no significant differences in demographic characteristics found between the three groups. PD-1 blockade was administered at 9.0±12.4 days after the first DEB-BACE session in group A, whereas DEB-BACE was performed at 17.0±17.8 days after MWA in groups A and B.

Outcomes

The details of the outcomes are presented in *Table 2*. The

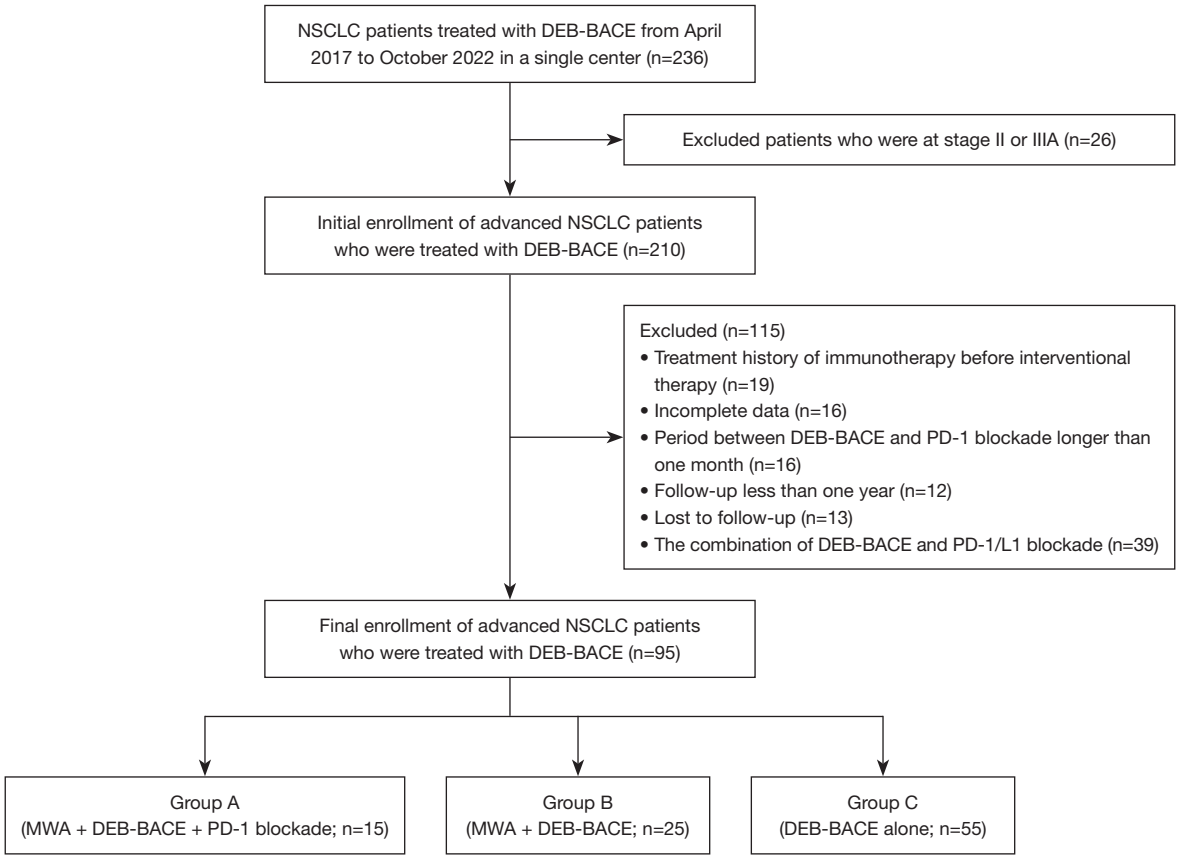

Figure 1 Patient selection flowchart. NSCLC, non-small cell lung cancer; DEB-BACE; drug-eluting bead bronchial artery chemoembolization; PD-1, programmed cell death protein 1; PD-L1, programmed cell death ligand 1; MWA, microwave ablation.

mean follow-up time was 35.1±15.2 months. A significantly higher DCR at 3 months after MWA or the first DEB-BACE session was observed in group A versus in groups B and C (100.0% *vs.* 76.0% *vs.* 45.5%; P<0.001). The estimated median PFS in the groups A–C groups was 33.0 [95% confidence interval (CI): 6.052–59.948], 7.0 (95% CI: 3.556–10.444), and 3.0 (95% CI: 2.491–3.509) months, respectively, whereas the estimated median OS in these groups was 33.0 (95% CI: 9.759–56.241), 13.0 (95% CI: 9.832–16.168), and 6.0 (95% CI: 1.963–10.037) months, respectively. The Kaplan-Meier method revealed that group A had prolonged median PFS (P<0.001; *Figure 2A*) and OS (P=0.002; *Figure 2B*) compared with the other two groups.

AEs

The incidence of pneumothorax was 40.0% (16/40), which ranked first among the MWA-related AEs. There were 12 patients (30.0%, 12/40) who received chest tube placement. The incidence of any degrees AEs in the groups A–C was 53.3% (8/15), 36.0% (9/25), and 32.7% (18/55), respectively, which did not represent a significant difference (P=0.42). The details of AEs are shown in *Table 2*, and no severe AEs (SAEs) occurred.

Survival analyses

The results of univariate and multivariate analyses are shown in *Tables 3* and *4*. For patients with advanced NSCLC treated with DEB-BACE, the predictors of PFS included PD-1 blockade [hazard ratio (HR): 0.345, 95% CI: 0.162–0.733; P=0.006; *Figure 3* and *Figure 4A*], tumor number (HR: 2.126, 95% CI: 1.184–3.815; P=0.01; *Figure 4B*), and DEB-BACE/BAI cycles (HR: 0.622, 95% CI:

Table 1 Clinical characteristics for patients with advanced NSCLC in the three groups

