CASE REPORT

Selective hypertrophy of the lobus caudatus as a novel approach enabling extended right hepatectomy in the presence of a non-perfused left lateral liver lobe

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Abstract

Introduction Portal vein embolization (PVE) is a well-established technique to enhance functional hepatic reserves of segments II and III before curative extended right hepatectomy for tumors of the right liver lobe. However, an adequate hepatopetal flow of the left lateral portal vein branches is required for a sufficient PVE-associated hypertrophy.

Case report Here, we report a 65-year old patient suffering from a locally advanced intrahepatic cholangiocarcinoma in the right liver lobe and segment IV. A curative extended right hepatectomy after preoperative PVE of liver segments IV–VIII was initially impossible because of partial thrombosis of the left lateral portal vein branches resulting in an ischemic-type atrophy of segments II and III. However, due to a massive hypertrophy of the caudate lobe following PVE of liver segments IV–VIII, subsequent extended right hepatectomy with intraoperative thrombectomy of segments II and III was made possible.

Conclusions To our knowledge this is the first case in which an extended right hepatectomy for a liver malignancy, in the presence of atrophic left lateral section, was made possible by a massive PVE-associated hypertrophy of the caudate lobe.

Keywords Extended right hepatectomy · Portal vein embolization · PVE · Cholangiocarcinoma

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Introduction

Extended right hepatectomy is required to obtain tumor-free surgical margins in up to one-third of oncological liver resections [1, 2]. However, major hepatectomies are associated with increased morbidity and mortality because of postoperative liver failure (PLF) [3, 4].

Intrahepatic cholangiocarcinoma (IHC) represents the second most common primary liver cancer and its incidence has risen over the past decades in Western countries [5]. Curative resection represents the treatment of choice for IHC, as it is the only chance of long-term survival with 5-year survival rates ranging between 21 and 35 % [6–10]. Results of radio- and conventional chemotherapy are limited with a median survival of 12 months [11–14].

Due to the mass-forming character of this tumor entity and the late onset of symptoms, patients are frequently diagnosed at an advanced tumor stage with the need of an extended right hepatectomy. In case of a predicted too low future liver remnant volume (FLRV) of left lateral liver segments II and III, the safety of major hepatic resection can be significantly improved by preoperative selective portal vein embolization (PVE) of the right liver lobe.

An adequate hepatopetal flow of the left lateral portal vein branches is required for an effective PVE-associated hypertrophy of segments II and III. Here, we report a patient with an advanced IHC in the right liver lobe and segment IV and a partial portal vein thrombosis of liver

segments II and III after selective PVE of liver segments IV–VIII resulting in an ischemic-type left lateral liver atrophy. However, extended right hepatectomy following PVE was made possible due to a massive hypertrophy of the caudate lobe.

Case report

A 65-year old female patient was referred to our center in April 2010 with a histopathologically confirmed, moderately differentiated cholangiocarcinoma of the right liver lobe and segment IV. The initial symptoms of the patient were reported as upper abdominal tension. The patient appeared to be in a good general condition and, except for a cholecystolithiasis, no further diseases were evident. The blood tests revealed elevated serum levels for carbohydrate antigen 19-9 (136 U/ml), normal findings for alpha-1-fetoprotein and carcinoembryonic antigen, and slightly elevated liver enzymes with a normal bilirubin level (Table 1).

Computed tomography (CT) of the abdomen showed a tumor spreading over liver segments IV–VIII with a maximum diameter of 9 cm (Fig. 1a). Consecutive CT volumetry of the liver revealed a total liver volume (TLV) of 1,800 cm^3 and an FLRV (liver segments I–III) of only 300 cm^3. The tumor volume was 430 cm^3. The TLV excluding tumor volume was 1,370 cm^3. This made a ratio of FLRV per TLV excluding tumor volume of 21.9 %. In addition, a preoperatively performed biopsy of the liver revealed fibrotic tissue and intracytoplasmatic siderosis. The caudate lobe and left lateral segments II and III were free of tumor. The diagnostic evaluation revealed no extrahepatic tumor manifestation. In the liver hilus, the portal vein was in direct proximity to the tumor mass. The common hepatic artery and the extrahepatic portal vein showed no abnormalities. Furthermore, the portal vein

branch to segment I diverted in direct proximity to the bifurcation of the main portal vein trunk (Fig. 1e). Due to insufficient FLRV an embolization of the portal branches to liver segments IV–VIII was performed (Fig. 1d, e). Because of an increased risk for an accidental embolization of the left-sided portal vein branches to segments II and III we did not perform initial embolization of segment I. Furthermore, an embolization of the caudate lobe would have additionally deprived the future liver remnant (FLR) from valuable healthy volume. We used non-calibrated particles to embolize the portal vein branches. Histoacryl coils or vascular plugs were also avoided because of the risk of accidental embolization of the left-sided liver segments, which might eventually compromise a successful hypertrophy and render the hepatic resection impossible.

