

Retrospective Study

Therapeutic efficacy and stent patency of transhepatic portal vein stenting after surgery

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Institutional review board statement: The study was reviewed and approved by the Pusan National University Yangsan Hospital Institutional Review Board.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declare no conflict of interest related to this study.

Data sharing statement: No additional data are available.

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Manuscript source: Unsolicited manuscript

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Received: September 9, 2016
Peer-review started: September 10, 2016
First decision: September 28, 2016
Revised: October 6, 2016
Accepted: October 30, 2016
Article in press: October 31, 2016
Published online: November 28, 2016

Abstract

AIM

To evaluate portal vein (PV) stenosis and stent patency after hepatobiliary and pancreatic surgery, using abdominal computed tomography (CT).

METHODS

Percutaneous portal venous stenting was attempted in 22 patients with significant PV stenosis (> 50%) - after hepatobiliary or pancreatic surgery - diagnosed by abdominal CT. Stents were placed in various stenotic lesions after percutaneous transhepatic portography. Pressure gradient across the stenotic segment was measured in 14 patients. Stents were placed when the pressure gradient across the stenotic segment was > 5 mmHg or PV stenosis was > 50%, as observed on transhepatic portography. Patients underwent follow-up abdominal CT and technical and clinical success, complications, and stent patency were evaluated.

RESULTS

Stent placement was successful in 21 patients (technical success rate: 95.5%). Stents were positioned through the main PV and superior mesenteric vein ($n = 13$), main PV ($n = 2$), right and main PV ($n = 1$), left and main PV ($n = 4$), or main PV and splenic vein ($n = 1$). Patients showed no complications after stent placement. The time between procedure and final follow-up CT was 41-761 d (mean: 374.5 d). Twenty stents remained patent during the entire follow-up. Stent obstruction - caused by invasion of the PV stent by a recurrent tumor - was observed in 1 patient in a follow-up CT performed after 155 d after the procedure. The cumulative stent patency rate was 95.7%. Small in-stent low-density areas were found in 11 (55%) patients; however, during successive follow-up CT, the extent of these areas had decreased.

CONCLUSION

Percutaneous transhepatic stent placement can be safe and effective in cases of PV stenosis after hepatobiliary and pancreatic surgery. Stents show excellent patency in follow-up abdominal CT, despite development of small in-stent low-density areas.

Key words: Liver; Vein; Stent; Computed tomography; Surveillance; Efficacy

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Core tip: Portal vein (PV) stenosis can occur after hepatobiliary and pancreatic surgery. Portal hypertension due to PV stenosis induces clinical manifestations in many organs, including intractable ascites, esophageal and gastrointestinal bleeding, and liver dysfunction. Percutaneous transhepatic stent placement can be safe and effective in cases of PV stenosis since stents show excellent patency on follow-up abdominal computed tomography despite the presence of small in-stent low-density areas.

Jeon UB, Kim CW, Kim TU, Choo KS, Jang JY, Nam KJ, Chu CW, Ryu JH. Therapeutic efficacy and stent patency of transhepatic portal vein stenting after surgery. *World J Gastroenterol* 2016; 22(44): 9822-9828 Available from: URL: <http://www.wjgnet.com/1007-9327/full/v22/i44/9822.htm> DOI: <http://dx.doi.org/10.3748/wjg.v22.i44.9822>

INTRODUCTION

Acquired portal vein (PV) stenosis is most commonly observed after liver transplantation (LT)^[1-3]. In the non-transplant population, PV stenosis can present with pancreatitis^[4] or tumor encasement^[5], or as a postsurgical complication^[6]. Portal hypertension from PV stenosis induces clinical manifestations in many organs, including intractable ascites, esophageal and gastrointestinal bleeding, and liver dysfunction^[7].

Treatment options for patients with PV stenosis or occlusions are limited. In the past, PV complications were managed surgically, such as by thrombectomy or surgical revision. However, surgical management of these complications has been limited by technical difficulties due to the development of postsurgical fibrosis and the length of the involved venous structures^[8]. Percutaneous interventional procedures have gained worldwide acceptance for alleviating the symptoms of portal hypertension, due to their minimal invasiveness and high success rates with low number of complications^[9]. Abdominal computed tomography (CT) and Doppler ultrasound tests have been the main modalities of patient follow-up after this procedure; the reported stent patency rate has been relatively good, ranging between 60 and 100% during the first year^[5,7,10,11]. Abdominal CT scans allow the visualization not only of the status of the original lesion, but also of changes in the PV stent. This study aimed to evaluate the therapeutic efficacy and stent patency of PV stenting after hepatobiliary and pancreatic surgery, using abdominal CT.

MATERIALS AND METHODS

Patients

From January 2011 to December 2012 at a single institution, percutaneous transhepatic stent placement was attempted in 22 patients [11 women, 11 men; mean age: 65.6 years (range: 26-78 years)] with significant PV stenosis (> 50% of the main PV diameter) diagnosed using abdominal CT after hepatobiliary or pancreatic surgery [pylorus-preserving pancreatoduodenectomy ($n = 7$), Whipple procedure ($n = 6$), distal pancreatectomy ($n = 2$), hepatectomy or hepatic segmentectomy ($n = 6$), and deceased donor liver transplant ($n = 1$)] (Table 1).

