

# Hepatic hilar transection method for liver surgery (with video)

Norihiro Kokudo · Taku Aoki

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**Abstract** The procedure used to isolate the hepatic artery, the portal vein and the bile duct separately at the hepatic hilum was first reported in the 1940s, and remains significant as an essential technique for liver surgery in the era of more complicated liver surgery and liver transplantation. The anatomy of the vessels at the hepatic hilum is highly variable; therefore, preoperative imaging studies are indispensable for understanding the anatomy in each individual patient. The minimal extent of the transection should be defined according to the operative procedure, as excessive disruption of the blood flow and lymphatic vessels can induce postoperative complications. When isolating the vessels, gentle handling and appropriate ligation/division of the vessels are required to avoid bleeding and injuries to the vessels to be preserved. The bile duct is wrapped with perivascular connective tissue and is difficult to isolate separately. Therefore, the hilar plate should be divided together with the bile duct, under the guidance of intraoperative cholangiography.

**Keywords** Hepatic hilar transection · Caudate branch of the portal vein · Hilar plate · Intraoperative cholangiography

## Introduction

The first report of a hepatic hilar transection, i.e., the separate ligation of the hepatic hilar vessels (the hepatic artery, portal vein, and bile duct), during a left lobectomy (resection of liver segments 2 and 3) dates back to the late 1940s. Donovan et al. [1] reported that hepatic resection of the left lobe was performed after the dissection of the umbilical fissure and subsequent individual ligations of the left hepatic artery, the left branch of the portal vein, and the left hepatic duct.

Ichio Honjo [2], who first performed a successful right lobectomy (extended right hemi-hepatectomy) of the liver in 1950, reported that “At first, the right branch of the hepatic artery was ligated and divided at a distance from the bifurcation, and the second was the right branch of the portal vein, and the third was the right branch of the hepatic duct, if possible.” In addition, he mentioned that the right branch of the portal vein should be ligated after the sufficient isolation of the vessel from the surrounding connective tissue and that a meticulous transection maneuver was required in the case of the bifurcation of the portal vein located adjacent to the liver parenchyma. During the same period, the French surgeon Lortat-Jacob [3] reported an anatomic resection of the right lobe of the liver. In his manuscript, he also described the individual ligations of the cystic duct, the right hepatic duct, the right hepatic artery, and the right branch of the portal vein after the dissection of the right side of the hepato-duodenal ligament. In the USA, Quattlebaum [4] and Pack [5] reported an anatomic

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N. Kokudo (✉) · T. Aoki  
Division of Hepato-Biliary-Pancreatic and Transplantation  
Surgery, Department of Surgery, Graduate School of Medicine,  
University of Tokyo, 7-3-1 Hongo, Bunkyo-ku,  
Tokyo 113-8655, Japan  
e-mail: KOKUDO-2SU@h.u-tokyo.ac.jp

right lobectomy of the liver. Quattlebaum reported the individual ligation of the right hepatic artery followed by the right hepatic duct and the right branch of the portal vein, while Pack ligated the right hepatic duct followed by the right hepatic artery and the right branch of the portal vein.

Later, operative procedures dividing the smaller part of the liver parenchyma were proposed. These procedures included an anatomic subsegmentectomy proposed by Makuuchi [6] and a limited hepatic resection proposed by Kanematsu [7]. As these smaller-extent liver resections have become popular, the number of situations in which the hepatic artery and the portal vein branch must be divided at the hepatic hilum has decreased. Nevertheless, the safe transection of the hepatic hilum is an indispensable technique for liver surgeons, especially when hemi-hepatic vascular occlusion is needed during a liver transection, or during a donor hepatectomy for living-donor liver transplantation.

## Methods

### Regional anatomy encountered during hepatic hilar transection

The anatomy of the vessels at the hepatic hilum is highly variable; therefore, the vascular anatomy should be identified using preoperative imaging findings in each individual case. Moreover, the hilar transection should also be performed after confirming the anatomy of the vessels using intraoperative ultrasonography.

