Minimally Invasive Therapy. 2014; Early Online, 1–7

Minim Invasive Ther Allied Technol. 2015 Apr;24(2):94-100.
doi: 10.3109/13645706.2014.951657. Epub 2014 Sep 29. PubMed

ORIGINAL ARTICLE

Balloon-occluded transarterial chemoembolization using a 1.8-French tip Coaxial microballoon catheter for hepatocellular carcinoma: Technical and safety considerations

TOMOHIRO MATSUMOTO[1]*, JUN ENDO[1], KAZUNOBU HASHIDA[1], HITOSHI ICHIKAWA[2], SEIICHIRO KOJIMA[2], SHINJI TAKASHIMIZU[2], NORIHITO WATANABE[2], TAKUJI YAMAGAMI[1,3] & TERUMITSU HASEBE[1]*

[1]*Department of Radiology, Tokai University Hachioji Hospital, Tokai University School of Medicine, Tokyo, Japan,* [2]*Department of Gastroenterology, Tokai University Hachioji Hospital, Tokai University School of Medicine, Tokyo, Japan, and* [3]*Department of Diagnostic Radiology, Institute and Graduate School of Biomedical Sciences, Hiroshima University Hospital, Hiroshima, Japan*

Abstract

Objective: To evaluate the technical feasibility and safety considerations of balloon-occluded transarterial chemoembolization (B-TACE) using a newly developed 1.8-French (Fr) tip microballoon catheter for hepatocellular carcinoma (HCC). **Material and methods**: Between February 2013 and May 2013, 31 patients (20 males, 11 females; age range 56–85 years) underwent B-TACE using a 1.8-Fr tip microballoon catheter for unresectable HCC. The technical success rate, procedural complications, and adverse events of B-TACE were retrospectively investigated. **Results**: A total of 31 patients were subjected to 70 sessions of B-TACE using a 1.8-Fr tip microballoon catheter. The level of B-TACE was sub-subsegmental in 11, subsegmental in 35, segmental in 14, lobar in five, and right inferior phrenic artery in five sessions. The overall technical success rate was 99% (69 out of 70 sessions). As procedural complications, rupturing of the microballoon (n = 3) and aneurysmal dilatation at the site of balloon occlusion (n = 2) were encountered. There were no significant differences in any parameters between blood biochemical examination before and between two to four weeks after the procedure. **Conclusion**: A 1.8-Fr tip microballoon catheter enables selective catheterization in patients with HCC and B-TACE using the 1.8-Fr tip microballoon catheter is a safe procedure.

Key words: *Interventional radiology, catheter interventions, minimally invasive procedures, balloon-occluded transarterial chemoembolization, hepatocellular carcinoma, microballoon catheter*

Introduction

Recently, Irie et al. (1) reported that selective balloon-occluded transarterial chemoembolization (B-TACE) using a 3-French (Fr) tip microballoon catheter could achieve dense Lipiodol (LPD; Andre Guerbet, Aulnaysous-Bois, France) emulsion accumulation in hepatocellular carcinoma (HCC) nodules in most treatments in which balloon-occluded arterial stump pressure was 64 mmHg or less and usually lower than systemic blood pressure. Because LPD accumulation is one of the significant prognostic factors affecting local recurrence (2,3), selective B-TACE could lead to useful treatment, as with superselective TACE using a conventional microcatheter. Moreover, Irie et al. (1) found that anastomotic vessels were revealed in 19 of 43 procedures of B-TACE. This finding may suggest that LPD suspension is injected into other small feeding branches through the anastomotic vessels, but on the other hand, LPD suspension may be injected into widespread liver parenchyma through the anastomotic vessels and this may result in serious liver damage.

Correspondence: T. Hasebe, Department of Radiology, Tokai University Hachioji Hospital, Tokai University School of Medicine, 1838 Ishikawa-machi, Hachioji, Tokyo 192-0032, Japan. Fax: +81 42 639 1144. E-mail: hasebe@tokai-u.jp
*Both authors equally contributed to this work.

