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Catheter-tip fixation of a percutaneously implanted port-catheter system to prevent dislocation

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Abstract The aim of this study was to evaluate the incidence of catheter tip dislocation in patients with percutaneously implanted port-catheters for hepatic arterial chemotherapy with catheter tip fixation. Forty-seven patients (31 men and 16 women; mean age 66 years) with unresectable advanced liver cancers (primary liver cancer, $n = 19$; metastatic liver cancer, $n = 28$) underwent percutaneously implantable port-catheter system placement with the tip fixed at the gastroduodenal artery with coils and side hole opened at the common hepatic artery. In 39 patients, n-butyl cyanoacrylate (NBCA) mixed with Lipiodol was added for fixation. The position of the side hole after the indwelling port-catheter system was investigated, and the correction method in cases with catheter dislocation was determined. In 2 (25%) of the 8 patients without NBCA fixation, dislocation of the catheter was noted, in contrast to none (0%) of 37 patients with NBCA fixation. Two patients in whom NBCA was used could not undergo long-term intra-arterial chemotherapy because of hepatic arterial thrombotic occlusion which occurred after placement of the indwelling catheter, and were excluded from the evaluation. Fixation of the catheter tip with combined use of coils and NBCA–Lipiodol mixture to the gastroduodenal artery is important to prevent dislocation of the port-catheter system.

Keywords Indwelling catheters · Hepatic artery · Intra-arterial infusion · Interventional radiology

Introduction

Repeated hepatic arterial infusion chemotherapy via an implanted port-catheter system has found widespread acceptance as one therapy for patients with unresectable advanced liver malignancies [1, 2, 3, 4, 5, 6]; however, hepatic arterial occlusion, which is one of the most frequent complications [6, 7, 8, 9], often interferes with effective hepatic arterial infusion chemotherapy. In previous non-randomized trials, the incidence of arterial thrombosis in surgically placed port catheters as opposed to percutaneously placed ports has been controversial. Although data from prospective, randomized trials are missing, some studies indicate a higher rate of thrombosis for percutaneous port-catheter insertion [10, 11]. One main cause of hepatic arterial occlusion is considered to be thrombotic occlusion due to stimulation of the vascular endothelium caused by movement of the tip of the indwelling catheter located at the common or proper hepatic artery [11]. Recently, development of methods to fix the distal tip of the indwelling catheter [11, 12, 13, 14] has decreased the rate of hepatic arterial occlusion [13], making long-term hepatic arterial infusion chemotherapy using an implanted port-catheter system inserted percutaneously possible [4, 11, 13]. Moreover, the problem of dislocation of the indwelling catheter can also be resolved by fixing the distal tip of the indwelling catheter [14]. However, paralleling the

increase in our experience of implanting port-catheter systems with the distal tip of the indwelling catheter fixed, cases of dislocation, although few, have been seen.

In this paper we evaluate catheter dislocation after fixation of the catheter tip with coils as opposed to fixation with coils and n-butyl cyanoacrylate (NBCA).

Materials and methods

During a 24-month period (from April 1998 to March 2000), 47 patients (31 men and 16 women; mean age 66 years, age range 41–83 years) with unresectable advanced liver cancers underwent percutaneously implantable port-catheter system placement with the tip fixed at the gastroduodenal artery with embolic agents and a side hole opened at the common hepatic artery to administer hepatic arterial infusion chemotherapy. Nineteen patients had primary liver cancers and 28 patients had metastatic liver cancers that originated from colo-rectal cancer ($n = 10$), breast cancer ($n = 6$), gastric cancer ($n = 6$), lung cancer ($n = 3$), pancreatic cancer ($n = 1$), ovarian cancer ($n = 1$), and jejunal cancer ($n = 1$). In all patients, diffuse or multiple (more than five) malignant lesions, or a few huge malignant lesions, were seen in both the right and left lobes of the liver, making surgical resection impossible. In addition, most patients had been administered systemic chemotherapy or other interventional treatments, only to develop intractable disease.