#### *Portal vein*

In most cases, the portal vein regularly forks to the right and the left branches at the hepatic hilum, but some variations exist. The significant variations include (1) the portal branch of the right posterior section branching separately from the main trunk of the portal vein, and (2) the left branch, the right anterior section branch, and the right posterior section branch separating at the same point. The round ligament of the liver (ligamentum teres hepatis) connects the umbilical portion of the left portal branch in most cases; however, in some cases, it connects the right branch of the portal vein (right-sided round ligament). In such cases, remarkable variations exist in terms of the branching pattern of the intrahepatic portal vein.

#### *Hepatic artery*

The extrahepatic running pattern of the hepatic arteries is highly variable. The normal type, in which the right and

left hepatic arteries originate from the proper hepatic artery at the left side of the hepato-duodenal ligament, is only found in two-thirds of all subjects. Common variants include (1) the replaced right hepatic artery originating from the superior mesenteric artery and running to the right-dorsal side of the portal vein (17%), and (2) the replaced left hepatic artery originating from the left gastric artery and running through the lesser omentum (16%) [8]. These variations can be detected using preoperative imaging, and artery pulsation should be confirmed by palpation during transection. The middle hepatic artery (A4) can originate both from the right hepatic artery and the left hepatic artery. Moreover, the middle hepatic artery runs in front of the left hepatic duct in some cases and crosses the left hepatic duct in other cases. Therefore, a sufficient dissection between the middle hepatic artery and the left hepatic duct (hilar plate) is needed to divide the left hepatic duct safely.

#### *Bile duct*

The branching pattern of the bile duct at the hepatic hilum is also variable, and two variations require special attention: in the first variation, the right posterior section bile duct branches separately from the common hepatic duct; in the second, the right posterior section bile duct flows into the left hepatic duct. When a variation in the biliary system is suspected preoperatively, a cholangiography should be performed soon after the start of the operation. In addition, an intraoperative cholangiography is mandatory at the time of the division of the hilar plate.

#### Operative technique: hepatic hilar transection from the right side of the hepato-duodenal ligament

Hilar transection from the right side of the hepato-duodenal ligament is performed during a right hemi-hepatectomy, a right anterior sectionectomy, and a right posterior sectionectomy (Fig. 1). When performing a left trisectionectomy (resection of segment 1–5 and segment 8), hilar transection from both the left and right sides is needed.

The first step in a hilar transection from the right side is a cholecystectomy. The cystic artery is ligated and divided at a point distal from its origination. A 4- or 5-Fr tube is inserted through the stump of the cystic duct to the common bile duct in preparation for a subsequent cholangiography. The common bile duct is dissected together with the surrounding connective tissue, and the common bile duct is then encircled at the level of the branching of the cystic duct. The bile duct is pulled to the left side, and the serosa on the right side of the hepato-duodenal ligament is divided on the cranial side of the cystic duct. The serosa is divided in parallel with the common hepatic duct, and the

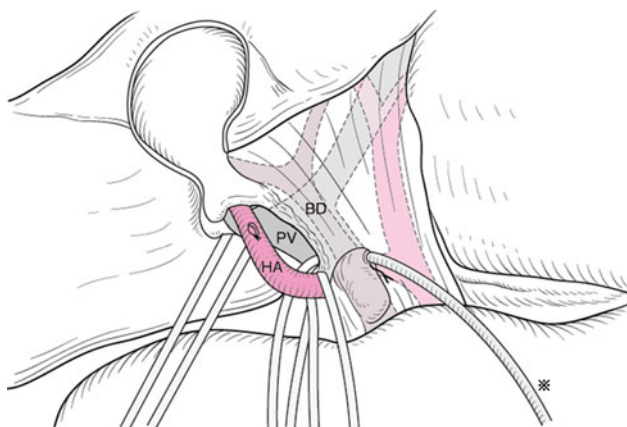


**Fig. 1** Hepatic hilar transection from the right side of the hepatoduodenal ligament. The gallbladder is removed and a tube (✕) is inserted through the cystic duct to the common bile duct. The right side of the hepatoduodenal ligament is divided longitudinally, and the right hepatic artery (HA), the main trunk of the portal vein (PV) and the right portal branch at the hilar region are encircled. The common bile duct (BD) can be seen through the hepatoduodenal ligament