ISSN 1364-5706 print/ISSN 1365-2931 online
DOI: 10.3109/13645706.2014.951657

According to our clinical experiences using this catheter, we sometimes encountered difficulty when coaxially advancing the 3-Fr tip microballoon catheter into the intented feeding arteries selectively or superselectively. In addition, we routinely need a 5-Fr or 6-Fr guiding catheter for B-TACE using a 3-Fr microballoon catheter, which is more invasive compared to a conventional TACE procedure.

Because more distal advancement of the microballoon catheter might be needed for dense iodized oil emulsion accumulation, it had been desirable to improve the microballoon catheter shaft to make it more flexible and thinner (1). A 1.8-Fr tip microballoon catheter, which was also newly invented in Japan, became available in February 2013. Surprisingly, we can coaxially advance this microballoon catheter less invasively through a usual 4-Fr angiographic catheter without any 5-Fr or 6-Fr guiding catheter because of the advanced technology for fabrication of a small-sized microballoon catheter for B-TACE. However, technical feasibility and safety consideration of selective B-TACE should be evaluated using a newly developed 1.8-Fr tip microballoon catheter before starting further prospective studies of B-TACE for HCC to prove the efficacy of this new treatment strategy.

To the best of our knowledge, this is the first and timely report in the literature regarding technical and safety issues of B-TACE using a 1.8-Fr tip microballoon catheter with advanced engineering technologies.

Material and methods

Patient characteristics

This retrospective study was conducted with the approval of the institutional review board. Informed consent was obtained for every diagnostic and interventional procedure. From February 2013 to May 2013, B-TACE using a 1.8-Fr tip microballoon catheter system was performed in 31 patients with unresectable HCC at our hospital (Table I). In our study, B-TACE was performed instead of conventional TACE. The diagnosis of HCC was made based on distinctive findings on computed tomography (CT) and magnetic resonance imaging (MRI), in addition to high serum levels of tumor markers (α-fetoprotein (AFP) or protein induced in vitamin K absence or antagonist II (PIVKA-II)).

Table I. Characteristics of patients undergoing B-TACE ($n = 31$).

Age	
Mean ± SD (range)	73 ± 7.5 (56–85)
Gender	
Male	20 (65%)
Female	11 (35%)
Child-Pugh classification	
A	19 (61%)
B	12 (39%)
C	0 (0%)
Etiology	
HBV	2 (6%)
HCV	22 (71%)
Alcohol	5 (16%)
Others	2 (6%)
Stage*	
I	1 (3%)
II	10 (32%)
III	16 (52%)
IV	4 (13%)
Maximum tumor size (cm)	
≤3.0	18 (58%)
3.1–5.0	8 (26%)
>5.0	5 (16%)
Previous TACE	
Absent	3 (10%)
Present	28 (90%)
AFP (ng/ml)	
Median (range)	42 (3.3–25487)
PIVKA-II (mAU/ml)	
Median (range)	96 (6.0–3230)

*Staging as proposed by the Liver Cancer Study Group of Japan. B-TACE = balloon-occluded transarterial chemoembolization; HBV = hepatitis B virus; HCV = hepatitis C virus; AFP = alfa-fetoprotein; PIVKA-II = protein induced by vitamin K absence or antagonists-II.

Microballoon catheter characteristics

We used two types of newly developed microballoon catheters, Attendant Delta (Terumo Clinical Supply, Gifu, Japan) and Logos (Piolax, Yokohama, Japan). Attendant Delta diameter is "2.7-Fr"; however, this is not the diameter of the real microballoon catheter tip but the diameter of the more proximal part of the microballoon. The measured shaft diameter of Attendant Delta is tapered from 1.98-Fr at the distal part of the microballoon to 1.8-Fr at the catheter tip, and a radiopaque marker is located just proximal to the catheter tip (Figure 1A). The diameter of the guidewire lumen is 0.017 inch. The compliant microballoon made of polyurethane resin is 5.5 mm in length and 4 mm in inflation diameter with an injection