Procedures

Percutaneous placement of long-term indwelling catheters was performed for frequent arterial infusion chemotherapy according to the procedure of Arai et al. [12] as follows:

1. A 5-F catheter (Clinical Supply, Gifu, Japan) was inserted from the left subclavian artery or a branch of the right femoral artery, both of which were exposed surgically under local anesthesia, and advanced to the common hepatic artery via the celiac artery. In some cases a second 5-F catheter (Clinical Supply) was inserted via the femoral artery during the same procedure. Next, celiac and/or common hepatic arteriography was performed to delineate the precise anatomy.
2. A micro-catheter (Renegade-18, Boston Scientific, Watertown, Mass.) was inserted coaxially, and then the posterosuperior pancreaticoduodenal and right gastric arteries were embolized with micro-coils (Diamond Coil, Boston Scientific) to prevent infusion into adjacent organs of the chemotherapeutic agents.
3. Using the catheter-exchange method, an indwelling catheter with a side hole was inserted with the tip into the gastroduodenal artery approximately 5–10 cm from the bifurcation. The side hole was placed into the common hepatic artery at a site just proximal to the bifurcation where the gastro-duodenal artery diverged. The location of the side hole was confirmed by test injection of contrast material to keep a sufficient distance from the celiac axis to prevent regurgitation of contrast material into the left gastric artery and splenic artery.
4. The distal lumen of the indwelling catheter was occluded with a 1.2-cm micro-coil (Hilal Embolization Microcoils, Cook Europe, Bjaeverskov, Denmark) through a coaxial micro-catheter (Renegade-18, Boston Scientific) advanced inside the catheter beyond the created side hole.
5. The gastroduodenal artery was embolized with stainless steel coils (Embolization Coils, Cook, Bloomington, Ind.) through a second 5-F catheter (Clinical Supply) inserted via the femoral artery, or with micro-coils (Diamond Coil, Boston Scientific) through the micro-catheter inserted through the side hole of the indwelling catheter coaxially to prevent catheter dislocation. The number and size of the coils were decided according to the speed of the blood flow and the diameter of the vessel lumen, respectively. Embolization was performed until stasis of blood flow in the gastroduodenal artery was confirmed.
6. After creating large comfortable curves in the aorta to give the indwelling catheter some leeway to adjust, the proximal end of the indwelling catheter was connected to a port system (Septum Port, Sumitomo Bakelite, Akita, Japan), and the port was implanted in the subcutaneous space adjacent to the skin incision. A polyurethane-covered catheter with tapered tip (the outer diameter being 5-F in the shaft and 2.7-F at the tip, the inner diameter being 0.035-in. in the shaft and 0.018 in. at the tip; Anthron P-U catheter, Toray Medical, Tokyo, Japan) was used as the indwelling catheter, and a side hole was created at the region where the diameter was tapered by chipping the indwelling catheter using small scissors after folding the indwelling catheter. The length between the side hole and distal end of the indwelling catheter was designed using a celiac arteriogram, and the redundant distal part of the catheter tip was cut off using small scissors.

For fixation of the distal tip of the indwelling catheter, micro-coils and/or stainless steel coils were used in all patients and in the final 39 patients after we had noted the effectiveness of NBCA to fix the catheter tip, 0.5–1.5 ml of NBCA (Histoacryl-Blue, Braun, Melsungen, Germany) mixed with Lipiodol (Laboratoire Guerbet, Roissy, France) was added (Fig. 1). The way to mix them was as follows: Firstly, NBCA was aspirated into a syringe, then Lipiodol was aspirated into the same syringe after changing the syringe needle, and finally the operator shook the syringe by hand. The NBCA:Lipiodol ratio was 1:1.5–2.0. The volume and rate of the NBCA and Lipiodol mixture were carefully regulated to prevent overflow of NBCA into the hepatic arteries. A few seconds after NBCA–Lipiodol was infused from the micro-catheter, the catheter was promptly withdrawn to prevent fixation of the micro-catheter tip in the artery. The selected access was the left subclavian artery in 44 patients and a branch of the right femoral artery in 3 patients.

All patients were examined by digital subtraction angiography and helical CT obtained after contrast material was infused via the port to confirm the patency of the hepatic artery and good distribution of the contrast material to the whole liver and to rule out extra-hepatic infusion, 5–7 days after implanting the catheter-port system and every 2–3 months thereafter. Informed consent from all the patients and approval by the institutional ethical committee were obtained before the start of the study.

Investigated parameters

In patients with indwelling catheters placed with the tip fixed to the gastroduodenal artery, any movement of the implanted catheter side hole was investigated, and for cases with dislocation re-intervention after this complication was examined.

