How I Do It

Step-by-step isolated resection of segment 1 of the liver using the hanging maneuver

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Abstract. The caudate lobe can be the origin of primary liver tumours or the sole site of liver metastases. This lobe is anatomically divided into 3 parts: Spiegel’s lobe (Couinaud’s segment 1), paracaval portion (Couinaud’s segment 9), and the caudate process. In this series of 4 cases, we provide a step-by-step description of a surgical technique variation that can be applied to resections of lesions localized in segment 1. We believe that other than size, lesion removal in this hepatic anatomic area, which is difficult to perform, can be done more easily using this new approach because it requires minimal mobilization without unnecessary parenchyma transection of other liver parts. Therefore, it reduces the risk of lesions in the inferior vena cava and the middle hepatic vein and respects adequate margins without the use of clamping maneuvers and in an acceptable surgical time.

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Liver tumor;
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The caudate lobe is commonly involved in metastatic or primary liver neoplasms. Historically, it has been regarded as an independent segment and was classified by Couinaud1 as segment 1 of the liver, which comprised 8 segments. Kumon2 first divided the caudate lobe into 3 parts: Spiegel’s lobe, which was the equivalent to Couinaud’s segment 1 and the conventional caudate lobe; the paracaval portion; and the caudate process. Couinaud,3 like Healey and Schory,4 later subdivided the caudate lobe into 2 subsegments named the left (segment 1 l) and right dorsal segments (segment 1r). Couinaud’s segment 1r is the equivalent to Kumon’s paracaval portion. Later, Couinaud5 called it segment 9, which encircled the side of the inferior vena cava (IVC). Therefore, the caudate lobe of the liver is anatomically divided into 3 parts: Spiegel’s lobe (Couinaud’s segment 1), the paracaval portion (Couinaud’s Segment 9), and the caudate process.

The resection of the caudate lobe can be performed as an extension of a lobectomy, other types of hepatectomies, or even as an isolated resection. We present a surgical variant for isolated segment 1 resection that differs from previously described techniques. We consider this to be an easier approach for a known difficult surgery because of its anatomic situation. We describe our experience using this technique.

Technique

Surgical anatomy

For surgical anatomy purposes, the caudate lobe is considered to have 2 parts: Spiegel’s lobe (Couinaud’s segment 1) on the left and the paracaval portion (Couinaud’s seg-
ment 9) on the right, which includes the caudate process (Fig 1A). Both parts are anatomically divided by a deep notch in 50% of individuals. In addition, the canal of Arantius, which is the ligamentum venosum in the embryonic phase, can be used as an anatomic reference to define the limit between segments 1 and 9.6,7

Although most arterial branches of the caudate lobe arise from the left hepatic artery, some arise from the right hepatic artery. In addition, there might also be several small branches from the portal vein to the caudate lobe. There is normally a large trunk about 1 mm in diameter and 5 mm in length. The identification and ligation of these arterial and venous branches are key steps in the resection of the caudate lobe. Although most portal vein branches to the caudate lobe come from the main left portal vein, they may also come through from the right vein or the bifurcation.8

The caudate lobe drains directly into the IVC and not typically through the left hepatic vein (LHV), right hepatic vein (RHV), or middle hepatic vein (MHV). According to the anatomical study of Kogure et al,9 the hepatic venous system not only comprises 1 or 2 proper hepatic veins draining the caudate lobe but also several small accessory hepatic veins. The number and size of these vary in each case, and they are distributed throughout the caudate lobe. The posterior edge of the caudate lobe over the left side normally has a fibrous attachment encircling the IVC to join segment 7. In up to 50% of patients, this fibrous band is replaced by hepatic paren-

Figure 1  (A) Transversal computed tomography scan image with a metastasis in segment 1 (red arrow). The black dotted line divides segments 1 and 9. (B) The anterior surface of the suprahepatic IVC is exposed, and the space between the RHV and the MHV is dissected 2 cm to 3 cm in the caudal direction using a right-angled clamp. (C) The infrahepatic IVC is dissected with direct vision between the anterior surface of the IVC and the posterior side of the liver (caudate segment) along 2 cm to 3 cm. (D) A long, curved Kelly clamp is inserted behind the caudal edge of the caudate lobe on the left side of the inferior RHV, if present. It is passed cranially along the anteromedian surface of the IVC toward the space between the previously dissected RHV and MHV. A tape is seized with the clamp and passed down between the anterior surface of the IVC and the posterior surface of the caudate lobe.
chyma that can actually embrace the IVC completely. This situation represents an additional obstacle to the resection of the caudate.

Regarding the biliary drainage of the caudate lobe, between 1 and 3 bile ducts usually drain each portion with a maximum of 5 ducts for the whole caudate. Most of Spiegel’s lobe ducts drain into the left hepatic duct, although some may drain into the right posterior sectoral duct and less commonly into the right hepatic duct or the confluence of the hepatic ducts. Most ducts from the paracaval portion drain into the right posterior sectoral duct, although a significant percentage (27%) drain into the left hepatic duct.