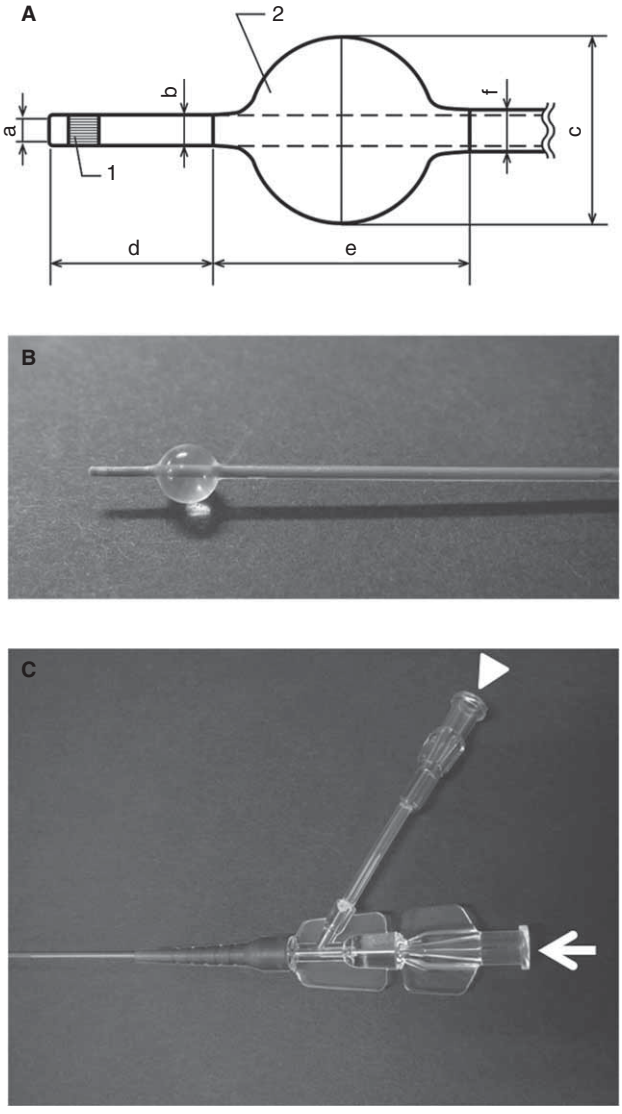

Figure 1. Details of Attendant Delta (Terumo Clinical Supply, Gifu, Japan): (A) Schema of the catheter tip and microballoon of Attendant Delta. *a* 1.8-French, *b* 1.98-French, *c* 4 mm, *d* 3.5 mm, *e* 5.5 mm, *f* 2.7-French *1* radiopaque marker, *2* microballoon; (B) photographic image of the catheter tip and microballoon of Attendant Delta; (C) photographic image of main lumen (white arrow) and balloon inflation lumen (white arrowhead) of Attendant Delta.