Results

As of June 2000, 15 of 47 patients had died, the survival period from the time of port-catheter-system placement ranging from 2 to 15 months (mean 5.7 months). The observation period of the 32 surviving patients from the

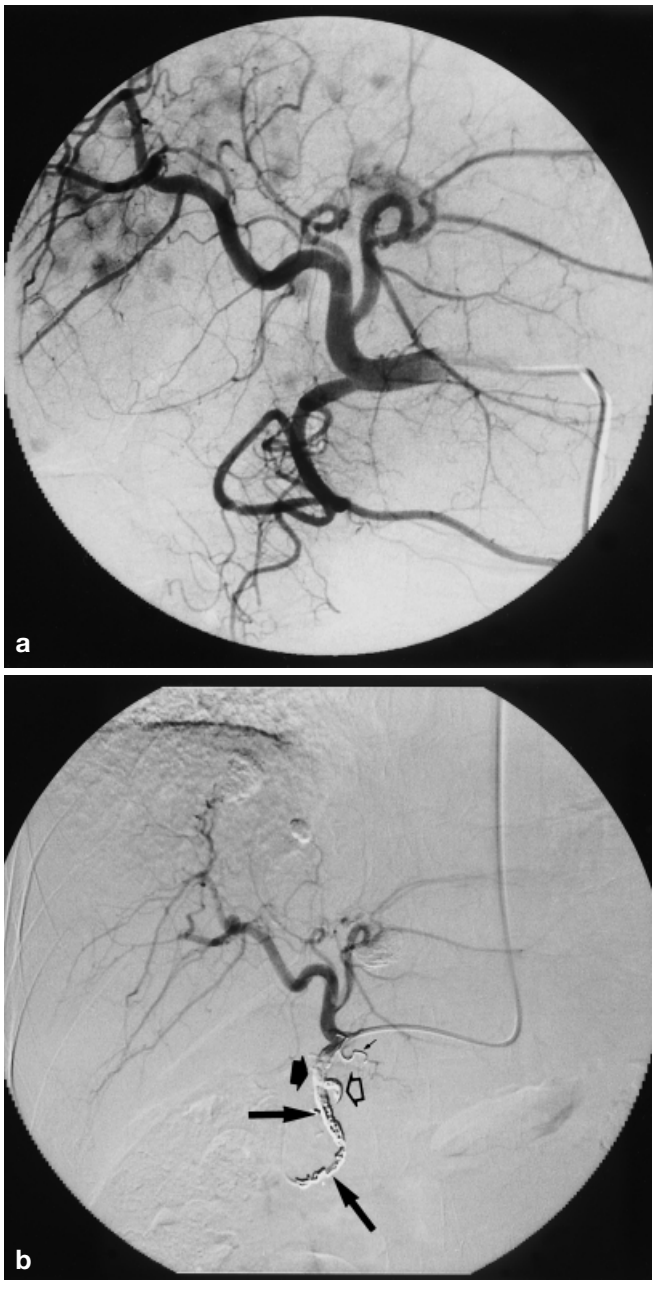

Fig. 1 a, b A 66-year-old man with advanced hepatocellular carcinoma. **a** Common hepatic arteriography before implantation of port-catheter system. **b** Arteriography via the port obtained just after implanting the port-catheter system shows that the indwelling port-catheter system is precisely implanted percutaneously, and all hepatic arterial branches are shown. The distal tip of the catheter is fixed to the gastroduodenal artery with six micro-coils *(large arrows)* and NBCA–Lipiodol mixture *(black arrowhead)*. The distal lumen of the indwelling catheter was occluded with a micro-coil. Note that the right gastric artery *(small arrow)* and the posterosuperior pancreaticoduodenal artery *(white arrowhead)* are embolized with micro-coils and that the right gastric artery is still visualized at this time but 1 week later has disappeared on the arteriography via the port

time of port-catheter-system placement ranged from 3 to 17 months (mean 8.8 months).

All patients were successfully implanted with the port-catheter system. The mean required time for all these procedures was 122 min (range 65–180 min). In the first 8 patients the catheter tip was fixed with the use of coils alone in the gastroduodenal artery, whereas in the final 39 coils and NBCA–Lipiodol mixture were used; however, hepatic arterial occlusion occurred in 2 patients, 10 days and 2 months, respectively, after placement of the port-catheter system fixed with coils and NBCA–Lipiodol. Despite attempts with various thrombolytic methods, these hepatic arterial occlusions could not be successfully treated. Both were right hepatic arterial occlusions, although tumor lesions were located mainly in the right lobe. Thus, further hepatic arterial chemotherapy was not attempted. These 2 patients were excluded from the subjects for the evaluation because follow-up digital subtraction angiography and CT were not obtained after hepatic arterial occlusion. Port-catheter occlusion was seen in no patients. The complications caused directly by the interventional procedures, other than hepatic arterial occlusion and catheter dislocation, were minor.