The reasons for surgery included pancreatic cancer ($n = 7$), common bile duct cancer ($n = 3$), Klatskin tumor ($n = 2$), colon cancer with duodenal invasion ($n = 1$), colon cancer with liver metastasis ($n = 1$), hepatocellular carcinoma ($n = 1$), gall bladder cancer ($n = 1$), gastrointestinal stromal tumor ($n = 1$), ampulla of Vater cancer ($n = 1$), chronic pancreatitis ($n = 1$), intrahepatic bile duct stone ($n = 1$), and hepatic failure after toxic hepatitis ($n = 1$). Clinical manifestations in patients with PV stenosis included intestinal angina-like abdominal pain (disabling mid-epigastric or central abdominal pain within 10-15 min after eating) and anorexia refractory to medical treatment, ascites, increased Jackson-Pratt (JP) drain output, and abnormal liver function test (LFT). The interval between surgery and stent placement was 5-274 d (mean: 34 d) (Table 2).

One patient was diagnosed with asymptomatic left PV stenosis after right hepatectomy, when the pressure gradient on transhepatic portography was 5 mmHg. She had undergone balloon angioplasty only and was excluded from this study.

Table 1 Types of surgery and lesion locations of the patients

patient No.	Age/sex	Surgery	Locations
1	65/F	DDLT	Main PV
2	74/F	Whipple's op	PV-SMV
3	58/M	Distal pancreatectomy + Spl-SMV bypass	PV-SMV
4	73/M	Whipple's op	PV-SMV
5	61/F	Whipple's op	PV-SMV
6	63/F	PPPD	PV-SMV
7	75/F	PPPD	PV-SMV
8	68/F	PPPD	PV-SMV
9	65/F	PPPD	PV-SMV
10	70/M	PPPD	PV-SMV
11	55/M	PPPD	PV-SMV
12	70/F	PPPD	Main PV
13	69/F	Whipple's op	PV-SMV
14	54/M	Right anterior segmentectomy	Right PV
15	76/M	Right hemicolectomy + PPPD	PV-SpV
16	26/M	Right lobectomy	Left PV
17	55/F	Right + caudate lobectomy	Left PV
18	66/M	Right + caudate lobectomy	Left PV
19	74/M	Subtotal pancreatectomy, Splenectomy, partial nephrectomy	PV-SMV
20	79/F	Trisegmentectomy + caudate lobectomy	Left PV
21	68/M	Whipple's op	PV-SMV
22	78/M	Central segmentectomy	Right PV

DDLT: Deceased donor liver transplant; PPPD: Pylorus-preserving pancreatoduodenectomy; PV: Portal vein; SMV: Superior mesenteric vein; SpV: Splenic vein.

Table 2 Clinical manifestations of patients

Clinical manifestations	No. of patients
Intestinal angina-like abdominal pain refractory to medical treatment	
Only pain	2
Worsening of PVS during the follow-up (> 2 wk)	4
Worsening of PVS during the follow-up (> 2 wk) + abnormal LFT	1
PVT after PCD	1
Abnormal LFT	1
Fail to PV anastomosis during the operation	1
Anorexia refractory to medical treatment (with increased JPDO)	1
Ascites	4
Increased JPDO	6
Abnormal LFT	1

"Worsening of PVS" indicates aggravation of the PVS on abdominal CT during the follow-up period. "Increased JPDO" indicates increased serosanguinous JP drain output-suspected ascites. CT: Computed tomography; JPDO: Jackson-Pratt drain output; PVS: Portal vein stenosis; PCD: Percutaneous drainage; PVT: Portal vein thrombosis.

Procedure

Informed consent was obtained from each patient. This retrospective study was approved by our institutional review board. All patients received local anesthesia consisting on subcutaneous injection of lidocaine and an intravenous injection of pentanyl (pentanyl citrate, Myung Moon Pharmaceutical; Seoul, Korea). Percutaneous transhepatic puncture of the

Table 3 The criteria for portal vein stenting - stenosis > 50% of the main portal vein diameter revealed by transhepatic portography, or a pressure gradient across the stenosis > 5 mmHg

Criteria	No. of patients
PVS > 50% with measuring of PrG	
PrG > 5 mmHg	11
PrG = 5 mmHg	
Contrast stagnation with collaterals formations	2
Kinking of PV (stenosis and acute angulation)	1
PVS > 50% without measuring of PrG	
Contrast stagnation with collaterals formations	3
Kinking of PV	3
Stenosis and partial PVT	1

PVS: Portal vein stenosis; PrG: Pressure gradient; PVT: Portal vein thrombosis.

intrahepatic PV was performed with a 21-gauge needle (PTC US needle, A&A M.D.; Seongnam, South Korea) under sonographic and fluoroscopic guidance. The needle was exchanged for a 5-French coaxial dilator, and an 8-French sheath was placed over a 0.035-inch guidewire. A 0.035-inch angled hydrophilic guidewire (Radifocus, Terumo, Tokyo, Japan) and a 5-French cobra catheter were used to traverse the PV stenosis. Direct main portography was performed with 12 mL of contrast medium injected into the patient's splenic or superior mesenteric vein (SMV) and the pressure gradient across the stenosis was measured. The criteria for PV stenting were as follows: stenosis > 50% of the main PV diameter revealed by transhepatic portography, or a pressure gradient across the stenosis > 5 mmHg (Table 3).