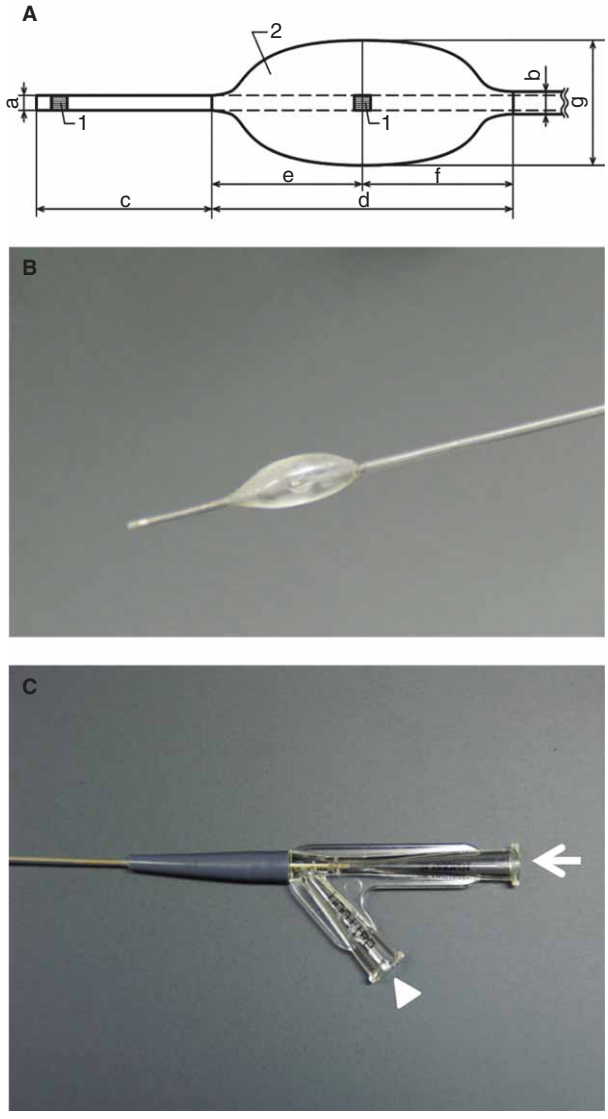

Figure 2. Details of Logos (Piolax, Yokohama, Japan): (A) Schema of the catheter tip and microballoon of Logos. *a* 1.8-French, *b* 2.4-French, *c* 7 mm, *d* 12 mm, *e* 6 mm, *f* 6 mm, *g* 3–5 mm, *1* radiopaque marker, *2* microballoon; (B) photographic image of catheter tip and microballoon of Logos; (C) photographic image of main lumen (white arrow) and balloon inflation lumen (white arrowhead) of Logos.

volume of 0.1 ml of 150-mgI contrast agent (recommended limit volume) (Figure 1A and 1B). Logos has a non-tapered 1.8-Fr catheter tip at the distal part of the microballoon (Figure 2A and 2B). The diameter of the guidewire lumen is 0.018 inch. The compliant microballoon made of polyurethane resin is 12 mm in length and 3–5 mm in inflation diameter range, with a volume of <0.21 ml of 150-mgI contrast agent (recommended limit volume) (Figure 2A). The distal side of each catheter surface is coated with hydrophilic polymer. In addition, of particular note is the fact that both microballoon catheters are compatible with the diagnostic 4-Fr catheter (Terumo Clinical Supply, Gifu, Japan). These are double lumen microballoon catheters; therefore, the proximal side consists of two ports: One is the microguidewire lumen and the other is the microballoon lumen (Figures 1C and 2C).

B-TACE using a 1.8-Fr tip microballoon catheter

The right common femoral artery was used as the access route in all cases. The artery was punctured using an 18-gauge needle without skin incision and the 4-Fr

diagnostic catheter was inserted using a 0.035-inch guidewire (Terumo Clinical Supply, Gifu, Japan) without a 4-Fr sheath for 26 patients and with a 4-Fr sheath for five patients. Selection of the 1.8-Fr tip microballoon catheter was determined based on the physician's preference. The 1.8-Fr tip microballoon catheter was coaxially inserted into the aimed portion through the 4-Fr catheter placed in the celiac artery ($n = 24$), superior mesenteric artery ($n = 5$), replaced right hepatic artery from the superior mesenteric artery ($n = 1$), or common hepatic artery ($n = 2$). To navigate the microballoon catheter, a 0.016-inch guidewire (Asahi Intecc Co., Ltd., Nagoya, Japan) was used in all cases. The locations and characteristics of the tumors were evaluated with a combination of digital subtraction angiography (DSA) and cone-beam CT imaging (DynaCT) using a flat-panel detector (Simens Medical Solutions, Forcheim, Germany). The microballoon catheter was advanced near the tumor-feeding artery in a selective manner. The microballoon was inflated to a diameter 5–10% larger than that of the occluded artery on DSA as described Irie et al. (1). Then, B-TACE was performed. A suspension of miriplatin hydrate (MPT; Dainippon Sumitomo Pharma Co., Ltd., Osaka, Japan) in LPD (MPT/LPD) warmed to 40°C in 30 patients or a suspension of cisplatin powder (CDDP; Nippon Kayaku, Tokyo, Japan) in LPD (CDDP/LPD) in one patient was injected through the microballoon catheter. The amount of LPD and MPT or CDDP was determined according to the tumor size and the degree of liver function. LPD suspension infusion was continued under balloon occlusion until the HCC nodule was filled with LPD suspension or the portal venous branches were beginning to be filled with LPD suspension. Then, 1-mm gelatin sponge particles (Nippon Kayaku, Tokyo, Japan) were injected to obstruct the tumor-feeding branch under the microballoon inflation.