Three weeks after embolization a CT volumetry of the liver displayed a FLRV of liver segments I–III of 380 cm^3 and a TLV of 1,709 cm^3. Interestingly, liver hypertrophy was evident only in the caudate lobe, but not in liver segments II and III where the CT scan revealed a constriction of the portal branches to liver segments II and III to be likely responsible for an inadequate left lateral hypertrophy. Prior to surgery it remained unclear whether the constriction of the left portal branches was due to tumor-related thrombosis or infiltration.

It was decided to perform an explorative laparotomy, where the tumor manifestation in liver segments IV–VIII was confirmed (Fig. 2a). No evidence for extrahepatic tumor dissemination or lymph node metastases was found. Further exploration confirmed a massive hypertrophy of the caudate lobe with a pre-existing atrophy of liver segments II and III (Fig. 2b). Thrombosis of the portal vein to segment II and III, as suspected in the CT scan, was confirmed by intraoperative ultrasound.

Preparation and exposition of the portal vein bifurcation was completed, followed by a thrombectomy of the left portal vein. A lymphadenectomy from the hepatic hilum to

Table 1 Liver function 1 day before and after PVE as well as 1 day before hepatic resection and on postoperative days 2 (POD 2) and 14 (POD 14)

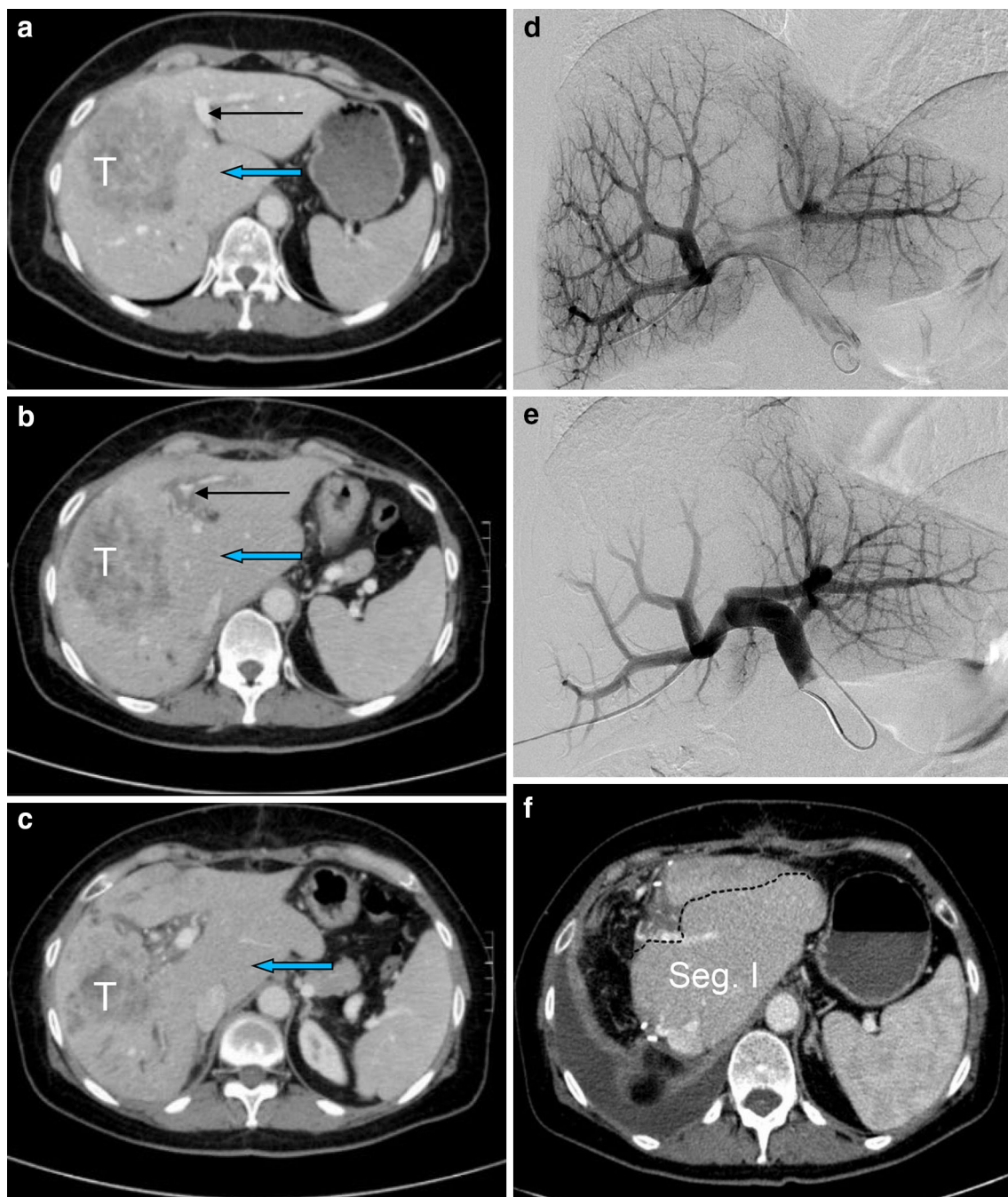|	Normal values	PVE		Hepatic resection		
		1 day before	1 day after	1 day before	POD 2	POD 14
Bilirubin	<17.1 μmol/l	5.9	11.4	8	12.6	11.4
Total protein in serum	66.0–87.0 g/l	69.9	72.5	75.2	60.1	59.3
Albumin in serum	35–52 g/l	44.5	44.4	47.7	30	29.5
ASAT	0.17–0.60 ukat/l	0.71	1.28	0.63	5.08	0.53
ALAT	0.17–0.60 ukat/l	0.64	1.54	0.67	6.79	0.75
AP	0.58–1.74 ukat/l	2.93	3.19	3.21	1.64	1.66
GGT	<0.65 ukat/l	3.44	3.67	4.28	1.95	2.14
Lipase	<1.0 ukat/l	0.63	0.56	0.97	1.88	1.26
Creatinine	45–84 μmol/l	50	48	56	43	91
Prothrombin time	>70 %	118	122	113	69	91