**Surgical technique**

The liver is exposed through a right subcostal abdominal incision. After an exploratory laparotomy, the liver is mobilized from its peritoneal attachments. Then, the lesser omentum is carefully divided by dissection so as not to injure a aberrant left hepatic artery, which is present in 18% of cases. An intraoperative ultrasonography must be performed, which allows the confirmation of the hepatic vascular anatomy in relation to the tumor and also rules out other lesions and enables diagnosis of possible vascular infiltrations.

Isolated resection of segment 1 involves 3 major steps: (1) control of the inflow blood supply from the left portal vein and left hepatic artery; (2) parenchymal section; and (3) dissection, ligature, and section of the retrohepatic veins.

**Step 1.** Normally, a dissection of the caudate blood supply at the base of the umbilical fissure is easy because segment 1 vessels coming from the left side of the portal vein and the left hepatic artery are identified and sectioned. If they are easily localized at this point, the biliary radicals of segment 1 can be ligated and sectioned; otherwise, this step can be done during the parenchymatous section.

**Step 2.** The anterior surface of the suprahepatic IVC is exposed, and the space between the RHV and the MHV is dissected 2 cm to 3 cm caudally using a right-angled clamp (Fig 1B). Then, the anterior surface of the infrahepatic IVC is dissected with direct visualization of 2 cm to 3 cm (Fig 1C). This is followed by the insertion of a long, curved Kelly clamp behind the caudal edge of the caudate lobe on the left side of the inferior RHV (if present), which is then passed cranially along the anteromedian surface of the IVC toward the space between the previously dissected RHV and MHV. About 2 cm to 3 cm are dissected without direct vision (Fig 1D). A tape is then seized with the clamp and passed down between the anterior surface of the IVC and the posterior surface of the caudate lobe (Fig 2A). After retracting the lateral segment of the liver, the ligamentum venosum is ligated and divided, and a tunnel is created on the posterior surface of the common trunk of the MHV and LHV. The cranial end of the tape is passed through the tunnel and pulled down behind the common trunk of the MHV and LHV, leaving the tape at the left side of the LHV (Fig 2B). Thereafter, the caudal end of the tape is relocated and passed to the left of the main portal vein (Fig 2C). Both ends of the tape are then pulled up to facilitate the direct exposure of segment 1 (Fig 2D). We prefer to use a 1 cm wide and 40 cm long cloth tape because those made of plastic or silicone break easily when touched with the cavitron ultrasonic surgical aspirator (CUSA).

At this point, the resection line of the right side of the segment 1 is decided, leaving an adequate tumor-free margin. We mark the line of the parenchyma section on the inferior edge of the caudate lobe, and 2 traction stitches are placed at both sides of the section line to delimit the line (Fig 3A). To perform the parenchyma resection, we pull from these 2 points to open the section line, at the same time pulling upward from the 2 ends of the tape to line up the parenchymal section, thus facilitating better hemostasis and preventing injury of the IVC and MHV. The hepatic parenchymal transection is performed by means of a CUSA, and Pringle’s maneuver is only used if necessary. The parenchymal transection progresses and continues cephalad along the tape, and all vasculobiliary branches found on the line of the hepatic section are resected between ligatures or clips until the section is completely finished (Fig 3B).

**Step 3.** Once the parenchymatous section has been completed, the exposed short hepatic veins draining directly into the IVC are seen much easier (Fig 3C), even though the tumor is larger. Segment 1 can be moved to the left of the cava vein, thus facilitating the individual ligations and divisions of the retrocaudate veins. Normally, there are 1 to 3 sizable veins and several fine veins at this location. When these have been divided, the hepatocave ligament surrounding the IVC is cut, and the resection is completed (Fig 3D). In addition, low central venous blood pressure controlled by the anesthesia team is recommended because this helps to reduce blood losses during the hepatectomy and in case of vein injury.

**Results**

We have performed the isolated resection of segment 1 with the hanging maneuver in 4 cases (Table 1). All of these procedures were completed successfully. Patients (3 men and 1 woman, aged 56–73 years) were diagnosed with metastases from colorectal cancer (3 cases) and breast cancer (1 case). No patient required blood transfusion during or after the operation. The mean tumor diameter was 3 cm (range 2–8 cm). The resection margin was negative in all patients (R0). There were no postoperative deaths and only 1 minor complication, a wound infection. There was no postoperative liver failure in any patient. The mean postoperative stay was 5 days (range 4–8 days). One relapse in a distant liver segment was observed after a 15-month follow-up, and 3 patients are disease free after a mean follow-up period of 16 months (range 8–20 months).
The caudate lobe is commonly involved in metastatic or primary liver neoplasms. Several techniques to resect tumors in this lobe, including lobectomy, segmentectomy, caudate lobectomy, isolated caudate lobectomy, and partial hepatectomy, have been described in the literature.\textsuperscript{6–8,12–17} This highlights the lack of a standard technique and absence of uniform criteria to perform this type of surgery, which is likely because of the difficulty in performing this resection given the depth and complicated location of the caudate lobe adjacent to major vessels. Isolated caudate lobectomy is a challenging technical procedure for which safe and reliable techniques have not yet been developed.