Parameters investigated

We investigated the technical success rate, procedural complications, and adverse effects. The technical success rate was defined as the rate of successful insertions of microballoon catheters selectively into all intended arteries for B-TACE in a treatment session. Adverse events related to B-TACE were graded according to the Common Terminology Criteria for Adverse Events version 4.0 (CTCAE v4.0). Within the first two weeks and two to four weeks (21 ± 3.0 days) after B-TACE, the toxicity evaluations were made.

For statistical analysis, quantitative variables were compared using Student's *t*-test and commercial software (JMP 5.1; SAS Japan, Tokyo, Japan) was used. Differences were considered significant when the *p*-value was < 0.05.

Results

Attendant Delta was used in 18 cases and Logos was used in 13 cases. Seventy sessions of B-TACE using the 1.8-Fr tip microballoon catheter were carried out. The mean number of embolized arteries per session was 2.3 arteries. The level of B-TACE was a subsubsegmental artery in 11 sessions, subsegmental in 35 sessions, segmental in 14 sessions, lobar in five sessions, and right inferior phrenic artery in five sessions. Regarding the breakdown of the five sessions of lobar B-TACE, three sessions were performed due to the presence of multiple nodular lesions of HCC; one session was performed due to HCC in the left hepatic lobe with multi-feeding arteries from the left hepatic artery; the remaining session was performed due to the presence of unclear feeding arteries of HCC on both DSA and DynaCT.

The overall technical success rate was 99% (69 out of 70 sessions). In only one session, B-TACE was performed at the level of the segmental branch because the microballoon catheter could not be inserted into the subsegmental branch due to the tortuosity of the vessel.

As procedural complication, in three sessions (9.7%), rupturing of Attendant Delta was revealed when injecting 1.5 ml into the microballoon; however, no vascular complications of the hepatic artery were observed. The other complication was an aneurysmal dilatation in two cases (6.5%) due to the overdilatation of Logos (Figure 3A–C) and Attendant Delta. In both cases, follow-up CT images seven weeks after the procedure showed no enlargement at the portions of aneurysmal dilatation.

The amounts of antitumor drugs, LPD and gelatin sponge which were used in B-TACE were as follows: MPT = 26.25–140 mg (average: 85 ± 35 mg), CDDP = 110 mg, LPD = 1.5–14 ml (average: 5.6 ± 3.0 ml) and gelatin sponge = 8–64 mg (average: 27 ± 13 mg).

CTCAE grade 4 elevations of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were seen in 13% and 6% of the patients, respectively (Table II). Elevation of the serum total bilirubin concentrations up to CTCAE grade 3 was observed in one patient (3%) (Table II). Recovery from these adverse effects took place within two weeks. However, in three patients (9%), elevation of serum total bilirubin was confirmed. In two of the three patients, the grade of serum total bilirubin rose from the normal level to grade 1 after the procedure. In the remaining patient,

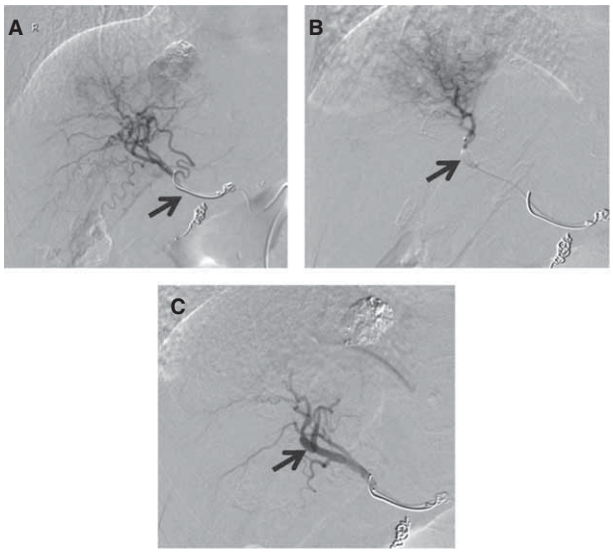

Figure 3. Aneurysmal dilatation due to overinflation of the microballoon. (A) There was no aneurismal dilatation on the arteriogram of the right hepatic artery before microballoon dilatation. Note that although an attempt at embolization with coils of the gastroduodenal artery for hepatic arterial infusion chemotherapy with fixed-catheter tip method had been made at another hospital, a coil migrated to the hepatic artery (arrow), and as a result, the placement of the port-catheter system for hepatic arterial infusion chemotherapy was stopped; (B) the microballoon (arrow) was dilated at the origin of the posterior branch; (C) An aneurysmal dilatation was revealed on the arteriogram of the posterior branch after deflation of the microballoon (arrow).