ASAT aspartate amino transferase, *ALAT* alanine amino transferase, *AP* alkaline phosphatase, *GGT* gamma glutamyl transferase

Fig. 1 **a** Computed tomography (CT) of the abdomen displaying an extended tumor manifestation prior to portal vein embolization. **b** CT of the abdomen 3 weeks after portal vein embolization. **c** CT of the abdomen 8 weeks after PVE and directly before extended right hepatectomy. **d** Antegrade transhepatic portography (with 4F pigtail catheter in the main portal vein trunk) showing normal contrasting of the patient's liver. **e** Antegrade transhepatic portography (with 4F sidewinder catheter in the main portal vein trunk) showing no more contrasting of the right-sided liver parenchyma. **f** CT of the abdomen 3 months after extended right hepatectomy and curative resection. *Black arrow* tumor-free portal vein branches to segments II and III (**a**); a tumor-related partial thrombosis of the portal vein branches to segments II and III (**b**). *Block arrow* segment I prior to embolization (**a**), after extensive hypertrophy following embolization (**b**, **c**). *Dashed line* border between segment II/III and segment I. *T* tumor, *Seg I* liver segment I

the celiac trunk was also performed. Even after portal thrombectomy, a very low blood flow was noted in the portal branches to liver segments II and III, likely due to a

tumor-associated portal vein stenosis. The caudate lobe displayed a significant hypertrophy with powerful perfusion via both portal vein and proper hepatic artery.

The operation was terminated as an exploratory laparotomy due to the ischemic-type atrophy of segments II and III associated with an expected marginal residual liver function of the FLR and an increased risk of PLF. The analysis of the intraoperative frozen sections and the definite histology of the thrombus and the excised lymph nodes showed no evidence of tumor manifestation. A control magnetic resonance imaging of the liver displayed a renewed closure of the portal vein branches to segments II and III.

Four weeks after the laparotomy and 7 weeks after PVE, another CT scan of the abdomen was performed for restaging and renewed volumetric analysis. Again the CT scan revealed a partial thrombosis of the portal branches to segments II and III (Fig. 1b); however, the tumor showed no progression with no tumor extension to segments II and III or to the caudate lobe. The CT volumetry revealed a FLRV for liver segments I–III of 400 cm^3 and a TLV of 1,250 cm^3 (tumor volume excluded). This made a ratio of FLRV per TLV excluding tumor volume of 32 %. Hypertrophy of the FLR was solely due to an enlargement of segment I (Figs. 1c, 2c). Despite the ischemic-type atrophy of segments II and III we decided to perform an extended right hepatectomy with curative intent.