Variable	Overall (n=95)	Group A (n=15)	Group B (n=25)	Group C (n=55)	P value
Age (years)	67.0±10.3	69.4±10.9	67.8±9.1	67.3±10.7	0.78
Gender					0.74
Male	73 (76.8%)	13 (86.7%)	19 (76.0%)	41 (74.5%)	
Female	22 (23.2%)	2 (13.3%)	6 (24.0%)	14 (25.5%)	
Indications of interventional therapy					0.23
Resistance to standard treatments	57 (60.0%)	7 (46.6%)	16 (64.0%)	24 (43.6%)	
Intolerance to standard treatments	38 (40.0%)	8 (53.3%)	12 (48.0%)	31 (56.4%)	
Comorbidity					
Hypertension	36 (37.9%)	4 (26.7%)	7 (28.0%)	25 (45.5%)	0.20
Cardiocerebrovascular diseases	24 (25.3%)	4 (26.7%)	6 (24.0%)	14 (25.5%)	>0.99
Tumor subtype					0.96
Adenocarcinoma	42 (44.2%)	6 (40.0%)	11 (44.0%)	25 (45.5%)	
Squamous cell carcinoma	44 (46.3%)	8 (53.3%)	11 (44.0%)	25 (45.5%)	
Others	9 (9.5%)	1 (6.7%)	3 (12.0%)	5 (9.1%)	
Tumor stage					0.84
III	50 (52.6%)	7 (46.7%)	14 (56.0%)	29 (52.7%)	
IV	45 (47.4%)	8 (53.3%)	11 (44.0%)	26 (47.3%)	
Treatment history					
Surgery	6 (6.3%)	0	1 (4.0%)	5 (9.1%)	0.59
Systemic chemotherapy	35 (36.8%)	4 (26.7%)	7 (28.0%)	24 (43.6%)	0.27
TKIs	22 (23.2%)	1 (6.7%)	6 (24.0%)	15 (27.3%)	0.28
Radiological feature					
Tumor diameter (cm)	6.0±2.5	5.9±1.8	5.4±2.2	6.4±2.7	0.22
Location					0.30
Lower or middle lobe	39 (41.1%)	7 (46.7%)	7 (28.0%)	25 (45.5%)	
Upper lobe	56 (58.9%)	8 (53.3%)	18 (72.0%)	20 (36.4%)	
Tumor number					0.70
1	78 (82.1%)	13 (86.7%)	19 (76.0%)	46 (83.6%)	
≥2	17 (17.9%)	2 (13.3%)	6 (24.0%)	9 (16.4%)	
Number of metastases					0.86
<2	61 (64.2%)	9 (60.0%)	17 (68.0%)	35 (63.6%)	
≥2	34 (35.8%)	6 (40.0%)	8 (32.0%)	20 (36.4%)	
Laboratory examination					
WBC ($\times10^9$/L)	7.5±2.6	8.8±2.8	7.2±2.6	7.3±2.6	0.13
PLT ($\times10^9$/L)	249.0±93.0	281.9±57.3	261.1±98.7	260.2±98.8	0.71
PT (s)	11.6±1.5	11.4±0.8	11.5±2.3	11.8±1.0	0.52

Table 1 (*continued*)

Table 1 (*continued*)

Variable	Overall (n=95)	Group A (n=15)	Group B (n=25)	Group C (n=55)	P value
Further treatment					
Radiotherapy	8 (8.4%)	1 (6.7%)	2 (8.0%)	5 (9.1%)	>0.99
Anlotinib	26 (27.4%)	3 (20.0%)	7 (28.0%)	16 (29.1%)	0.90
Immunotherapy-related factors					
Cycles of PD-1 blockade	–	10.3±8.6	–	–	–
MWA-related factor					
Maximum power (W)	–	50.7±12.2	46.4±10.8	–	–
Ablation time (min)	–	13.5±6.7	12.6±6.7	–	–
DEB-BACE related factor					
Diameter of microsphere (μm)					>0.99
100–300	11 (11.6%)	1 (6.7%)	3 (12.0%)	7 (12.7%)	
300–500	84 (88.4%)	14 (93.3%)	22 (88.0%)	48 (87.3%)	
Number of embolized arteries	1.0±0.3	1.1±0.4	1.1±0.3	1.1±0.3	0.99
DEB-BACE/BAI cycles	2.0±1.2	2.5±1.6	1.6±1.1	1.8±1.1	0.06

Frequencies and percentages are reported for categorical variables, and the mean ± SD are reported for continuous variables. Group A: MWA + DEB-BACE + PD-1 blockade. Group B: MWA + DEB-BACE. Group C: DEB-BACE alone. NSCLC, non-small cell lung cancer; TKI, tyrosine kinase inhibitor; WBC, white blood cell; PLT, platelet; PT, prothrombin time; PD-1, programmed cell death protein 1; MWA, microwave ablation; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; BAI, bronchial artery infusion; SD, standard deviation.

Table 2 Details of AEs and outcomes for patients with advanced NSCLC in the three groups

Variable	Overall (n=95)	Group A (n=15)	Group B (n=25)	Group C (n=55)	P value
Overall AEs	35 (36.8)	8 (53.3)	9 (36.0)	18 (32.7)	0.42
irAEs					
Grade 1	–	–	–	–	–
RCCEP	–	3 (20.0)	–	–	–
Fever	–	1 (6.7)	–	–	–
Pneumonia	–	1 (6.7)	–	–	–
Grade 2	–	–	–	–	–
RCCEP	–	2 (13.3)	–	–	–
Pneumonia	–	2 (13.3)	–	–	–
DEB-BACE-related AEs					
Grade 1					
Chest congestion or pain	18 (18.9)	3 (20.0)	5 (20.0)	10 (18.2)	>0.99
Fever	11 (11.6)	2 (13.3)	3 (12.0)	6 (10.9)	>0.99
Myelosuppression	10 (10.5)	2 (13.3)	3 (12.0)	5 (9.1)	0.72

Table 2 (*continued*)

Table 2 (*continued*)