Lai et al\textsuperscript{18} proposed the previous approach for right hepatic tumors, which are difficult to mobilize with a view to facilitate their handling. Belghiti et al\textsuperscript{19} proposed the liver hanging maneuver using a tape placed in the anterior surface of the IVC as a complement to facilitate the previous approach in right hepatectomies. This assistance has been further spread to other types of resections,\textsuperscript{20} and its use has been described in caudate resections.\textsuperscript{21} Two tunnelings are required in this maneuver: one is retrohepatic and in front of the IVC, and the other is caudal to the common trunk of the MHV and LHV. These tunnelings should not be attempted when tumors either invade the retrohepatic IVC or are behind the common trunk of the MHV and LHV because they may cause profuse hemorrhaging or tumor spillage. However, this technique offers several advantages. A straight transection plane from the anterior surface of the liver to the IVC can be obtained, and the lifting of the tape pulls the liver up, providing a better exposure, protection of the IVC, and easy control of any bleeding in the transection surface or the deeper parenchyma of the liver.

Based on previous findings, we have performed the same surgical technique in 4 clinical cases (Table 1) and have also introduced several modifications that facilitate the resection.

**Figure 2** (A) The tape is placed on the anterior surface of the retrohepatic IVC. (B) A tunnel is created on the posterior surface of the common trunk of the MHV and the LHV. Through the tunnel, the cranial end of the tape is passed toward the left side of the LHV. (C) The caudal end of the tape is relocated and passed to the left of the portal trunk. (D) Pulling up both ends of the tape plays an important role in raising the liver. The blue vessel loop is placed around the left portal vein. The red vessel loop is placed around the left hepatic artery. The cranial end of the tape arises from the left of the LHV and the caudal end does so from the left side of the portal trunk.
with the previously described technique.\(^{21}\) We performed the parenchymatous section before approaching the retrohepatic direct veins. The mobilization of the caudate lobe in large tumors is a very challenging technique to perform, given the problems involved in exposing the surgical area. This technique can generate hemorrhages or lead to mandatory vascular controls of major vessels with subsequent hemodynamic disorder. Moreover, it involves intense manipulations of the tumor, potentially causing tumor dissemination.

In addition, we disagree that a hepatic inflow occlusion (Pringle’s maneuver) is mandatory as others have proposed.\(^{12}\) In fact, we did not use this technique in any of our patients. Inflow occlusion of the caudate lobe can be achieved by portal dissection, even without lowering the hilar plate. Although seemingly tedious, the afferents from the portal veins to the caudate lobe can be visualized and controlled with meticulous dissections. Back bleeding from the small hepatic veins is rarely an issue because it is controlled before portal dissection. Moreover, we did not clamp the LHV or MHV during resection, and we had no hemorrhaging. The initial control of the arterial and portal veins minimizes the risk of bleeding during the parenchymatous transection. Furthermore, the section can be completed with a meticulous dissection of the parenchyma by CUSA without Pringle’s maneuver, which may lead to disorders because of the ischemic injuries in the remaining liver, specifically in those with previous chemotherapy and/or cirrhosis.
The traction of the caudate by stitches at both sides of the parenchymatous section line facilitates alignment during transection, opens up the section line, and facilitates exposure. Together with the elevation of the parenchyma by pulling up the tape, this reduces the risk of vascular lesions to the cava vein and the MHV. It also increases hemostasis with the compression of the vessels crossing the section line, which, in our experience, has significantly contributed to good results, including adequate resection margins and less need for blood transfusions, within an acceptable surgical timeframe. The tape used in this procedure plays 2 important roles: it acts as a guide to the transection plane as well as a means to retract the liver. The parenchymal transection plane can be effectively oriented by aiming at the tape and ensuring that both ends of the tape surround the resection plane of the caudate lobe when pulled anteroinferiorly.

The importance of obtaining a clear microscopic margin in the surgical resection of malignant processes has been shown in multiple patient series from many institutions, including our own.22,23 Previous experiences in isolated resections of colorectal carcinoma metastasis in this local-ization have provided good results.24 Resection of the caudate lobe has been infrequently used in the past because of the difficulty of dissection and the perception of an early date lobe has been infrequently used in the past because of vascular controls, therefore achieving tumor-free margins in an acceptable surgical time with no need for blood transfusions.

**References**


**Table 1** Clinical and pathological features

<table>
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<th>Patient</th>
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<th>Blood transfusion (mL)</th>
<th>Surgical time (min)</th>
<th>Tumor size (cm)</th>
<th>Resection margin (R)</th>
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CCR = colorectal cancer; M = male; F = female; R = resection.