Surg Today (2005) 35:765–769
DOI 10.1007/s00595-005-2993-8

SURGERY TODAY

Case Reports

Percutaneous Right Portal Vein Embolization with Polyvinyl Alcohol Particles in Gastric Cancer Metastasis: Report of a Case

RAMAZAN KUTLU[1], KAYA SARAC[1], SEZAI YILMAZ[2], VEDAT KIRIMLIOGLU[2], TAMER BAYSAL[1], ALPAY ALKAN[1], and AHMET SIGIRCI[1]

Departments of [1]Radiology and [2]General Surgery, Inonu University School of Medicine, Turgut Ozal Medical Center, 44069 Malatya, Turkey

Abstract
Polyvinyl alcohol (PVA) particles are used for the embolization of various vascular tumors. They are also used before hepatic resection to embolize the ipsilateral portal vein, causing hypertrophy of the remaining liver. We report our first experience with portal vein embolization (PVE) with PVA particles to treat gastric cancer metastasis to the liver. PVE with PVA is a safe interventional radiologic procedure, which does not cause problems during surgery and can improve the outcome of hepatic resection.

Key words Portal vein embolization · Polyvinyl alcohol · Liver · Metastasis

Introduction

Mortality after major hepatectomy has decreased remarkably as a result of advances in surgery, but the morbidity related to the size and function of the remaining liver is still a major problem. Portal vein embolization (PVE) has been shown to be an effective way of promoting contralateral hypertrophy of the remnant liver to prevent complications resulting from hepatectomy.[1,2] Percutaneous transhepatic portal embolization (PTPE) is an important interventional radiologic procedure to overcome these problems. We report a case of gastric cancer metastasis to the right lobe of the liver, which was treated with PTPE with polyvinyl alcohol (PVA) before right hemihepatectomy.

Reprint requests to: R. Kutlu
Received: July 12, 2002 / Accepted: October 1, 2004

Case Report

A 48-year-old man underwent an upper gastrointestinal endoscopy for stomach pain and weight loss, which revealed infiltration of the antrum, angulus, and pylorus by a hard, irregular, and ulcerated mass. Endoscopic biopsy showed well-differentiated intestinal-type adenocarcinoma. The patient was referred to our surgical clinic and underwent a subtotal gastrectomy with gastroenterostomy, Braun anastomosis, and appendectomy. He was discharged on postoperative day 10 after an uneventful postoperative course. He also received six cycles of ELF (Etoposide 200 mg + leucoverin 500 mg + 5-FU 900 mg) chemotherapy. About 9 months later, an abdominal ultrasonography (USG) showed multiple metastases in the right lobe of the liver, the largest one being 8 cm in diameter. Doppler examination showed that the blood volume flow (ml/min) values of the main, right, and left portal veins were 645, 287, and 343, respectively. Computed tomography during arterial portography (CTAP) examination through the superior mesenteric artery injection revealed multiple metastases in the liver, the largest ones being located in the sixth and seventh segments, but there were also metastases in the fourth segment (Fig. 1). A right hemihepatectomy was considered, and volume calculations were made on a separate GE workstation (General Electric Medical Systems, Milwaukee, WI, USA) by manually tracing the liver contours of each slice. The measured areas were multiplied by slice thickness, to calculate the volume of each slice. The total liver volume (TLV) was calculated as 1720 cm^3 by summing all the slice volumes. The volumes of the right and left lobes were 1393 and 327 cm^3, respectively. We decided that the volume of the remaining left lobe would not be sufficient for liver function; therefore, we performed embolization of the right portal vein to promote hypertrophy of the left lobe. The patient was given 1 g of cefazolin prophylactically before the procedure. The

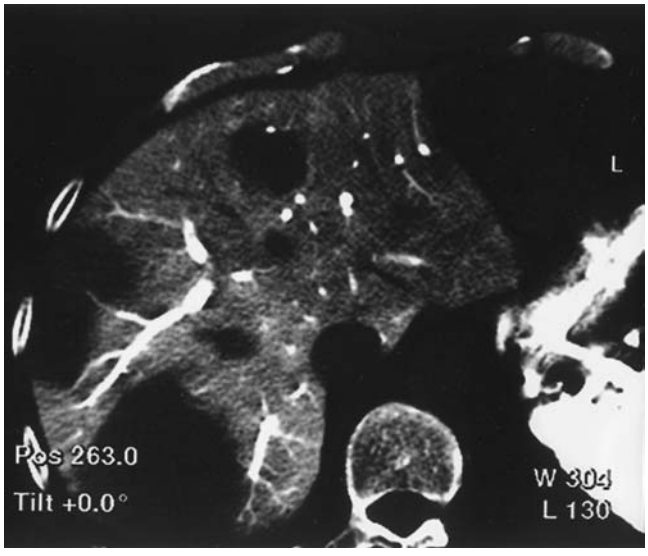

Fig. 1. A preprocedure computed tomography during arterial portography slice shows multiple metastases in segments 4, 6, and 7