Variable	Overall (n=95)	Group A (n=15)	Group B (n=25)	Group C (n=55)	P value
Grade 2					
Chest congestion or pain	8 (8.4)	1 (6.7)	2 (8.0)	5 (9.1)	>0.99
Fever	6 (6.3)	1 (6.7)	1 (4.0)	4 (7.3)	>0.99
MWA-related AEs					
Grade 1	–	–	–	–	–
Pneumothorax	–	4 (26.7)	0	–	–
Pleural effusion	–	0	3 (12.0)	–	–
Postablation syndrome	–	3 (20.0)	4 (16.0)	–	–
Grade 2	–			–	–
Pneumothorax	–	4 (26.7)	6 (24.0)	–	–
Pleural effusion	–	0	1 (4.0)	–	–
Postablation syndrome	–	1 (6.7)	3 (12.0)	–	–
Pneumonia	–	0	1 (4.0)	–	–
Hemothorax	–	1 (6.7)	1 (4.0)	–	–
Response					<0.001
Complete response	–	–	–	–	
Partial response	9 (9.5)	5 (33.3)	2 (8.0)	2 (3.6)	
Stable disease	50 (52.6)	10 (66.7)	17 (68.0)	23 (41.8)	
Progressive disease	36 (37.9)	0	6 (24.0)	30 (54.5)	
DCR	59 (62.1)	15 (100.0)	19 (76.0)	25 (45.5)	<0.001
PFS status					0.003
Progression or death	77 (81.1)	8 (53.3)	19 (76.0)	50 (90.9)	
Progression and death free	18 (18.9)	7 (46.7)	6 (24.0)	5 (9.1)	
OS status					0.01
Survival	25 (26.3)	8 (53.3)	8 (32.0)	9 (16.4)	
Death	70 (73.7)	7 (46.7)	17 (68.0)	46 (83.6)	
1-year PFS rate	22 (23.2)	8 (53.3)	6 (24.0)	8 (14.5)	0.007
2-year PFS rate	8 (8.4)	7 (46.7)	0	1 (1.8)	<0.001
1-year OS rate	42 (44.2)	12 (80.0)	14 (56.0)	16 (29.1)	0.001
2-year OS rate	13 (13.7)	8 (53.3)	0	5 (9.1)	<0.001

Data are represented as number (%). Group A: MWA + DEB-BACE + PD-1 blockade. Group B: MWA + DEB-BACE. Group C: DEB-BACE alone. AE, adverse event; NSCLC, non-small cell lung cancer; irAE, immune-related adverse event; RCCEP, reactive cutaneous capillary endothelial proliferation; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; MWA, microwave ablation; DCR, disease control rate; PFS, progression-free survival; OS, overall survival; PD-1, programmed cell death protein 1.

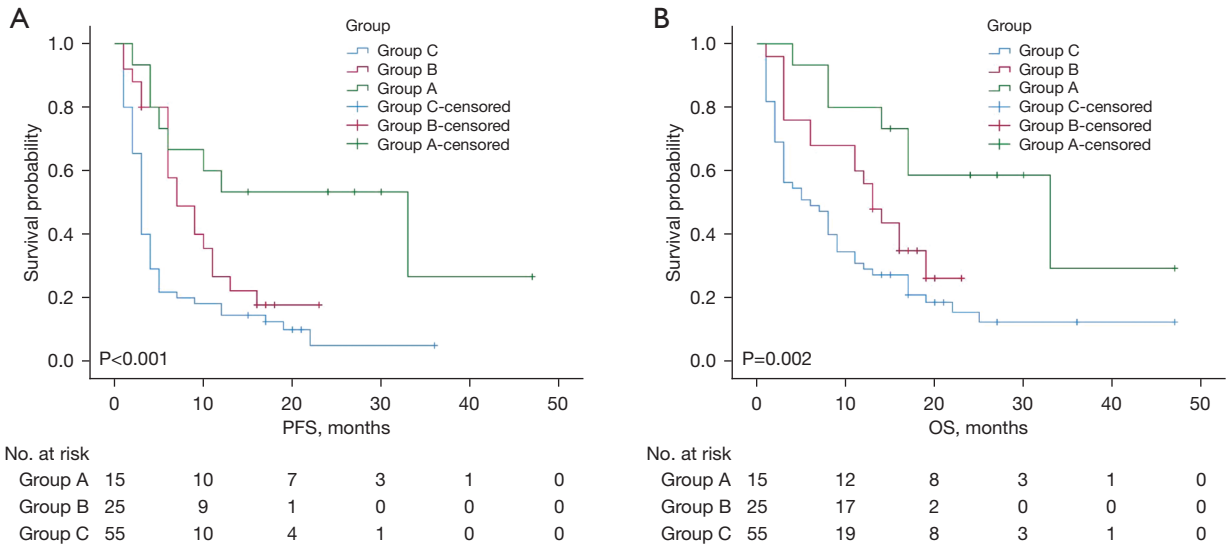

Figure 2 Comparison of median PFS or OS for patients with advanced NSCLC in the three groups. (A) The median PFS was 15.0, 7.0, and 3.0 months for patients in group A, B, and C, respectively. (B) The median OS was 24.0, 13.0, and 6.5 months in groups A, B, and C, respectively. Group A: MWA + DEB-BACE + PD-1 blockade. Group B: MWA + DEB-BACE. Group C: DEB-BACE alone. PFS, progression-free survival; OS, overall survival; NSCLC, non-small cell lung cancer; MWA, microwave ablation; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; PD-1, programmed cell death protein 1.

Table 3 Univariate and multivariate analyses for PFS in patients with advanced NSCLC treated with DEB-BACE

Variable	Univariate analysis		Multivariate analysis	
	Estimated median PFS (95% CI)	P value*	HR (95% CI)	P value**
PD-1 blockade		0.001		0.006
Yes	33.0 (6.052–59.948)		0.345 (0.162–0.733)	
No	4.0 (3.213–4.787)		1	
Number of metastases		0.01		
<2	6.0 (3.495–8.505)			
≥2	3.0 (2.054–3.946)			
Tumor number		<0.001		0.01
1	5.0 (3.295–6.705)		2.126 (1.184–3.815)	
≥2	2.0 (0.848–3.152)		1	
DEB-BACE/BAI cycles		0.003		0.04
1	3.0 (2.182–3.818)		1	
≥2	9.0 (3.388–14.612)		0.622 (0.388–0.997)	

*, log-rank test was used; **, Cox proportional hazards regression analysis was used. PFS, progression-free survival; NSCLC, non-small cell lung cancer; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; HR, hazard ratio; CI, confidence interval; PD-1, programmed cell death protein 1; BAI, bronchial artery infusion.