In 2 (4.4 %) of the evaluated 45 patients, dislocation of the side hole of the implanted catheter was seen (Figs. 2, 3) and was noted at the time of the first digital subtraction angiography obtained after contrast material was infused via the port performed within 1 week after the placement of the port-catheter system in both cases. In both patients the side hole had moved distally, and there had occurred a re-canalization of the gastroduodenal artery because this artery was not occluded completely despite of implantation of coils. NBCA mixed with Lipiodol was not used for the fixation of the catheter tip in either case with catheter dislocation. Thus, in 2 (25 %) of 8 cases without fixation of the catheter tip at the gastroduodenal artery with NBCA–Lipiodol, the side hole moved in contrast to none of 37 patients with fixation using NBCA–Lipiodol. According to the statistical analysis, dislocation of the side hole was seen at a significantly higher rate in the cases with fixation of the catheter tip without NBCA–Lipiodol ($p < 0.01$, chi-square test for independence).

For the cases with dislocation of the side hole, re-interventional procedure was performed as follows:

1. A 5-F hook catheter was inserted from the right femoral artery.
2. The inserted catheter was wound to the indwelling catheter while being pushed up proximally.
3. The side-hole position was confirmed to be re-located in the common hepatic artery by test injection of contrast material infused via the port. In 1 case, in addition to these procedures, fixation of the indwelling catheter tip at the gastroduodenal artery was