the grade of serum total bilirubin rose from grade 1 to grade 2 after the procedure. In one patient (3%), elevation of ALT from the normal level to grade one was confirmed after the procedure. In 1 patient (3%), elevation of AST from grade 1 to grade 2 was confirmed after the procedure. However, comparison of pre and post B-TACE blood biochemical examinations showed that there were no significant differences in any parameters (Table III).

Discussion

Indeed, superselective TACE using a conventional microcatheter as described by Miyayama et al. (4) is known to be an effective procedure to treat HCC. However, excessive advancement of the catheter may also lead to procedure-related tumor recurrence by missing a small feeding branch. On the other hand, in B-TACE, LPD suspension may be injected into other small feeding branches through the anastomotic vessels even though the small feeding branch is missed.

In our study, in most sessions (99%), we were able to advance the microballoon catheters selectively into the intended arteries.Thus, both types of microballoon catheters have excellent flexibility and can be advanced less traumatically into targeted vessels.

Rupturing of microballoon catheter (9.7%) during balloon inflation was confirmed. As described in the product labeling of Attendant Delta, inflation by injection of up to 0.20 ml of 150-mgI contrast agent

Table II. Adverse events of B-TACE for HCC.

		Grading (CTCAE version 4)			
Characteristics	Total	1	2	3	4
Nausea	12 (39%)	12 (39%)	0	0	0
Vomiting	6 (19%)	6 (19%)	0	0	0
Fever	21 (68%)	17 (55%)	4 (13%)	0	0
Abdominal pain	10 (32%)	10 (32%)	0	0	0
Anorexia	16 (52%)	15 (48%)	1 (3%)	0	0
WBC	16 (52%)	11 (35%)	5 (16%)	0	0
Platelets	27 (87%)	14 (45%)	7 (23%)	6 (19%)	0
AST	31 (100%)	7 (23%)	8 (26%)	12 (39%)	4 (13%)
ALT	28 (90%)	12 (39%)	7 (23%)	7 (23%)	2 (6%)
Total bilirubin	21 (68%)	10 (32%)	10 (32%)	1 (3%)	0

B-TACE = balloon-occluded transarterial chemoembolization; HCC = hepatocellular carcinoma; CTCAE = Common Terminology Criteria for Adverse Events; WBC = white blood cell; AST = aspartate aminotransferase; ALT = alanine aminotransferase.

Table III. Blood biochemical examination before and between 2 to 4 weeks after B-TACE.

Characteristics	Pre-treatment*	Post-treatment**	*p*-Value
WBC (/μl)	4.0 ± 1.5	4.4 ± 1.7	0.34
Platelet ($\times 10^3$/μl)	12.0 ± 5.9	13.2 ± 6.7	0.46
Total bilirubin (mg/dl)	0.9 ± 0.6	1 ± 0.6	0.61
AST (U/l)	57 ± 38	62 ± 53	0.64
ALT (U/l)	43 ± 33	41 ± 34	0.78
Albmin (g/dl)	3.3 ± 0.5	3.2 ± 0.4	0.31
Prothrombin activity (%)	72 ± 13	67 ± 13	0.15

*Within 2 weeks before B-TACE.
**Between 2 to 4 weeks (mean, 21 days) after B-TACE.
B-TACE = balloon-occluded transarterial chemoembolization; WBC = white blood cell; AST = aspartate aminotransferase; ALT = alanine aminotransferase.

into the microballoon outside the body is generally considered safe. However, in our results, rupturing of Attendant Delta was revealed when injecting 1.5 ml into the microballoon. Therefore, we speculated that the situation of balloon inflation in a small or tortuous vessel is different from that of inflation at outside the body. We recommend that the microballoon be inflated using <1.0 ml to avoid unintended balloon rupturing, especially in a tortuous feeding artery, in order to accomplish B-TACE.