Table 4 Univariate and multivariate analyses for OS in patients with advanced NSCLC treated with DEB-BACE

Variable	Univariate analysis		Multivariate analysis	
	Estimated median OS (95% CI)	P value*	HR (95% CI)	P value**
PD-1 blockade		0.004		<0.001
Yes	33.0 (9.759–56.241)		0.221 (0.096–0.508)	
No	8.0 (4.714–11.286)		1	
Number of metastases		0.002		<0.001
<2	14.0 (9.379–18.621)		2.699 (1.589–4.585)	
≥2	3.0 (0.551–5.449)		1	
Tumor diameter		0.02		<0.001
<4	Not reached		4.324 (1.971–9.488)	
≥4	9.0 (6.140–11.860)		1	
Tumor number		0.007		
1	11.0 (6.305–15.695)			
≥2	3.0 (0.000–8.042)			
DEB-BACE/BAI cycles		0.001		0.02
1	3.0 (1.529–4.471)		1	
≥2	17.0 (12.248–21.752)		0.550 (0.333–0.908)	

*, log-rank test was used; **, Cox proportional hazards regression analysis was used. OS, overall survival; NSCLC, non-small cell lung cancer; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; HR, hazard ratio; CI, confidence interval; PD-1, programmed cell death protein 1; BAI, bronchial artery infusion.

0.388–0.997; P=0.04; *Figure 4C*), while the predictors of OS included PD-1 blockade (HR: 0.221, 95% CI: 0.096–0.508; P<0.001; *Figure 5A*), number of metastases (HR: 2.699, 95% CI: 1.589–4.585; P<0.001; *Figure 5B*), tumor diameter (HR: 4.324, 95% CI: 1.971–9.488; P<0.001; *Figure 5C*), and DEB-BACE/BAI cycles (HR, 0.550; 95% CI: 0.333–0.908; P=0.02; *Figure 5D*).

Discussion

This study revealed superior outcomes for the maintenance treatment of PD-1 blockade after MWA plus DEB-BACE, with the estimated median PFS and OS of both being 33.0 months. Meanwhile, most patients in group A had received 1–2 cycles of immunotherapy before the first evaluation, which could explain the higher DCR in group A compared to the other two groups. It is worth noting that 50% of patients survived until the last follow-up in group A, which indicates a possible improved survival if the follow-up had been continued. Moreover, the incidence of any grade of AEs was 37.9% in this study, and the risk of AEs was not significantly increased with the addition of therapeutic methods. An incidence of 37% for SAEs was previously reported in patients with NSCLC who were treated with platinum-based systemic chemotherapy (5). In contrast, in our study, group A had a milder degree of AEs although the incidence of any grade AEs was 53.3%.

The tolerance and efficacy of systemic chemotherapy for advanced NSCLC might be influenced by the accompaniment of severe comorbidities or poor PS (8,22). Thus, an effective and well-tolerated systemic treatment besides chemotherapy is still required for patients with systemic chemotherapy-resistant/intolerant advanced NSCLC. Unlike chemotherapeutic drugs, PD-1/L1 blockade can disturb the binding between PD-1 on T cells and PD-L1 on cancer cells and thus improve T cell-mediated immune response (3).

Patients with stage IA NSCLC are optimal candidates for thermal ablation (4,19), and MWA has demonstrated the superiority of a higher temperature, a larger ablation scope, and reduced treatment interval compared to other ablative techniques (7). A previous study found that 81.3%