right hepatic artery is exposed with the division of the right-dorsal side of the common hepatic duct. In many cases, the cystic artery originates from the right hepatic artery, and the branching point is located where the right hepatic artery turns from a horizontal course to a cranial course. Therefore, the cystic artery is a good landmark for finding the right hepatic artery (Fig. 2). When performing a right hemi-hepatectomy, the right hepatic artery is ligated and divided at the right side of the common hepatic duct. After the division of the right hepatic artery and the dissection of the dorsal side of the right hepatic artery, the wall of the portal vein can be seen through the serosal tissue around the vessel. The wall of the main trunk of the portal vein is exposed with the division of the serosa, and the anterior wall of the portal vein is transected toward the hepatic hilum. After the bifurcation of the right and left branches of the portal vein is identified, the right portal branch is exposed. In some cases, the lymph nodes along the common bile duct may be enlarged, hindering the exposure of the portal vein. In such cases, all the connective tissues including the lymph node should be dissected from the portal vein longitudinally. Drawing these surrounding tissues upwards and downwards extends the operative view and simplifies the exposure of the portal vein. In addition, during the dissection of the tissues surrounding the portal vein, the operator should compress the portal vein upward and downward or should grasp the wall of the portal vein extensively. These manipulations enable the smooth exposure of the entire portal vein. Several caudate branches that flow into the caudate lobe are usually found near the bifurcation of the portal vein. These thin caudate branches should be ligated and divided carefully,

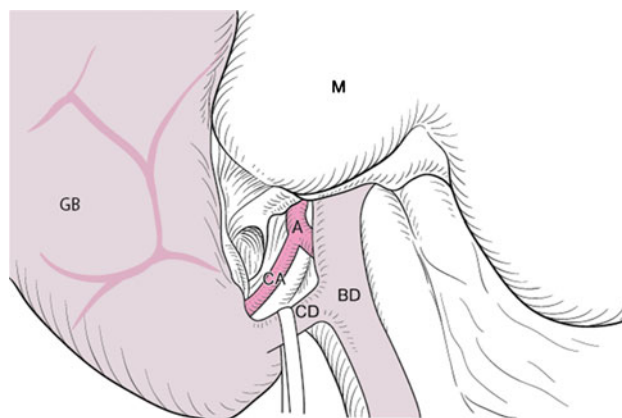


**Fig. 2** Relationship between the cystic artery and the right hepatic artery. The serosa is opened at the neck of the gallbladder, and the right side of the common bile duct (BD) is exposed and the cystic duct (CD) is encircled. The right hepatic artery is exposed at the cranial-dorsal part of the branching point of the cystic duct, where the cystic artery branches from the right hepatic artery at the point where the right hepatic artery turns from a horizontal to a cranial course. GB Gallbladder, M left medial section (segment 4)

as injuries to these branches may induce unexpected bleeding. When a right anterior sectionectomy or a right posterior sectionectomy is scheduled, the right anterior branch or the right posterior branch of the hepatic artery and the portal vein are encircled, respectively. If the division of the hepatic artery branch is easy, the artery branch can be divided. Before division of the arterial branch, the targeting branch should be clamped to confirm arterial flow to the remnant liver segments. If the division of the arterial branch is possible, the subsequent transection of the portal vein may proceed smoothly. Moreover, the major branches of the hepatic artery should be doubly ligated and divided using a transfixing suture. In the case of a right posterior sectionectomy, the right posterior branch of the bile duct can be dissected at this time, if it originates from the common hepatic duct independently. In most cases, however, the division of the bile duct is performed during the transection of the liver parenchyma. The bile duct is, apart from the hepatic artery and the portal vein, wrapped with perivascular connective tissue, such as the hilar plate. Thus, encircling the bile duct separately may be difficult in many cases. Therefore, the division of the bile duct should be performed using either of the following two procedures: (1) the dissection point of the bile duct is determined under the guidance of intraoperative cholangiography, and thereafter the entire hilar plate is encircled, ligated and divided; or (2) after determining the cut line of the bile duct using cholangiography, the whole hilar plate is divided using multiple transfixing sutures.

During a donor hepatectomy, the dissection of the right hepatic artery should be performed with special attention so as not to injure the intima or induce vasospasm.