anterior division of the right portal vein was accessed via a transhepatic intercostal approach by puncturing it with a 19G needle under USG guidance and inserting a 5F introducer. To achieve distal embolization, third-order branches of the right anterior and posterior branches were occluded with 200-µm PVA particles (Contour, Cook, Bloomington, IL, USA) suspended in iohexol 300 through a 4F Simmons 2 catheter. After distal embolization, larger PVA particles (300 µm) were used. A total of 150 ml of iohexol 300, and 2300 mg of 200-µm-PVA and 400 mg of 300-µm-PVA particles were used, and the right portal vein was completely embolized. We did not use anything to embolize the tract, as the sheath was withdrawn. The procedure was completed in 2 h. Portography at the end of the procedure showed no filling of the right portal vein branches (Fig. 2A–D). There was no evidence of postembolization syndrome. The patient tolerated the procedure well and was discharged after an overnight stay. By 4 weeks later, control abdominal computed tomography (CT) showed sufficient hypertrophy of the left lobe. The total hepatic volume had decreased from 1720 to 1598 cm^3. The volume of the left side of the liver had increased from 327 cm^3 (19% of TLV) to 623 cm^3

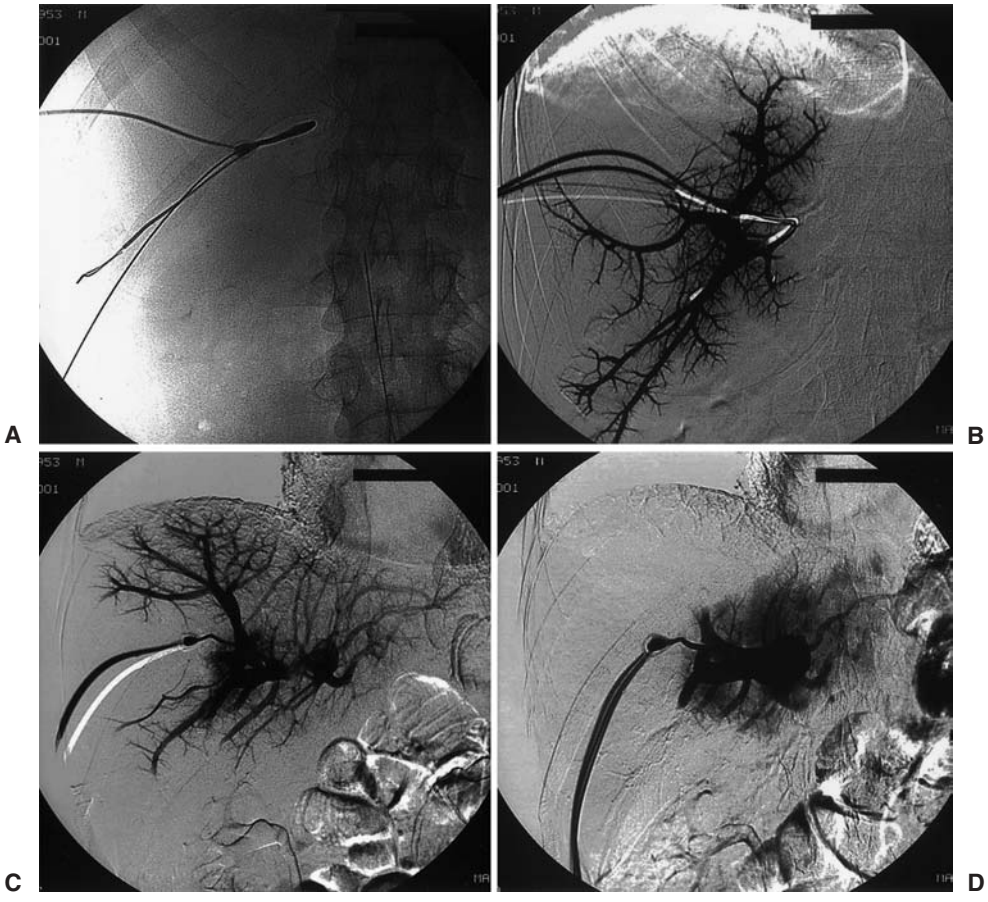

Fig. 2. A 5F introducer and guidewire was inserted percutaneously into the right portal vein (**A**). Portograms show the selective infusion of polyvinyl alcohol (PVA) through the catheter in the right anterior portal vein branch (**B**), and occlusion of the right anterior branch after PVA infusion (**C**). Portogram at the end of the procedure shows complete occlusion of the right portal vein (**D**)