As a specific complication of B-TACE, aneurysmal dilatation (6.5%) due to overinflation of the microballoon catheter was confirmed. In the procedure, the microballoon was inflated to >10% of the diameter of the occluded artery. The microballoon catheter tends to suddenly inflate compared to a conventional balloon catheter. This could be due to less balloon volume and incomplete removal of air in the microballoon lumen. In our study, aneurysmal dilatation due to overinflation was noted in the earlier cases after we started to use the microballoon catheters. In these cases, we confirmed incomplete removal of air in the microballoon lumen. Therefore, we think that the microballoon needs to be improved in order to inflate more gradually, however we experienced a sufficient learning curve for using the microballoon catheter and an aneurysmal dilatation due to the overinflation rarely occurred in our recent cases. Moreover, careful inflation of the microballoon to a suitable size in order to occlude the aimed vessel under fluoroscopy guidance is important to avoid aneurysmal dilatation due to overinflation of the microballoon.

In our study, warmed MPT/LPD was chosen as the anticancer agent of B-TACE for most patients. Various anticancer agents have been used as TACE agents for HCC. However, the most effective and least toxic TACE protocol for HCC has yet to be identified (5–7). MPT is a lipophilic platinum complex and 1,2-diaminocyclohexane platinum (II) dichloride, the active platinum compound binding to the nuclear DNA of tumor cells causing cytotoxicity, is gradually released from MPT/LPD accumulated in the tumor (8–11). Kora et al. (12,13) found that the viscosity of MPT/LPD warmed to 40°C decreased by half compared to that at room temperature, and that TACE using warmed MPT/LPD had better short-term local therapeutic effects.

In our results, B-TACE produced elevations of serum AST and ALT levels up to CTCAE grade 3 or grade 4 in 52% and 19% of cases, respectively. Transient elevations of the serum transaminase levels are commonly observed following TACE using other anticancer agents (14–17). Moreover, there were no significant differences in any of the parameters in our results, meaning that liver function recovered after B-TACE within four weeks in almost all patients.

There are some limitations to the present study, the first being its retrospective nature. Second, this study was limited by its small sample size. Third, we did not include the local control rate of HCC nodule by B-TACE at this moment, because this present study was evaluated in a retrospective manner and the clinical follow-up schedules were different among hepatologists. Last, we could not confirm the safety issues of B-TACE with other anticancer drugs except in the case of using MPT/LPD, because MPT/LPD was chosen as the anticancer agent of B-TACE for most patients in this study. Further prospective studies are needed to prove the efficacy of this new strategy; however, to the best our knowledge, the present study is the first work that shows the technical feasibility and safety of B-TACE using a less invasive 1.8-Fr tip microballoon catheter.

In conclusion, a newly developed 1.8-Fr tip microballoon catheter enables selective catheterization in patients with HCC and B-TACE using the 1.8-Fr tip microballoon catheter is a safe procedure.

Acknowledgments

We would like to thank Prof. Tetsuya Suzuki, Prof. Atsushi Hotta and their students of the Department of Mechanical Engineering, Keio University, for their help in the creation some of the figures.

Declaration of interest: The authors report no conflict of interest.

References

1. Irie T, Kuramochi M, Takahashi N. Dense accumulation of lipiodol emulsion in hepatocellular carcinoma nodule during selective balloon-occluded transarterial chemoembolization: measurement of balloon-occluded arterial stump pressure. Cardiovasc Intervent Radiol. 2013;36:706–13.
2. Mondazzi L, Bottelli R, Brambilla G, Rampoldi A, Rezakovic I, Zavaglia C, et al. Transarterial oily chemoembolization for the treatment of hepatocellular carcinoma: a multivariate analysis of prognostic factors. Hepatology. 1994;19:1115–23.
3. Takayasu K, Muramatsu Y, Maeda T, Iwata R, Furukawa H, Muramatsu Y, et al. Targeted transarterial oily chemoembolization for small foci of hepatocellular carcinoma using a unified helical CT and angiography system: analysis of factors affecting local recurrence and survival rates. AJR Am J Roentgenol. 2001;176:681–8.
4. Miyayama S, Matsui O, Yamashiro M, Ryu Y, Kaito K, Ozaki K, et al. Ultraselective transcatheter arterial chemoembolization with a 2-f tip microcatheter for small hepatocellular carcinomas: relationship between local tumor recurrence and