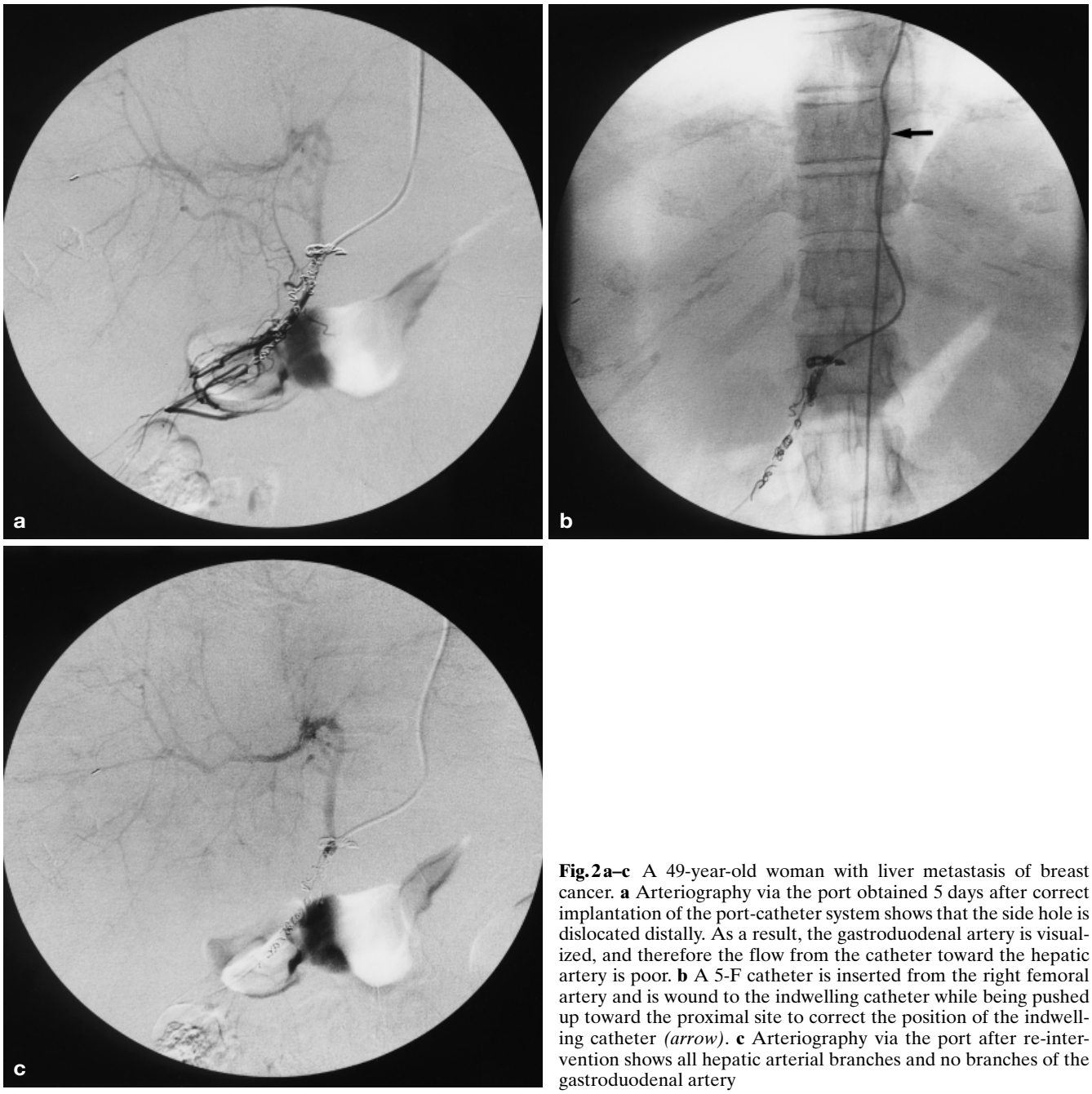

Fig. 2 a–c A 49-year-old woman with liver metastasis of breast cancer. **a** Arteriography via the port obtained 5 days after correct implantation of the port-catheter system shows that the side hole is dislocated distally. As a result, the gastroduodenal artery is visualized, and therefore the flow from the catheter toward the hepatic artery is poor. **b** A 5-F catheter is inserted from the right femoral artery and is wound to the indwelling catheter while being pushed up toward the proximal site to correct the position of the indwelling catheter *(arrow)*. **c** Arteriography via the port after re-intervention shows all hepatic arterial branches and no branches of the gastroduodenal artery

added using 0.6 ml of NBCA–Lipiodol mixture through the micro-catheter advanced through the 5-F catheter, with the tip located at the celiac artery, coaxially (Fig. 3). These re-interventions in cases with catheter dislocation resulted in the ability to administer repeated hepatic arterial infusion chemotherapy via the implanted port-catheter system at the outpatient clinic in all cases, until the death of the patient or to date in the currently surviving patients.

Discussion

Hepatic arterial infusion chemotherapy is one of the treatments of choice for unresectable advanced liver cancers, for which systemic chemotherapy or other interventional therapies are not effective [1, 2, 3, 4]. In the past, anti-cancer drugs were infused via a catheter with its tip located at the hepatic artery via the gastroduodenal artery exposed at surgical laparotomy under general

Fig. 3 a–d A 58-year-old man with advanced hepatocellular carcinoma. **a** Arteriography via the port obtained 7 days after correct implantation of the port-catheter system shows that the side hole is dislocated distally and the gastroduodenal artery is visualized, whereas visualization of the right hepatic branches is poor. Note that the micro-coils inserted at the replaced right hepatic artery to convert two hepatic arteries into a single vascular supply are seen *(arrows)*. **b** A 5-F catheter is inserted from the right femoral artery and is wound to the indwelling catheter while being pushed up proximally to correct the position of the indwelling catheter. Arteriography via the port shows no visualization of the gastroduodenal artery. **c** Superior mesenteric arteriography shows recanalization of the replaced right hepatic artery. **d** Arteriography via the port obtained after correcting the indwelling catheter dislocation and re-embolization of the replaced right hepatic artery shows visualization of all hepatic branches and no extra-hepatic arteries. The NBCA–Lipiodol mixture added to fix the indwelling catheter tip through the micro-catheter coaxially advanced via the 5-F catheter, whose tip is located at the celiac artery, is seen *(arrow)*

anesthesia [5, 6, 15]; however, the recent development of interventional techniques has made it possible to implant port-catheter systems percutaneously under local anesthesia [3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17]. Thus, attention has come to be paid to hepatic arterial infusion chemotherapy which can be performed repeatedly at the outpatient clinic via a percutaneously implanted port-catheter system for patients with advanced liver cancer as one effective treatment from the point of view of prolonging normal-quality survival [2]. Prolongation of the survival period and the actual improvement of quality of life in patients undergoing this therapy are controversial [1, 2, 6]. Also in the present cases, the mean survival period of the treated but already dead patients was short, i.e., 5.7 months, whereas the mean observation period from placement of the indwelling catheter of the surviving cases is relatively long (mean 8.8 months).