(39% of TLV), whereas the volume of the right side had decreased from 1393 cm^3 (81% of TLV) to 975 cm^3 (61% of TLV). The metastases had not changed in size in the 4 weeks. A control Doppler examination confirmed the absence of blood flow in the right portal vein. The blood flow of the main and left portal veins was 582 and 536 ml/min, respectively. Thereafter, the patient underwent right hemihepatectomy and wedge resection of the tumor from segment 4. A clear demarcation was evident between the embolized right and the untreated left hemilivers. No difficulties were encountered during surgery as a result of perivascular inflammatory changes from the portal vein embolization. Pathological examination of the resected masses revealed adenocarcinoma metastasis and multinuclear giant cells inside the portal vein. Postoperative T-tube cholangiography showed patency of the common and left lobe bile ducts. There was some oozing of contrast material through the cut surface of the left lobe, which resolved in 3 weeks. Liver function test results were within normal values, and the patient was discharged without any problems. A follow-up abdominal CT scan done in the second month after the operation showed sufficient volume of the remaining liver and a 2 × 2 cm hypodense cystic area in segment 4. A fine-needle aspiration biopsy from this lesion revealed metastasis. A CTAP examination was performed, which showed another lesion next to this lesion. We performed intraoperative radiofrequency ablation of these two lesions. Intraoperative USG showed two well-defined metastases, 2 × 2 cm in size. A follow-up abdominal CT scan after radiofrequency ablation showed two hypodense necrotic areas containing air.

Discussion

The PVE technique was first described in 1986 by Kinoshita et al.[3] for patients undergoing hepatic resection for hepatocellular carcinoma, and later by Makuuchi et al.[4,5] for patients undergoing extended hepatic resections for bile duct cancer. Even though it was initially described for patients with bile duct or gallbladder cancers, the utility of this technique has been demonstrated in patients with resectable hepatocellular cancer[6] and metastatic colorectal cancer.[1,7]

Major hepatectomy has become possible through advances both in surgical techniques and interventional radiological procedures; however, some factors limit the number of patients who can benefit from this operation. One of these factors is the amount of remaining liver after hepatectomy.[1] Studies as early as 1920 showed that portal vein ligation induces ipsilateral hepatic lobe atrophy and contralateral lobe hypertrophy.[8] Although the underlying mechanisms are not well known, various hepatic and extrahepatic factors are thought to be responsible; the extrahepatic factors are primarily controlled by the portal vein.[3] Although 60% of the nontumorous liver parenchyma can be safely resected in patients with normal liver function,[9] it may be necessary to resect 60% or more of the nontumorous parenchyma in patients with metastatic disease, small tumors in proximity to major hepatic inflow or outflow vessels, metastatic deposits with unfavorable "lesion distribution," or anatomically favorable lesion distribution but small volume disease.[1] If the portal vein on the resected side is compromised by the tumor, then liver failure is not an important problem after major hepatic resection.[4] Normal hepatic function is an important issue for sufficient hypertrophy. The hypertrophy that develops after PVE is not as marked in patients with severe impairment of hepatic function as it is in those with normal hepatic function.[10]

Hepatectomy for colorectal liver metastases is often associated with good results. Conversely, liver metastases from gastric cancer are reported to have the worst prognosis among noncolorectal metastases, and curative resection is not feasible in most cases.[11] Even if the metastases are potentially resectable, surgery for liver metastases from gastric cancer is controversial owing to the reported unpredictable and rarely long-term survival rates, the aggressive biologic behavior of gastric cancer, and quality of life issues.[11–13] Surgery may be considered for some patients with liver metastases from gastric cancer (whose selection criteria are not generally accepted) if complete resection seems feasible after careful pre- and intraoperative staging and may improve their prognosis.[11,12,14] Before hepatectomy, we ruled out other sites of metastases in our patient, as previously suggested.[11,12,15] Multiple metastases, once recognized, are generally scattered throughout both lobes of the liver, as they were in our patient, who had additional metastases in segment four. However, we decided to perform hepatectomy based on other reports that the number of hepatic metastases is of little importance as a prognostic indicator, and that hepatectomy should not be abandoned simply because multiple tumors are present in the liver, considering the high survival rates achieved by complete resection.[11–13]