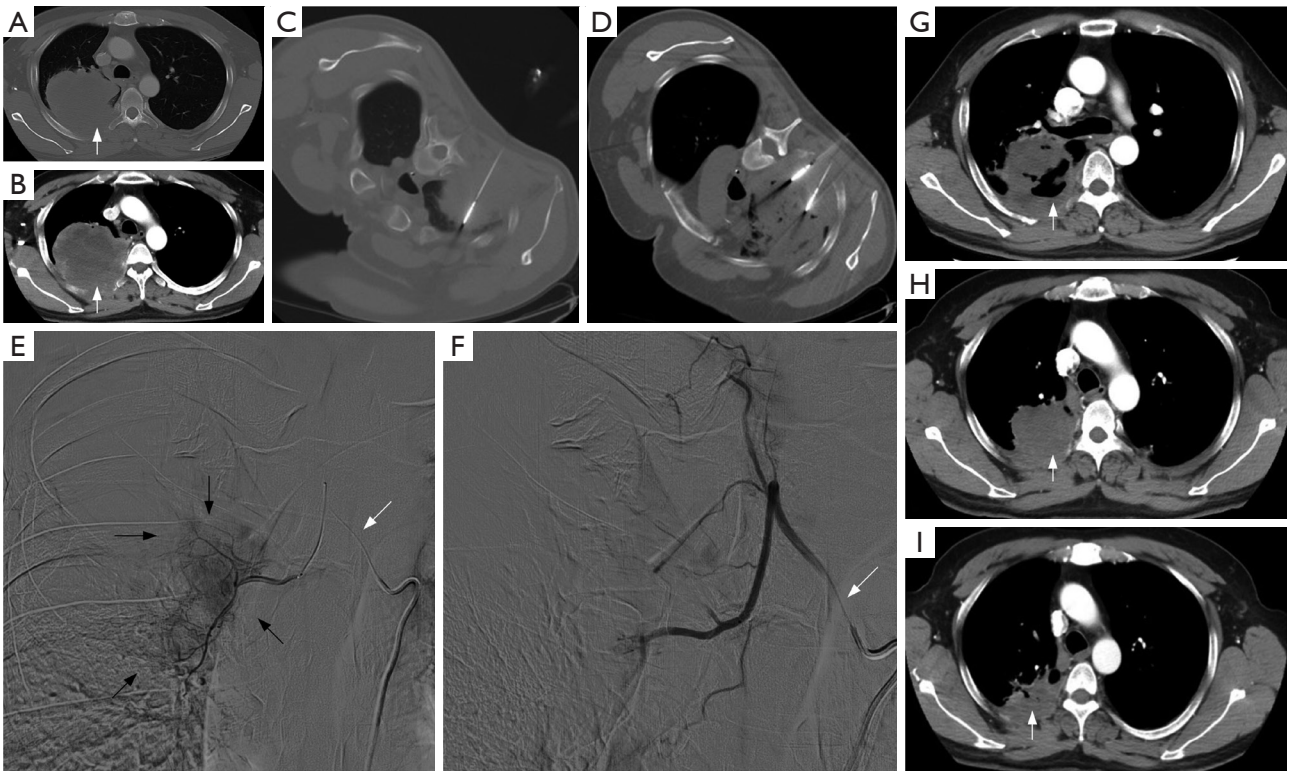

Figure 3 A typical case of advanced NSCLC treated with the maintenance treatment of PD-1 blockade after MWA and DEB-BACE. (A,B) A 47-year-old patient with NSCLC with a primary tumor stage of IV (T4N1M1) received first-line chemotherapy (pemetrexed plus carboplatin) and anti-angiogenesis therapy (bevacizumab). The CT scans revealed an enlarged pulmonary lesion with a tumor diameter of 9.7 cm × 9.5 cm (white arrow), which revealed resistance to systemic chemotherapy. (C,D) CT-guided MWA was performed to inactivate the tumor as much as possible, with three MWA antennas being used, a maximum power of 60 W being released, and a total ablation time of 27 minutes. (E) DEB-BACE was performed 1 week after MWA, with the superselective catheterization being performed via a microcatheter (white arrow). Sequential angiography revealed that the right bronchial artery was the main tumor-feeding artery with the presence of abundant tumor staining (black arrow). (F) Chemoembolization was performed with 300- to 500-μm CalliSpheres loaded with gemcitabine (600 mg) via the microcatheter (white arrow). Angiography indicated the disappearance of tumor staining. PD-1 blockade of toripalimab (240 mg) was administered 1 month after DEB-BACE, and a total of 27 cycles of immunotherapy were performed per month. (G) CT reexamination at 3 months after DEB-BACE showed an obvious reduction in tumor size and cavity formation (white arrow) and PR response. (H) The CT scan at 15 months revealed a continued reduction in the primary lesion and the absorption of the cavity (white arrow). (I) CT reexamination at 36 months after MWA showed a continuous reduction of tumor size (white arrow). Neither local progression nor distant metastases had occurred as of the last follow-up. NSCLC, non-small cell lung cancer; PD-1, programmed cell death protein 1; MWA, microwave ablation; DEB-BACE, drug-eluting beads bronchial artery chemoembolization; CT, computed tomography; PR, partial response.

of the local recurrence after MWA occurred in patients with NSCLC with a tumor diameter ≥3 cm, with the potential related mechanisms including the limited tumor necrosis scope offered by thermal ablation and the heat-sink effect induced by tumor-feeding arteries (23). A phase III trial compared systemic chemotherapy with or without upfront MWA in advanced NSCLC, reporting a higher median PFS of 10.3 months and an unreached median OS in the combination therapy, which supports the effectiveness of MWA plus systemic treatments for advanced NSCLC (8).

DEB-BACE shows milder toxicity than does systemic chemotherapy and has been used as salvage/replacement treatment for systemic chemotherapy-resistant/intolerant advanced NSCLC, demonstrating a median PFS of

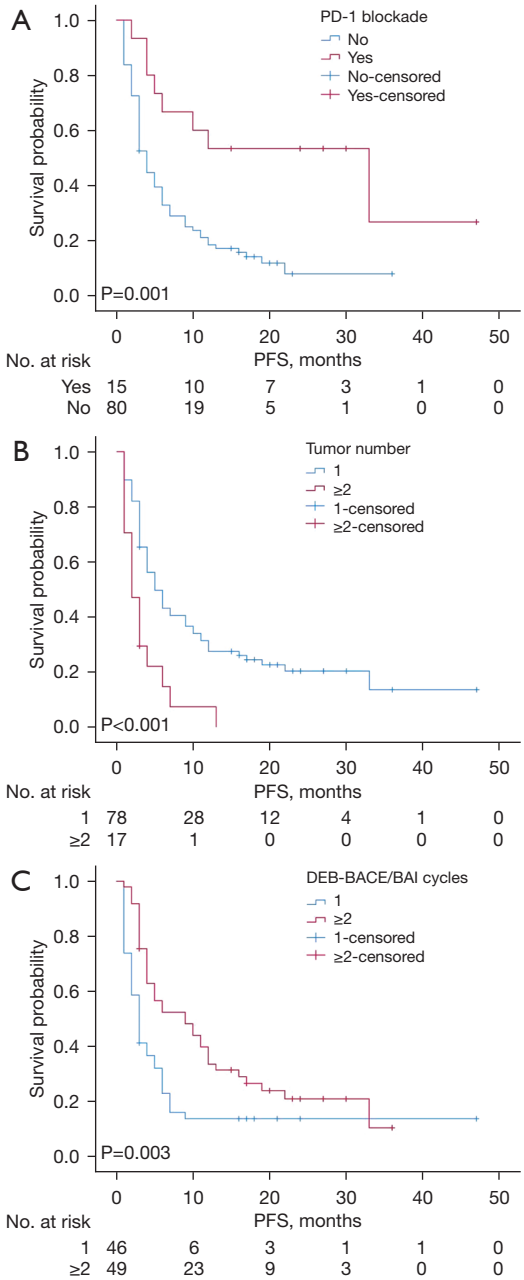

Figure 4 Kaplan-Meier analyses of PFS in patients with advanced NSCLC treated with DEB-BACE. (A) The estimated median PFS was 33.0 months for patients treated with PD-1 blockade, compared with 4.0 months for those patients without. (B) The estimated median PFS was 5.0 months for patients with 1 tumor and was 2.0 months for patients with ≥2 tumors. (C) The estimated median PFS was 9.0 months for patients treated with one cycle of DEB-BACE and was 3.0 months for those treated with no less than two cycles of DEB-BACE/BAI. PFS, progression-free survival; PD-1, programmed cell death protein 1; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; BAI, bronchial artery infusion; NSCLC, non-small cell lung cancer.

4.0–6.3 months and a median OS of 8.0–15.6 months (10-15). Dual therapeutic effects can be achieved in DEB-BACE, including a continuous delivery of loaded drugs from the DEB microspheres to tumor sites within 1–2 months and the tumor ischemia or necrosis produced by artery embolization, which provide better local efficacy and reduced systemic toxicity (9). However, the heterogeneity of techniques and distribution of tumor-feeding arteries, along with the absence of evidence, limits the application of DEB-BACE (4,24). The combination therapy of DEB-TACE and MWA for early-stage liver cancer was attempted, and a superior prognosis than that of MWA monotherapy was found (25). A retrospective study examined the use of DEB-BACE plus MWA in 77 patients with advanced NSCLC and found a prolonged median PFS compared with that of DEB-BACE monotherapy. This superior effect was attributed to the necrosis of tumor tissues via direct thermal ablation, the reduction of the collateral arteries, and the synergistic anticancer effects on residual tumor tissue achieved by DEB-BACE (13).