The operator must not grasp the arterial wall directly with forceps. The right hepatic artery is isolated centrally to the left side of the common hepatic duct, and if the middle hepatic artery originates from the right hepatic artery, its bifurcation is exposed and preserved. The right hepatic artery is isolated distally to the bifurcation point of the right anterior and right posterior branches. The artery must be meticulously dissected from the bile duct (and the surrounding perivascular connective tissue) and the portal vein. The caudate branches of the portal vein are then ligated and divided in a manner similar to that used during a right hemi-hepatectomy. During the dissection of the caudate branches, care should be taken not to induce stricture of the portal vein by suturing the caudate branches together with the wall of the portal trunk. When dividing the right portal branch, the stump should be doubly ligated or closed using a running suture with vascular forceps.

In cases with a replaced right hepatic artery originating from the superior mesenteric artery, the replaced artery should be encircled at the right-dorsal side of the main portal trunk and pulsation should be manually confirmed. Thereafter, the artery is isolated towards the hepatic hilum, and the right anterior and the right posterior arterial branches are also encircled (Fig. 3).

Operative technique: hepatic hilar transection from the left side of the hepato-duodenal ligament

Hilar transection from the left side of the hepato-duodenal ligament is applied in cases requiring a left hemi-hepatectomy or extended left hepatectomy (Fig. 4). First, a cholecystectomy is performed and the common bile duct is encircled at the level of the branching of the cystic duct with the surrounding tissues, in a manner similar to that used during transection from the right side. The direction of the left portal branch can be easily recognized by asking an assistant to pull the round ligament upwards, as the left portal branch and the umbilical portion are extended straight, though excessive extension can injure the vessels. The serosa of the left side of the hepato-duodenal ligament is divided, and the left hepatic artery is exposed. The left hepatic artery is isolated both centrally and distally, and the right hepatic artery, the middle hepatic artery, and the proper hepatic artery are exposed. In the case of a left hemi-hepatectomy, the left hepatic artery is ligated and divided; in the case of a donor operation, each arterial branch is encircled. The branching point of the middle hepatic artery should be confirmed using preoperative imaging results; additionally, attention should be paid not to injure this artery intraoperatively. Afterwards, the left side of the common hepatic duct and the dorsal side of the left hepatic artery are dissected, and the anterior wall of the main portal trunk is exposed. The portal vein is dissected

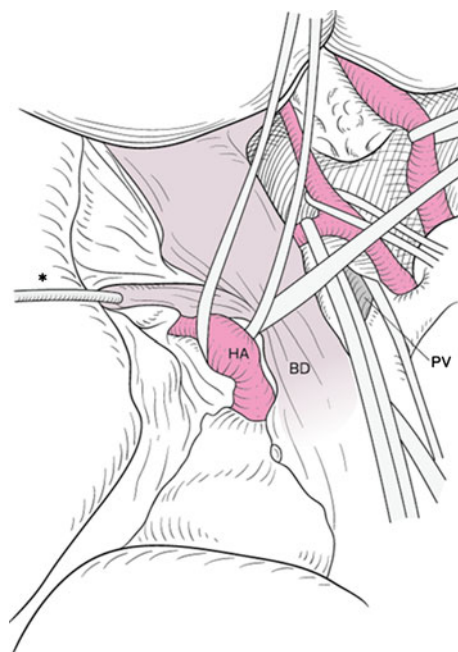


**Fig. 3** Replaced right hepatic artery. The gallbladder is removed and a tube (asterisk) is inserted through the cystic duct to the common bile duct. The common bile duct (BD) is encircled at the branching level of the cystic duct. The common bile duct is pulled to the left and the replaced right hepatic artery (HA) originating from the superior mesenteric artery is encircled at the right-dorsal part of the main trunk of the portal vein (PV)