visualization of the portal vein with iodized oil. J Vasc Interv Radiol. 2007;18:365–76.
5. Ikeda M, Maeda S, Ashihara H, Nagahama H, Tanaka M, Sasaki Y. Transcatheter arterial infusion chemotherapy with cisplatin-lipiodol suspension in patients with hepatocellular carcinoma. J Gastroenterol. 2010;45:60–7.
6. Kamada K, Nakanishi T, Kitamoto M, Aikata H, Kawakami Y, Ito K, et al. Long-term prognosis of patients undergoing transcatheter arterial chemoembolization for unresectable hepatocellular carcinoma: comparison of cisplatin lipiodol suspension and doxorubicin hydrochloride emulsion. J Vasc Interv Radiol. 2001;12:847–54.
7. Marelli L, Stigliano R, Triantos C, Senzolo M, Cholongitas E, Davies N, et al. Transarterial therapy for hepatocellular carcinoma: which technique is more effective? A systematic review of cohort and randomized studies. Cardiovasc Intervent Radiol. 2007;30:6–25.
8. Hanada M, Baba A, Tsutsumishita Y, Noguchi T, Yamaoka T, Chiba N, et al. Intra-hepatic arterial administration with miriplatin suspended in an oily lymphographic agent inhibits the growth of tumors implanted in rat livers by inducing platinum-DNA adducts to form and massive apoptosis. Cancer Chemother Pharmacol. 2009;64:473–83.
9. Ikeda K, Okusaka T, Ikeda M, Morimoto M. Transcatheter arterial chemoembolization with a lipophilic platinum complex SM-11355(miriplatin hydrate)–safety and efficacy in combination with embolizing agents. Gan To Kagaku Ryoho. 2010;37:271–5.
10. Kishimoto S, Noguchi T, Yamaoka T, Fukushima S, Takeuchi Y. In vitro release of SM-11355, cis[((1R,2R)-1,2-cyclohexanediamine-N,N')bis(myristato)] platinum(II) suspended in lipiodol. Biol Pharm Bull. 2000;23:637–40.
11. Okusaka T, Okada S, Nakanishi T, Fujiyama S, Kubo Y. Phase II trial of intra-arterial chemotherapy using a novel lipophilic platinum derivative (SM-11355) in patients with hepatocellular carcinoma. Invest New Drugs. 2004;22:169–76.
12. Kora S, Urakawa H, Mitsufuji T, Osame A, Higashihara H, Ohki T, et al. Warming effect on miriplatin-lipiodol suspension for potential use as a chemotherapeutic agent for transarterial chemoembolization of hepatocellular carcinoma: In vitro study. Hepatol Res. 2013;43:1100–4.
13. Kora S, Urakawa H, Mitsufuji T, Osame A, Higashihara H, Yoshimitsu K. Warming effect on miriplatin-lipiodol suspension as a chemotherapeutic agent for transarterial chemoembolization for hepatocellular carcinoma: preliminary clinical experience. Cardiovasc Intervent Radiol. 2013;36:1023–9.
14. Ikeda M, Maeda S, Shibata J, Muta R, Ashihara H, Tanaka M, et al. Transcatheter arterial chemotherapy with and without embolization in patients with hepatocellular carcinoma. Oncology. 2004;66:24–31.
15. Kawamura Y, Ikeda K, Hirakawa M, Hosaka T, Kobayashi M, Saitoh S, et al. Efficacy of platinum analogue for advanced hepatocellular carcinoma unresponsive to transcatheter arterial chemoembolization with epirubicin. Hepatol Res. 2009;39:346–54.
16. Ono Y, Yoshimasu T, Ashikaga R, Inoue M, Shindou H, Fuji K, et al. Long-term results of lipiodol-transcatheter arterial embolization with cisplatin or doxorubicin for unresectable hepatocellular carcinoma. Am J Clin Oncol. 2000;23:564–8.
17. Yodono H, Matsuo K, Shinohara A. A retrospective comparative study of epirubicin-lipiodol emulsion and cisplatin-lipiodol suspension for use with transcatheter arterial chemoembolization for treatment of hepatocellular carcinoma. Anticancer Drugs. 2011;22:277–82.