In theory, the combination of immunotherapy and locoregional interventional therapy can simultaneously achieve both local and systemic efficacy. Ablation or TACE can directly induce tumor necrosis, which is a form of tumor cell death. The potential processes of antitumor immunity modulated by thermal ablation or TACE include the releasing of neoantigen, sequential activation of antigen-presenting cells and effector immune cells, upregulation of immune cells in peripheral blood, increase in the abundance of tumor-infiltrating lymphocytes, and decrease in abundance of regulatory T (Treg) cells (26-30). Of these, Treg cells can promote tumor growth via inhibiting antitumor immunity (31). An increased number of CD8+ T cells and a reduction of Treg cells after MWA in lung cancer have been reported (32), with the changes in Treg cells being associated with prolonged PFS. Some chemotherapeutic drugs, including gemcitabine, possess immunogenic properties and can trigger a significant tumor-specific immunological effect (33).

Three studies have examined the combination of ICIs and a single interventional technique for advanced NSCLC (17,34,35). A retrospective study reported a median PFS of 5.1 months and an unreached median OS for MWA plus PD-1 blockade in advanced NSCLC (34). Another retrospective study performed DEB-BACE/BAI plus sintilimab in 10 patients with advanced NSCLC, reporting a median PFS and OS of 11.0 and 8.0 months, respectively. Meanwhile, a median PFS and OS of 12.0 and 27.0 months,

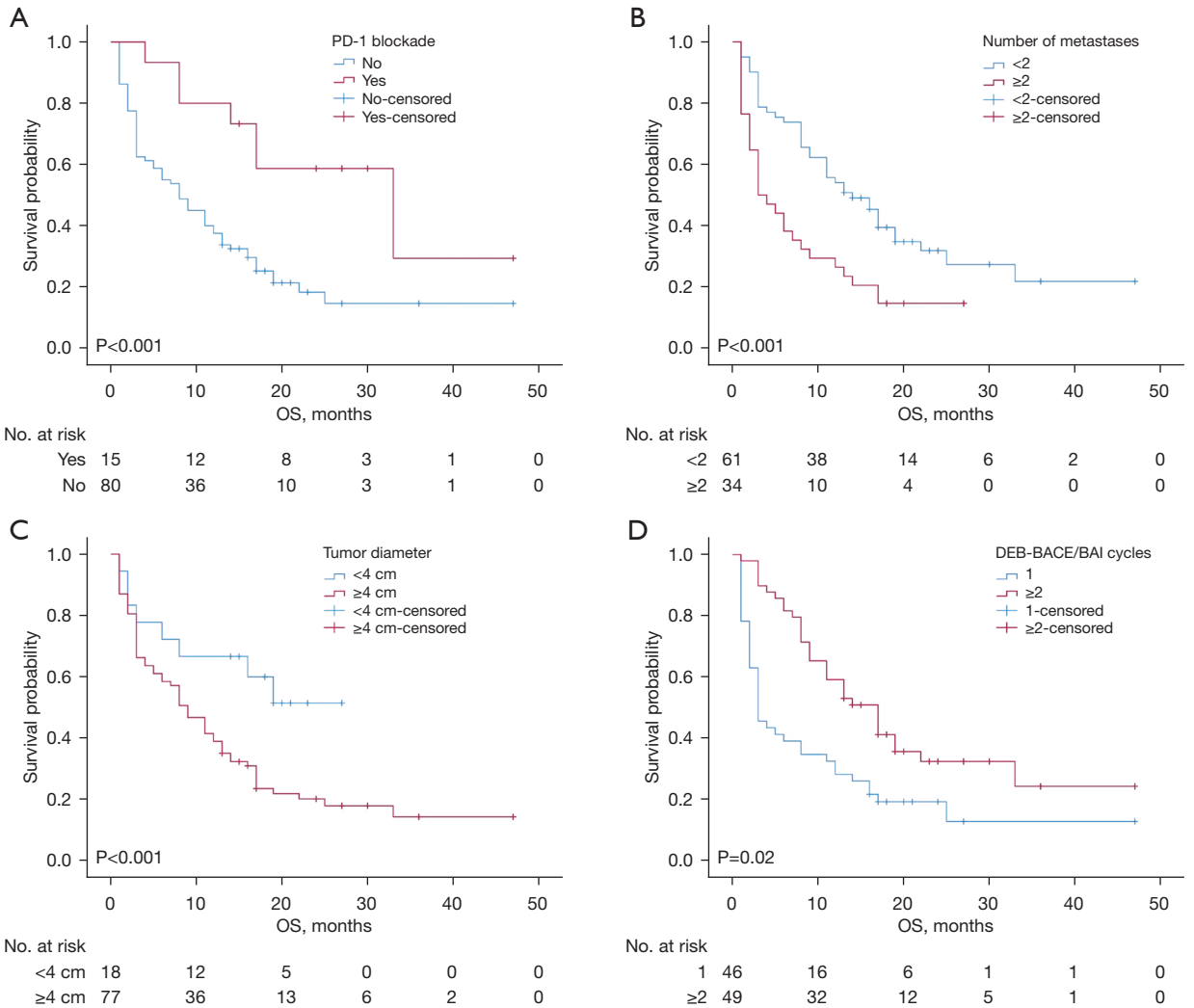

Figure 5 Kaplan-Meier analyses of OS in patients with advanced NSCLC treated with DEB-BACE. (A) The estimated median OS was 33.0 months for patients treated with PD-1 blockade and 8.0 months for patients who were not. (B) The estimated median OS was 14.0 months for patients with <2 metastases and 3.0 months for those patients with ≥2 metastases. (C) The estimated median OS was not reached for patients with a tumor diameter <4 cm and was 9.0 months for patients with a tumor diameter ≥4 cm. (D) The estimated median OS was 3.0 months for patients treated with one cycle of DEB-BACE and was 17.0 months for those patients treated with fewer than two cycles of DEB-BACE/BAI. OS, overall survival; PD-1, programmed cell death protein 1; DEB-BACE, drug-eluting bead bronchial artery chemoembolization; BAI, bronchial artery infusion; NSCLC, non-small cell lung cancer.

respectively, was found in a study with identical therapeutic strategies, but with more cases and longer follow-up (17,35). The potential mechanisms of the effectiveness of PD-1 blockade after MWA plus DEB-BACE are as follows: (I) direct local tumor necrosis and synergistic antitumor effects induced by MWA and DEB-BACE, (II) dual synergistic antitumor immunity induced by MWA and embolization, and (III) chemotherapeutic drugs delivered from DEB microspheres inducing the chemotherapy-related inflammation and triggering the upregulation of immunogenic cell death markers (36).