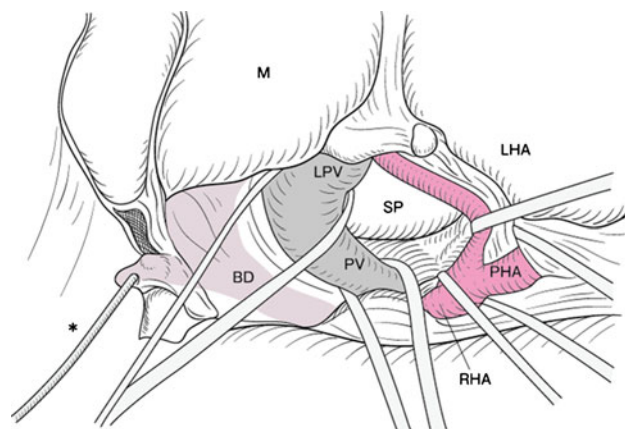


**Fig. 4** Hepatic hilar transection from the left side of the hepato-duodenal ligament. The gallbladder is removed and a tube (asterisk) is inserted through the cystic duct to the common bile duct. The left hepatic artery (LHA), the right hepatic artery (RHA), and the proper hepatic artery (PHA) are encircled individually. The distal area of the bifurcation of the left and right hepatic arteries is dissected, and the main trunk of the portal vein (PV) and the left portal branch (LPV) are identified and encircled. M Left medial section (segment 4), SP Spiegel lobe

towards the hepatic hilum, and the bifurcation of the right and left portal branches are exposed. When the liver is cirrhotic, small vessels in the hepato-duodenal ligament are

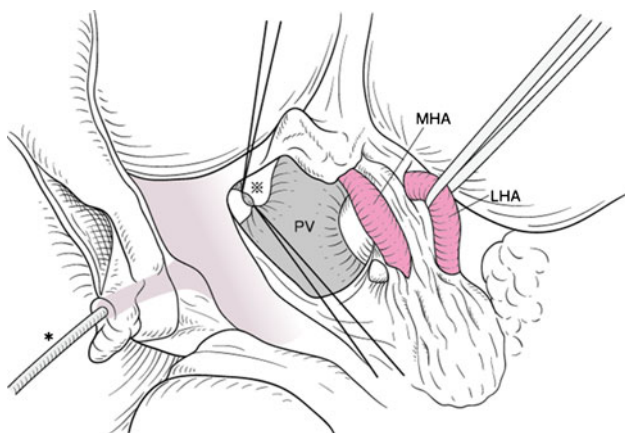


**Fig. 5** Several caudate branches of the portal vein (※) flow to the cranial or dorsal side of the bifurcation of the portal vein. These caudate branches are ligated and divided meticulously, avoiding unexpected bleeding. *LHA* Left hepatic artery, *MHA* middle hepatic artery, *PV* portal vein; ※: tube inserted into the common bile duct

enlarged and may bleed easily during transection. The connective tissues must be dissected meticulously, paying attention to these co-lateral vessels and to the diligent ligation of these vessels. The lymphatic vessels in the hepato-duodenal ligament are also enlarged in cirrhotic patients; in such cases, the lymphatic vessels should be ligated diligently to avoid postoperative lymphorrhea. After encircling the main portal trunk, the root of the left branch of the portal vein is isolated. Small caudate branches also divaricate from the left branch, and these caudate branches are ligated and divided meticulously (Fig. 5). When dividing the left hepatic duct, the same procedures as the transection from the right side are applied. After determining the cut point of the left hepatic duct using a cholangiography, the hilar plate is entirely ligated and divided or is divided using repeated transfixing sutures.

**Operative technique: hepatic hilar transection in cases with hilar bile duct cancer**

The operation for hilar bile duct cancer is unique in that (1) a lymphadenectomy of the hepato-duodenal ligament is needed, and (2) the entire caudate lobe is resected to secure a sufficient surgical margin for the caudate bile ducts (Figs. 6, 7). Therefore, the hilar transection procedure differs from that for hepatocellular carcinoma or donor hepatectomy. The lymphadenectomy procedure starts with the dissection of the lymph nodes along the common hepatic artery; the common hepatic artery, proper hepatic artery, and hepatic arteries are then skeletonized, exposing the adventitia. The arteries are encircled individually and gently pulled to the left side, exposing the left wall of the main portal trunk. The lower part of the common bile duct is encircled and divided at the supra-pancreatic level, and