Among various methods to implant port-catheter systems using interventional techniques [7, 8, 9, 10, 12, 16, 17], the procedure of Arai et al. [12] (which we employ), in which the distal tip of the implanted catheter is fixed at the gastroduodenal artery and the created side hole is precisely positioned at the common hepatic artery, is of advantage in performing long-term infusion chemotherapy because the frequency of hepatic arterial occlusion is low, occurring in only 5.3 % of 115 patients [13]. Although a few reports of indwelling port-catheter systems using other interventional procedures showed a lower frequency of hepatic arterial occlusion [10, 16, 17], the numbers of subjects in these reports were much smaller than in that of Arai et al. [12]. According to Seki et al. [11], hepatic artery patency was statistically higher in the group in which port-catheter systems were implanted by Arai's method than in that in which the catheter tip was placed in the proper or common hepatic artery without fixation of the catheter tip. This result leads us to speculate that one main cause of hepatic arterial thrombotic occlusion is mechanical stimulation to the vascular wall of the common or proper hepatic artery by movement the catheter tip, if it is not fixed. However, hepatic arterial occlusion due to other mechanisms, such as chemical stimulation of anti-cancer drugs and foreign body material with increased thrombogenicity, cannot be prevented even with fixation of the catheter tip. Paralleling the increase in the number of cases in which hepatic arterial occlusion is prevented, the therapeutic effect obtainable by repeated arterial infusion chemotherapy for advanced liver cancers, especially for some types of liver metastasis, has improved [3, 4].

To achieve such a good effect, long-term repetition of infusion chemotherapy without difficulties related to the port-catheter system, such as dislocation, is necessary. In the most common interventional procedure, in which the indwelling catheter tip is positioned in the proper or the common hepatic artery, indwelling catheter dislocation occurs at a relatively high rate (6–18 %) [7, 10, 16, 17]. On the other hand, the method which we chose is theoretically less subject to dislocation because the distal tip of the catheter is tightly fixed to the gastroduodenal artery, although in practice, dislocation of the side hole to the distal site occurred in 4.4 % of cases in the present study. The fact that dislocation was not seen in cases with the catheter tip fixed with the combination of stainless coils and NBCA–Lipiodol mixture, but only in those in which the NBCA–Lipiodol mixture was not used, led us to suggest that just after indwelling port-catheter placement the shape of the catheter is changeable, and insufficient fixation of the catheter tip may promote its dislocation. The present study also suggests that even if the indwelling catheter dislocates, planned intra-arterial infusion chemotherapy can be performed without problem if the dislocation is corrected using comparatively easy interventional techniques.

NBCA is widely used as a permanent embolic agent especially in the field of intracerebral interventional radiology including embolization of arteriovenous malformation [18, 19]. By adding Lipiodol to the NBCA, the embolized vessel can be visualized. And the adhesion time can be flexibly adjusted according to the rate of mixed Lipiodol.

The limitation of the catheter tip fixation technique is the inability to safely withdraw the catheter. If either the patient or the referring physician wants the catheter to be retracted at some point during the follow-up or after successful treatment of hepatic malignant lesions, this is impossible.

In conclusion, although fixation of the catheter tip with combined use of coils and NBCA–Lipiodol mixture to the gastroduodenal artery was developed out of consideration of the complication of hepatic arterial occlusion, it has proved to be also useful from the standpoint of prevention of catheter dislocation.

References

1. Lorenz M, Muller HH (2000) Randomized, multicenter trial of fluorouracil plus leucovorin administered either via hepatic arterial or intravenous infusion versus fluorodeoxyuridine administered via hepatic arterial infusion in patients with nonresectable liver metastases from colorectal carcinoma. J Clin Oncol 18: 243–254
2. Allen-Mersh TG, Earlam S, Fordy C, Abrams K, Houghton J (1994) Quality of life and survival with continuous hepatic-artery floxuridine infusion for colorectal liver metastasis. Lancet 344: 1255–1260
3. Arai Y, Endo T, Sone Y et al. (1992) Management of patients with unresectable liver metastasis from colorectal and gastric cancer employing an implantable port system. Cancer Chemother Pharmacol 31 (Suppl): S99–S102