Gelfoam,[4,5,7] PVA particles,[1] various cyanoacrylate[7] and fibrin glues,[16,17] absolute ethanol,[6,18] and stainless steel coils[18] are used for the embolization of vessels. Most of these agents have been used for PTPE, but there is still no consensus about which agent or combination of agents is best for this procedure. Ideally, the agent should induce complete and durable obstruction of the portal vein and its branches, with little possibility of recanalization; be widely available and easy to administer; be able to deliver the embolic material from an ipsilateral approach to diminish the likelihood of injury

or occlusion to the contralateral portal vein; not cause any inflammatory reaction that may render surgical dissection at the hilus difficult; not cause damage to any nontarget portal vessels; not induce hepatic necrosis or postembolization clinical syndrome; and not cause postembolization syndrome.[1] We used PVA particles for PTPE because they fulfil these requirements. It is important to have complete PVE without portal venous recanalization in the lobe to be resected. In a series of 13 patients who underwent right PVE with a mixture of gelatin powder, thrombin, gentamicin sulfate, and diatrizoate sodium meglumine, there was no recanalization of the embolized portal vein.[19] Cyanoacrylate has been reported to achieve better results than Gelfoam and thrombin, which may allow recanalization,[3] and the combination of PVA with coils has also been reported to achieve more permanent occlusion.[3] The PVA induced complete occlusion of the right portal vein without recanalization in our patient, as confirmed by Doppler examination.

Although little is known about the effect of PVE on blood flow and liver function, a close link between portal blood flow and liver hypertrophy after hepatectomy has been reported.[19,20] In PVE, the distribution of lobar blood flow changes drastically without an immediate change in the functional hepatic mass.[19] Doppler USG studies have shown that portal blood flow to the nonembolized lobe increases significantly, and then decreases toward the baseline but without reaching the baseline value.[20,21] This increase in the portal blood flow, which contains hepatotrophic factors such as insulin and hepatic growth factor, is presumed to trigger hypertrophy of the nonembolized lobe, and the rate of hypertrophy correlates well with the flow-rate measurements.[20–22] Doppler examination in our patient confirmed a significant increase in the blood volume flow of the left portal vein, almost reaching the value of the main portal vein. This shows that the entire portal flow is redistributed to the nonembolized left lobe, inducing adequate hypertrophy after PTPE.

Various factors are involved in the regeneration process, and sufficient hypertrophy of the liver may be seen within 2 weeks.[17] Since this was our first case, we waited 4 weeks before performing resection to ensure maximum benefit from the procedure, and postembolization syndrome did not occur. Although the condition of the patient improves after resection, the metastatic process does not cease. In fact, recurrence after hepatic resection develops in approximately 70% of patients with liver metastasis from gastric cancer, most commonly again in the liver.[13] One study emphasized that hepatectomy for liver metastasis is like a lottery for each patient.[14] Accordingly, our patient was found to have a recurrence 2 months after hepatectomy. However, the new metastases may be treated by a combination of surgical and interventional radiological procedures, such as radiofrequency ablation.

In conclusion, PTPE with PVA is a safe interventional radiologic procedure, which does not interfere with the surgical procedure. Although the results of and indications for hepatic resection to treat gastric cancer metastasis to the liver are controversial, PTPE can improve the outcome of selected patients.

Acknowledgment. We thank Professor Ahmet Memis, M.D., of Ege University School of Medicine, Department of Radiology, Izmir, Turkey, for his encouragement and continuous support.