Our study involved certain limitations that should be noted. First, the retrospective nature of the design might have introduced a degree of patient selection bias. Second, the superiority of the combination DEB-BACE, MWA, and immunotherapy needs to be further validated with

a larger sample size. Third, a heterogeneity in enrolled patients and immunotherapy regimens may exist owing to the different treatment histories and PD-1 blockade manufacturers. Fourth, the treatment sequence of the three strategies might have influenced the outcomes, and the optimal sequence needs to be further investigated. Finally, this study lacked comparative groups of patients treated with monoimmunotherapy or immunotherapy plus a single interventional technique, which might better indicate the superiority of the combination of immunotherapy and multiple interventional techniques.

In conclusion, compared with MWA plus DEB-BACE or DEB-BACE alone, the maintenance treatment of immunotherapy after MWA plus DEB-BACE might provide superior prognosis for those with advanced NSCLC without increasing the risk of AEs.

Acknowledgments

Funding: This work was funded by the National High Level Hospital Clinical Research Fund (No. BJ-2020-164) and the Capital's Funds for Health Improvement and Research (CFH-2022-2-4053). The funding sources had no involvement in the conduct of the research or preparation of the article.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-23-1876/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1876/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the institutional ethics review board of Beijing Hospital. The need for written informed consent was waived for this retrospective analysis.

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin 2021;71:209-49.
2. Chen W, Zheng R, Baade PD, Zhang S, Zeng H, Bray F, Jemal A, Yu XQ, He J. Cancer statistics in China, 2015. CA Cancer J Clin 2016;66:115-32.
3. Vaddepally RK, Kharel P, Pandey R, Garje R, Chandra AB. Review of Indications of FDA-Approved Immune Checkpoint Inhibitors per NCCN Guidelines with the Level of Evidence. Cancers (Basel) 2020;12:738.
4. Non-Small Cell Lung Cancer. Clinical Practice Guidelines in Oncology. NSCLC 2023 V4. Available online: https://www.nccn.org/guidelines/guidelines-detail?category=1&id=1450
5. Zhou C, Li M, Wang Z, An D, Li B. Adverse events of immunotherapy in non-small cell lung cancer: A systematic review and network meta-analysis. Int Immunopharmacol 2022;102:108353.
6. Bozcuk H, Yıldırım M, Sever Ö, Mutlu H, Artaç M. Checkpoint inhibitors in advanced nonsmall-cell lung cancer; a Bayesian network meta-analysis. J Cancer Res Ther 2020;16:828-37.
7. Simon CJ, Dupuy DE, Mayo-Smith WW. Microwave ablation: principles and applications. Radiographics 2005;25 Suppl 1:S69-83.
8. Wei Z, Yang X, Ye X, Feng Q, Xu Y, Zhang L, et al. Microwave ablation plus chemotherapy versus chemotherapy in advanced non-small cell lung cancer: a multicenter, randomized, controlled, phase III clinical trial. Eur Radiol 2020;30:2692-702.
9. Melchiorre F, Patella F, Pescatori L, Pesapane F, Fumarola E, Biondetti P, Brambillasca P, Monaco C, Ierardi AM, Franceschelli G, Carrafiello G. DEB-TACE: a standard review. Future Oncol 2018;14:2969-84.
10. Bie Z, Li Y, Li B, Wang D, Li L, Li X. The efficacy of drug-eluting beads bronchial arterial chemoembolization