4. Arai Y, Matseda K, Inaba Y, Aramaki T, Yamaura H, Dendo S, Tanaka T (1999) Hepatic arterial infusion chemotherapy (HAIC) for liver metastasis: new concept led by interventional radiology. Cardiovasc Intervent Radiol 22 (Suppl)1:S45
5. Valeri A, Mini E, Tonelli P, Veneri F, Neri B, Borrelli D, Mazzei T (1994) Intra-arterial hepatic chemotherapy with 5-Fluorouracil and 5-Methyltetrahydrofolate in the treatment of unresectable liver metastases from colorectal cancer. Anticancer Res 14: 2215–2220
6. Rougier P, Laplanche A, Huguier M et al. (1992) Hepatic arterial infusion of floxuridine in patients with liver metastases from colorectal carcinoma: long-term results of a prospective randomized trial. J Clin Oncol 10: 1112–1118
7. Wacker FK, Boese-Landgraf J, Wagner A, Albrecht D, Wolf K-J, Fobbe F (1997) Minimally invasive catheter implantation for regional chemotherapy of the liver: a new percutaneous transsubclavian approach. Cardiovasc Intervent Radiol 20: 128–132
8. Clouse ME, Ahmed R, Ryan RB, Oberfield RA, McCaffrey JA (1977) Complications of long term transbrachial hepatic arterial infusion chemotherapy. AJR 129: 799–803
9. Oberfield RA, McCaffrey JA, Polio J, Clouse ME, Hamilton T (1979) Prolonged and continuous percutaneous intra-arterial hepatic infusion chemotherapy in advanced metastatic liver adenocarcinoma from colorectal primary. Cancer 44: 414–423
10. Herrmann KA, Waggershauser T, Sittek H, Reiser MF (2000) Liver intraarterial chemotherapy: use of the femoral artery for percutaneous implantation of catheter-port systems. Radiology 215: 294–299
11. Seki H, Kimura M, Yoshimura N, Yamamoto S, Ozaki T, Sakai K (1999) Hepatic arterial infusion chemotherapy using percutaneous catheter placement with an implantable port: assessment of factors affecting patency of the hepatic artery. Clin Radiol 54: 221–227
12. Arai Y, Inaba Y, Takeuchi Y (1997) Interventional techniques for hepatic arterial infusion chemotherapy. In: Castaneda-Zuniga WR (ed) Interventional Radiology, 3rd edn. Williams and Wilkins, Baltimore, Maryland, pp 192–205
13. Takeuchi Y, Arai Y, Inaba Y et al. (1996) A new percutaneous catheterization "side-holed catheter placement with fixation" for a long term arterial chemotherapeutic infusion: its effectiveness to prevent hepatic arterial occlusion. Japan J Interv Radiol 11: 471–476 (in Japanese)
14. Shindoh N, Ozaki Y, Kyogoku S, Yamana D, Sumi Y, Katayama H (1999) Stabilization of a percutaneously implanted port-catheter system for hepatic artery chemotherapy infusion. Cardiovasc Intervent Radiol 22: 344–347
15. Huk I, Entsheff P, Prager M, Schulz F, Polterauer P, Funovics J (1990) Patency rate of implantable devices during long-term intraarterial chemotherapy. Angiology 41: 936–941
16. Germer CT, Boese-Landgraf J, Albrecht D, Wagner A, Wolf KJ, Buhr HJ (1996) The totally implantable minimally invasive hepatic arterial catheter for intraarterial chemotherapy of unresectable liver metastasis in cases of dysfunction of arterial access devices. Chirurg 67: 458–462
17. Strecker E-PK, Boos IBL, Ostheim-Dzerowycz W, Heber R, Vetter SC (1997) Percutaneously implantable catheter-port system: preliminary technical results. Radiology 202: 574–577
18. Han MH, Seong SO, Kim HD, Chang KH, Yeon KM, Han MC (1999) Craniofacial arteriovenous malformation: preoperative embolization with direct puncture and injection of n-butyl cyanoacrylate. Radiology 211: 661–666
19. Debrun GM, Aletich V, Ausman JI, Charbel F, Dujovny M (1997) Embolization of the nidus of brain arteriovenous malformations with n-butyl cyanoacrylate. Neurosurgery 40: 112–121