References

1. Brown KTM, Brody LAM, Decorato DRM, Getrajdman GIM. Portal vein embolization with use of polyvinyl alcohol particles. J Vasc Interv Radiol 2001;12:882–7.
2. Hashimoto M, Watanabe G. Changes in functional capacity after portal branch ligation in rats. Surg Today 2001;31:1065–9.
3. Abdalla EK, Hicks ME, Vauthey JN. Portal vein embolization: rationale, technique and future prospects. Br J Surg 2001;88:165–75.
4. Makuuchi M, Thai BL, Takayasu K, Takayama T, Kosuge T, Gunven P, et al. Preoperative portal embolization to increase safety of major hepatectomy for hilar bile duct carcinoma: a preliminary report. Surgery 1990;107:521–7.
5. Makuuchi M, Takayasu K, Takuma T, Takayama T, Kosuge T, Gunven P, et al. Preoperative transcatheter embolization of the portal venous branch for patients receiving extended lobectomy due to bile duct carcinoma. Nihon Rinshogeka Gakkai Zasshi 1984;45:1558–64.
6. Shimamura T, Nakajima Y, Une Y, Namieno T, Ogasawara K, Yamashita K, et al. Efficacy and safety of pre-operative percutaneous transhepatic portal embolization with absolute ethanol: a clinical study. Surgery 1997;121:135–41.
7. de Baere T, Roche A, Vavasseur D, Therasse E, Indushekar S, Elias D, et al. Portal vein embolization: utility for inducing left hepatic lobe hypertrophy before surgery. Radiology 1993;188:73–7.
8. Rous P, Larimore LD. Relation of the portal blood to liver maintenance. A demonstration of liver atrophy conditional on compensation. J Exp Med 1920;31:609–32.
9. Kubota K, Makuuchi M, Kusaka K, Kobayashi T, Miki K, Hasegawa K, et al. Measurement of liver volume and hepatic functional reserve as a guide to decision-making in resectional surgery for hepatic tumors. Hepatology 1997;26:1176–81.
10. Tanaka H, Kinoshita H, Hirohashi K, Kubo S, Fujio N, Iwasa R, et al. Preoperative percutaneous portal vein embolization to extend the indication for hepatectomy, and increase the safety of extended hepatectomy for hepatocellular cancer. Nippon Geka Gakkai Zasshi 1992;93:1317–23.
11. Zacherl J, Zacherl M, Scheuba C, Steininger R, Wenzl E, Muhlbacher F, et al. Analysis of hepatic resection of metastasis originating from gastric adenocarcinoma. J Gastrointest Surg 2002;6:682–9.
12. Kunieda K, Saji S, Sugiyama Y, Osada S, Sano J, Nagao N, et al. Evaluation of treatment for synchronous hepatic metastases from gastric cancer with special reference to long-term survivors. Surg Today 2002;32:587–93.
13. Okano K, Maeba, T, Ishimura K, Karasawa Y, Goda F, Wakabayashi H, et al. Hepatic resection for metastatic tumors from gastric cancer. Ann Surg 2002;235:86–91.

14. Elias D, Cavalcanti de Albuquerque A, Eggenspieler P, Plaud B, Ducreux M, Spielmann M, et al. Resection of liver metastases from a noncolorectal primary: indications and results based on 147 monocentric patients. J Am Coll Surg 1998;187:487–93.
15. Koide N, Watanabe H, Shimozawa N, Hanazaki K, Kajikawa S, Adachi W, et al. Four resections for hepatic metastasis from gastric cancer: histochemical analysis of cell proliferation, apoptosis, and angiogenesis. J Gastroenterol 2000;35:150–4.
16. Nagino M, Nimura Y, Kamiya J, Kondo S, Uesaka K, Kin Y, et al. Right or left trisegment portal vein embolization before hepatic trisegmentectomy for hilar bile duct carcinoma. Surgery 1995;117: 677–81.
17. Nagino M, Nimura Y, Kamiya J, Kondo S, Uesaka K, Kin Y, et al. Changes in hepatic lobe volume in biliary tract cancer patients after right portal vein embolization. Hepatology 1995;21:434–9.
18. Yamakado K, Takeda K, Nishide Y, Jin J, Matsumura K, Nakatsuka A, et al. Portal vein embolization with steel coils and absolute ethanol: a comparative experimental study with canine liver. Hepatology 1995;22:1812–8.
19. Shimada R, Imamura H, Nakayama A, Miyagawa S, Kawasaki S. Changes in blood flow and function of the liver after right portal vein embolization. Arch Surg 2002;137:1384–8.
20. Goto Y, Nagino M, Nimura Y. Doppler estimation of portal blood flow after percutaneous transhepatic portal vein embolization. Ann Surg 1998;228:209–13.
21. Madoff DC, Hicks ME, Vauthey JN, Charnsangavej C, Morello FA Jr, Ahrar K, et al. Transhepatic portal vein embolization: anatomy, indications, and technical considerations. Radiographics 2002;22:1063–76.
22. Denys AL, Abehsera M, Leloutre B, Sauvanet A, Vilgrain V, O'Toole D, et al. Intrahepatic hemodynamic changes following portal vein embolization: a prospective Doppler study. Eur Radiol 2000;10:1703–7.