loaded with gemcitabine for treatment of non-small cell lung cancer. Thorac Cancer 2019;10:1770-8.
11. Bi Y, Shi X, Yi M, Han X, Ren J. Pirarubicin-loaded CalliSpheres® drug-eluting beads for the treatment of patients with stage III-IV lung cancer. Acta Radiol 2022;63:311-8.
12. Shang B, Li J, Wang X, Li D, Liang B, Wang Y, Han X, Dou W, Chen G, Shang J, Jiang S. Clinical effect of bronchial arterial infusion chemotherapy and CalliSpheres drug-eluting beads in patients with stage II-IV lung cancer: A prospective cohort study. Thorac Cancer 2020;11:2155-62.
13. Xu S, Bie ZX, Li YM, Li B, Kong FL, Peng JZ, Li XG. Drug-Eluting Bead Bronchial Arterial Chemoembolization With and Without Microwave Ablation for the Treatment of Advanced and Standard Treatment-Refractory/Ineligible Non-Small Cell Lung Cancer: A Comparative Study. Front Oncol 2022;12:851830.
14. Zeng Y, Yin M, Zhao Y, Liu Y, Li X, Qi Y, Ma Y, Li Z, Li C, Wu G. Combination of Bronchial Arterial Infusion Chemotherapy plus Drug-Eluting Embolic Transarterial Chemoembolization for Treatment of Advanced Lung Cancer-A Retrospective Analysis of 23 Patients. J Vasc Interv Radiol 2020;31:1645-53.
15. Bi Y, Zhang B, Ren J, Han X, Wu W. Clinical outcomes of gemcitabine-loaded callispheres drug-eluting beads for patients with advanced and inoperable lung cancer: A case series study. Front Pharmacol 2022;13:992526.
16. Llovet JM, De Baere T, Kulik L, Haber PK, Greten TF, Meyer T, Lencioni R. Locoregional therapies in the era of molecular and immune treatments for hepatocellular carcinoma. Nat Rev Gastroenterol Hepatol 2021;18:293-313.
17. Li YM, Guo RQ, Bie ZX, Li B, Li XG. Sintilimab plus Bronchial Arterial Infusion Chemotherapy/Drug-Eluting Embolic Chemoembolization for Advanced Non-Small Cell Lung Cancer: A Preliminary Study of 10 Patients. J Vasc Interv Radiol 2021;32:1679-87.
18. Goldstraw P, Chansky K, Crowley J, Rami-Porta R, Asamura H, Eberhardt WE, Nicholson AG, Groome P, Mitchell A, Bolejack V; International Association for the Study of Lung Cancer Staging and Prognostic Factors Committee, Advisory Boards, and Participating Institutions; International Association for the Study of Lung Cancer Staging and Prognostic Factors Committee Advisory Boards and Participating Institutions. The IASLC Lung Cancer Staging Project: Proposals for Revision of the TNM Stage Groupings in the Forthcoming (Eighth) Edition of the TNM Classification for Lung Cancer. J Thorac Oncol 2016;11:39-51.
19. Genshaft SJ, Suh RD, Abtin F, Baerlocher MO, Dariushnia SR, Devane AM, Himes E, Lisberg A, Padia S, Patel S, Yanagawa J. Society of Interventional Radiology Quality Improvement Standards on Percutaneous Ablation of Non-Small Cell Lung Cancer and Metastatic Disease to the Lungs. J Vasc Interv Radiol 2021;32:1242.e1-1242.e10.
20. Common Terminology Criteria for Adverse Events (CTCAE) v5.0. Available online: https://ctep.cancer.gov/protocolDevelopment/electronic_applications/docs/CTCAE_v5_Quick_Reference_5x7.pdf. Accessed December 31, 2023.
21. Schwartz LH, Litière S, de Vries E, Ford R, Gwyther S, Mandrekar S, Shankar L, Bogaerts J, Chen A, Dancey J, Hayes W, Hodi FS, Hoekstra OS, Huang EP, Lin N, Liu Y, Therasse P, Wolchok JD, Seymour L. RECIST 1.1-Update and clarification: From the RECIST committee. Eur J Cancer 2016;62:132-7.
22. Kim ES. Chemotherapy Resistance in Lung Cancer. Adv Exp Med Biol 2016;893:189-209.
23. Zhong L, Sun S, Shi J, Cao F, Han X, Bao X, You Q. Clinical analysis on 113 patients with lung cancer treated by percutaneous CT-guided microwave ablation. J Thorac Dis 2017;9:590-7.
24. Nakanishi M, Demura Y, Umeda Y, Mizuno S, Ameshima S, Chiba Y, Ishizaki T. Multi-arterial infusion chemotherapy for non-small cell lung carcinoma--significance of detecting feeding arteries and tumor staining. Lung Cancer 2008;61:227-34.
25. Liu J, Zhang W, Lu H, Li H, Zhou X, Li J, Han X. Drug-eluting bead trans-arterial chemoembolization combined with microwave ablation therapy vs. microwave ablation alone for early stage hepatocellular carcinoma: a preliminary investigation of clinical value. J Cancer Res Clin Oncol 2022;148:1781-8.
26. Fietta AM, Morosini M, Passadore I, Cascina A, Draghi P, Dore R, Rossi S, Pozzi E, Meloni F. Systemic inflammatory response and downmodulation of peripheral CD25+Foxp3+ T-regulatory cells in patients undergoing radiofrequency thermal ablation for lung cancer. Hum Immunol 2009;70:477-86.
27. Ito F, Vardam TD, Appenheimer MM, Eng KH, Gollnick SO, Muhitch JB, Evans SS. In situ thermal ablation augments antitumor efficacy of adoptive T cell therapy. Int J Hyperthermia 2019;36:22-36.
28. Pinato DJ, Murray SM, Forner A, Kaneko T, Fessas P, Toniutto P, et al. Trans-arterial chemoembolization as

a loco-regional inducer of immunogenic cell death in hepatocellular carcinoma: implications for immunotherapy. J Immunother Cancer 2021;9:e003311.
29. Ayaru L, Pereira SP, Alisa A, Pathan AA, Williams R, Davidson B, Burroughs AK, Meyer T, Behboudi S. Unmasking of alpha-fetoprotein-specific CD4(+) T cell responses in hepatocellular carcinoma patients undergoing embolization. J Immunol 2007;178:1914-22.
30. Greten TF, Mauda-Havakuk M, Heinrich B, Korangy F, Wood BJ. Combined locoregional-immunotherapy for liver cancer. J Hepatol 2019;70:999-1007.
31. Wang H, Franco F, Ho PC. Metabolic Regulation of Tregs in Cancer: Opportunities for Immunotherapy. Trends Cancer 2017;3:583-92.
32. Zhang L, Zhang M, Wang J, Li Y, Wang T, Xia J, Feng B, Shen J. Immunogenic change after percutaneous microwave ablation in pulmonary malignancies: Variation in immune cell subsets and cytokines in peripheral blood. Front Immunol 2022;13:1069192.
33. Wang YJ, Fletcher R, Yu J, Zhang L. Immunogenic effects of chemotherapy-induced tumor cell death. Genes Dis 2018;5:194-203.
34. Wei Z, Yang X, Ye X, Huang G, Li W, Han X, Wang J, Meng M, Ni Y, Zou Z, Wen Q. Camrelizumab combined with microwave ablation improves the objective response rate in advanced non-small cell lung cancer. J Cancer Res Ther 2019;15:1629-34.
35. Xu S, Li YM, Bie ZX, Li XG. Drug-eluting beads bronchial arterial chemoembolization/bronchial arterial infusion chemotherapy with and without PD-1 blockade for advanced non-small cell lung cancer: a comparative single-center cohort study. Quant Imaging Med Surg 2023;13:6241-56.
36. He X, Du Y, Wang Z, Wang X, Duan J, Wan R, Xu J, Zhang P, Wang D, Tian Y, Han J, Fei K, Bai H, Tian J, Wang J. Upfront dose-reduced chemotherapy synergizes with immunotherapy to optimize chemoimmunotherapy in squamous cell lung carcinoma. J Immunother Cancer 2020;8:e000807.

Cite this article as: Xu S, Bie ZX, Li YM, Qi J, Peng JZ, Li XG. Maintenance treatment of immunotherapy after microwave ablation plus drug-eluting bead bronchial arterial chemoembolization for advanced non-small cell lung cancer: a retrospective single-center cohort study. Quant Imaging Med Surg 2024;14(5):3473-3488. doi: 10.21037/qims-23-1876