During the second operation, we explored the abdominal cavity and excluded extrahepatic tumor manifestations. As the intraoperative ultrasound confirmed the restriction of the tumor to segments IV–VIII, we affirmed the indication to perform an extended right hepatectomy. Parenchymal transection was performed using an ultrasonic dissection device (Cavitron Ultrasonic Surgical Aspirator, CUSA®, Valleylab, Boulder, CO, USA) without any intraoperative
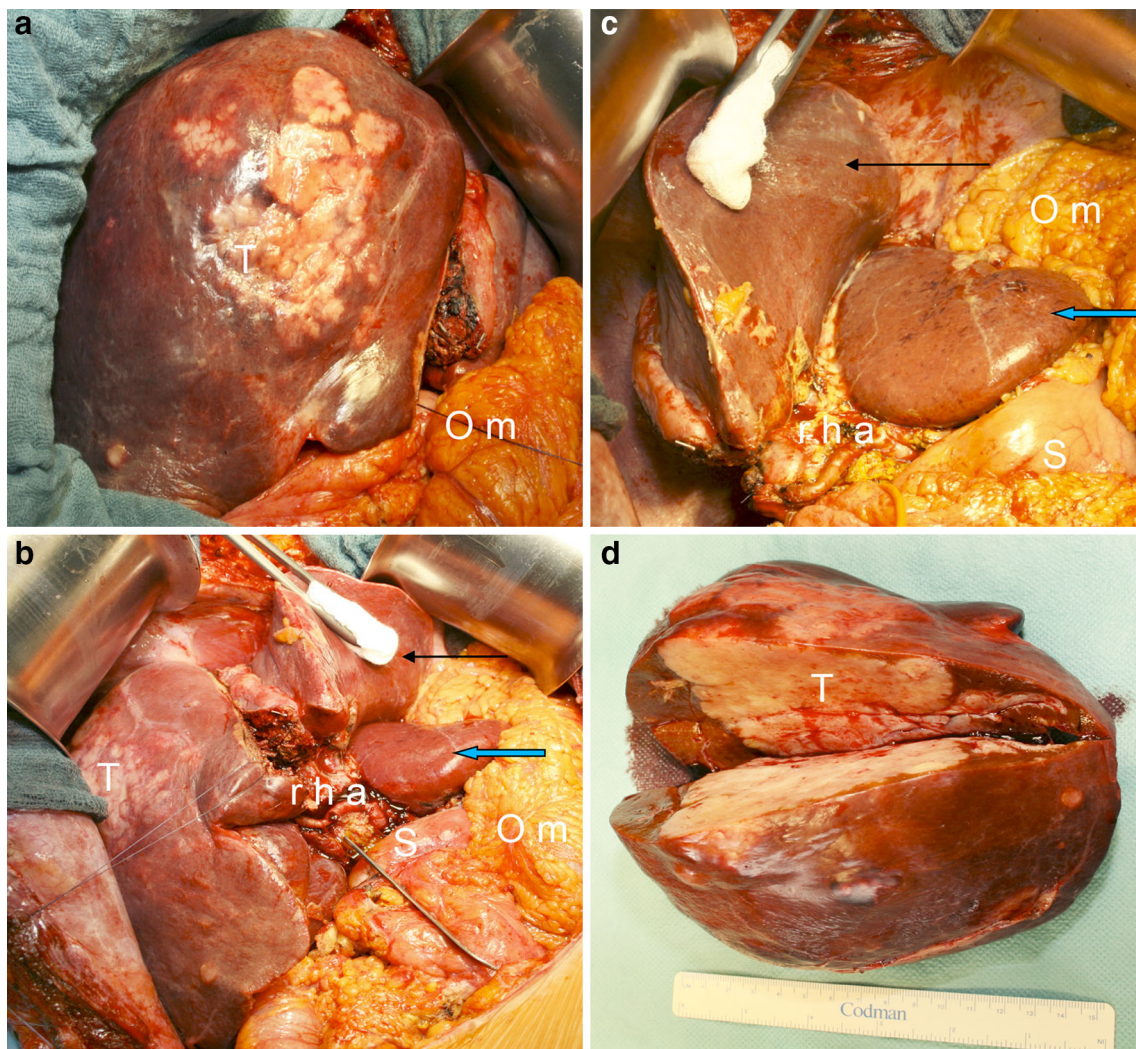

Fig. 2 a Tumor manifestation in the right liver lobe before resection. b Extensive hypertrophy of segment I, atrophic left lateral section (segment II and III) and the already isolated right hepatic artery prior to division. c Situs after hepatic resection with prominent caudate lobe, atrophic segments II and III and stump of the right hepatic artery after division. d Hepatectomy specimen after curative resection. T tumor, O m Omentum majus, block arrow segment I, black arrow segments II and III, r h a right hepatic artery, S stomach

complications. Due to a risk of biliary leakage a T drain was routinely inserted in the main bile duct for decompression and easy access cholangiography.