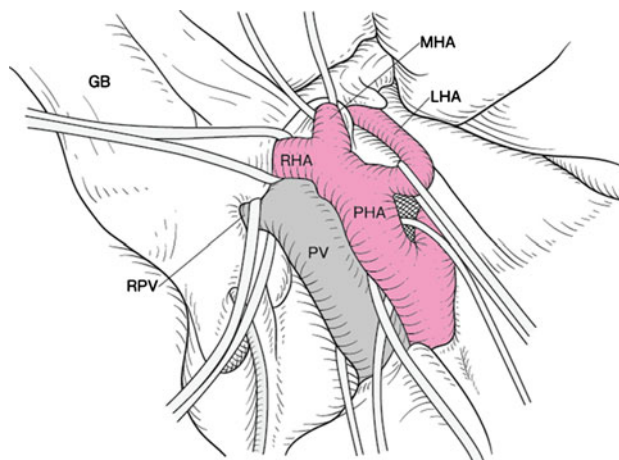


**Fig. 6** Hepatic hilar transection in cases with hilar bile duct cancer. The common bile duct is divided at the supra-pancreatic level and is pulled to the right side. The proper hepatic artery (*PHA*), the left hepatic artery (*LHA*), the middle hepatic artery (*MHA*), the right hepatic artery (*RHA*), and the main trunk of the portal vein (*PV*) and the right portal branch (*RPV*) are encircled. *GB* Gallbladder

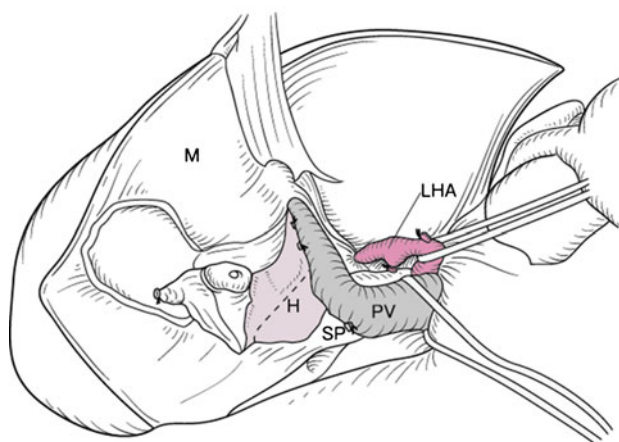


**Fig. 7** Extended right hepatectomy for hilar bile duct cancer. When performing an extended right hepatectomy for hilar bile duct cancer, all the caudate portal branches are divided after the division of the right hepatic artery and the right portal branch. Dissecting the left portal branch from the hilar plate to the right edge of the umbilical portion is an important step. Also, the arterial branches should be isolated at the point where the vessels flow into the liver parenchyma. In this particular case, the gallbladder has already been removed and the A4 branch has been divided. *H* Hilar plate, *PV* main trunk of the portal vein, *M* left medial section (segment 4), *SP* Spiegel lobe

the lymphadenectomy proceeds to the right and cranial side with traction of the common bile duct cranial-ventrally. The right hepatic artery and the right portal branch in the case of an extended right hepatectomy or the left hepatic artery and the left portal branch in the case of an extended left hepatectomy are ligated and divided, respectively. Afterwards, the remaining arterial and portal venous branches must be sufficiently isolated: in the case of an extended right hepatectomy, the left hepatic artery and the

left portal branch are isolated to the level of the segmental (S2, 3 and 4) branches; and in the case of an extended left hepatectomy, the right hepatic artery and the right portal branch are isolated to the level of the bifurcation of the right anterior and posterior branches. These procedures make the subsequent division of the hilar plate easier and safer to perform.

## Summary and conclusions

The key points for the hepatic hilar transection method are summarized as follows:

1. The surgical anatomy at the hepatic hilum is highly variable; therefore, the operator must use preoperative imaging results to ensure an understanding of the pattern present in each patient. Intraoperatively, attention should be paid to the orientation of the vessels, and re-confirmation is needed using a clamp test before dividing the major vessels.
2. With the exception of a lymphadenectomy, the transection of the hilar region should be kept to a minimum. Excessive division of the lymphatic vessels and reduction of the blood flow to the biliary system are to be avoided.
3. While isolating the portal vein, attention should be paid to the caudate branches. These caudate branches are to be isolated and divided meticulously, avoiding the stricture of the portal vein.
4. The dissection of the hepatic arteries should be performed with special attention not to injure the

intima. The operator should not seize the wall of the remaining arteries directly.

5. As the bile duct is wrapped with perivascular connective tissue, it can be difficult to isolate and encircle separately. An intraoperative cholangiography is recommended to visualize the precise anatomy of the bile ducts.

**Conflict of interest** The authors declare that they have no conflict of interest.

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