In the postoperative course no signs of insufficient liver function were notable. During the postoperative stay in the intensive care unit the patient did not develop any significant complications. Ten days after resection, the patient developed a small abscess at the resection surface which was successfully treated by percutaneous drainage. There was no bilioma or bile leak evident. The postoperative duplex ultrasound of the liver revealed a powerful orthotopic flow of the left hepatic artery and of the hepatic veins and no evidence for central portal vein thrombosis but a persistent thrombosis in the left portal vein trunk. The conclusive pathological result showed a poorly differentiated cholangiocarcinoma without lymph node metastases (UICC stage II), hepatocellular steatosis and siderosis as well as cholestasis and cholangitis. The resection was categorized as formally curative (Figs. 1f; 2c, d). After a total postoperative hospitalization of 30 days the patient was dismissed in good general condition. The follow-up visits at 6, 12 and 18 months after resection revealed normal liver function and no evidence of recurrent disease.

Discussion

Liver resection represents the only curative treatment option for IHC and is currently considered as the treatment of choice in this tumor entity. Studies about the efficacy of liver resection in patients with IHC showed long-term survival rates ranging from 30−60 % at 5 years after resection [15–17]. Even in the presence of a more advanced tumor stage, partial hepatectomy can provide long-term survival in a considerable share of patients and the growing experience in liver surgery facilitates extended hepatectomies and provides a chance of cure in formerly non-resectable liver malignancies [15]. The published results of large series of patients who received liver resection within the last 2 years underlined not only the therapeutic efficacy of this treatment but also its safety. The mortality rate even after major liver resections is mostly <5 % in high-volume centers [18]. Hepatic surgery in the current era is regarded as a safe procedure, and its role in primary and secondary liver cancers is well established [19].

However, PLF remains a potentially life-threatening complication and often proves fatal, especially after major hepatectomy [18]. The risk of PLF depends on the quality of the parenchyma and the volume of the remnant liver. Once liver failure is established, no reliable disease-specific therapy is currently available and liver transplantation is mostly contraindicated in these patients, resulting in reported mortality rates of 60−80 % [20, 21]. Thus, a sufficient FLRV is crucial for the success of major hepatectomies in these patients. Few treatment modalities are established to minimize the risk of postoperative liver insufficiency by improving liver function and the remnant volume before major hepatectomies, such as PVE and selective biliary decompression in patients with biliary stasis [22]. Recently, novel strategies have been proposed, i.e., inclusive CD133+ hematopoietic stem cells therapy, which seems to positively impact overall outcomes after extended right hepatectomy or in situ split techniques in combination with portal vein ligature [23–25].

Here, we propose a selective hypertrophy of the caudate lobe as a novel approach to facilitate extended right hepatectomy in patients with large tumors of the right liver lobe. Extended right hepatectomy may be considered impossible in cases of ischemic-type atrophy of left lateral segments. However, in contrast to liver segments II and III, the caudate lobe appeared well perfused and of good parenchymal quality in the present patient. Due to a significant hypertrophy of segment I during the post-interventional course following PVE, extended right hepatetcomy became feasible with no major complications apparent postoperatively. In particular, the liver function did not reveal any signs of significant insufficiency in spite of the atrophy of segments II and III.

This case is of major interest for patients with severely limited left lateral liver function scheduled for uni- or bilobular hepatectomies. These patients are widely excluded from curative treatment strategies due to the anticipated risk of PLF. Therefore, an induction of hypertrophy of segment I could be a promising approach and, unless the diagnosis is hilar cholangiocarcinoma, may provide a sufficient remnant liver function to perform curative liver resection. How can hypertrophy of segment I be induced tactically? Aware of the fact that isolated, massive hypertrophy of segment I following PVE is possible, initial embolization of this segment could be avoided. In selected patients, one could consider initial embolization of segments 4–8 only, thus awaiting potential hypertrophy induction of segment I.

In conclusion, extended right hepatectomy in the presence of thrombosis of the left portal vein branches to segments II and III is feasible if liver segment I reveals an adequate hypertrophy. To our knowledge, this is the first case in which an extended right hepatectomy was made possible by massive PVE-associated hypertrophy of the caudate lobe. Therefore, atrophy of segments II and III may not represent a general contraindication to extended right hepatectomy.

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