Stent placement was performed using stents from the following vendors: Smart (Cordis; Miami Lakes, FL, United States), Zilver (Cook; Bloomington, IN, United States), Protégé (Covidien; St. Paul, MN, United States), Hercules (S&G Biotech Inc.; Seongnam, South Korea), Complete SE (Medtronic Inc.; Minneapolis, MN, United States), and Express LD (Boston Scientific; Natick, MA, United States). Stents of the same diameter or with a diameter 1-2 mm larger than that of the non-stenotic extrahepatic PV were used.

Balloon angioplasty following stent placement was not routinely performed; however, balloon angioplasty was performed in cases in which the deployed stent showed an hourglass deformity of < 50% its normal diameter or the pressure gradient across the stenosis was > 5 mmHg. Angioplasty was carefully performed using a balloon catheter of the same (or smaller than the deployed stent to prevent PV rupture).

After transhepatic portography and stent placement, the PV pressure gradient was measured to evaluate whether the stenosis or occlusion was resolved. The transhepatic parenchymal track was embolized with several 0.035-inch stainless steel coils (Cook; Bloomington, IN, United States), gelfoam slurry (Cutanplast, Mascia Brunelli; Milano, Italy), or n-butyl cyanoacrylate (NBCA; Histoacryl, B. Braun;

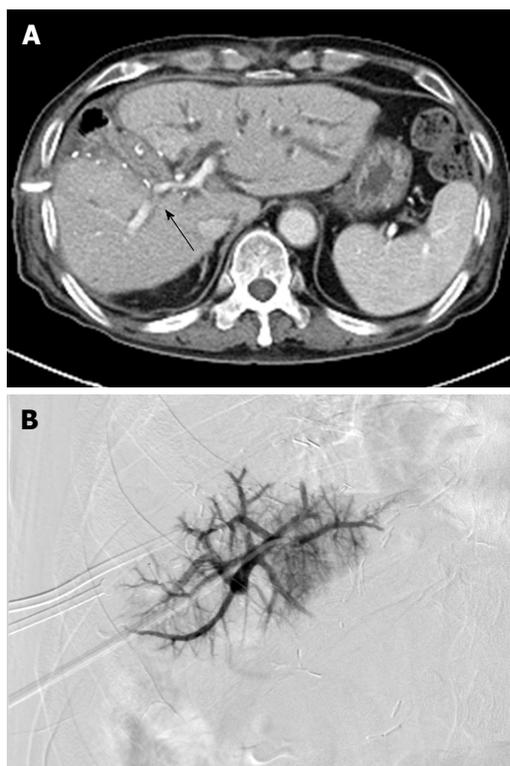


Figure 1 A selection failure case. A 78-year-old man (patient No. 23) presenting with right PV stenosis after hepatic central segmentectomy with liver metastasis from colon cancer. A: Axial CT scan 40 d after surgery showing severe stenosis (arrow) at the right PV. B: Percutaneous transhepatic portogram showing peripheral right PV. Main PV was not selected due to severe stenosis at the right PV. CT: Computed tomography; PV: Portal vein.

Melsungen, Germany) to prevent bleeding. No routine anticoagulation therapy was administered after the procedure.

Study endpoints

The following parameters were retrospectively documented: technical success, clinical success, development of complications, PV flow after stent placement, and pressure gradient across the area before and after stent placement. Technical success was defined as successful stent placement in the intended location in the PV with subsequent improvement in portal venous flow and < 30% residual stenosis. Clinical success was defined as improvement on patient clinical manifestations, such as nausea, abdominal pain, abnormal liver function, and ascites. Major complications included those requiring increased level of care or additional surgical or interventional manipulation and those resulting in adverse sequelae or death. Minor complications defined self-limiting events.

Patency of the PV stents was evaluated with follow-up abdominal CT 3-6 mo after the procedure and, after that, annually. According to clinician discretion, however, the follow-up schedule could be altered. Axial CT image of portal venous phase (5 mm-thick slice) was routinely used for evaluation. In cases in which

the luminal changes caused by the stents were not fully visualized with axial images, some of the axial images were transferred to a workstation in which a PC-based three-dimensional reconstruction software (Aquarius iNtuition 4.4, TeraRecon; San Mateo, CA, United States) was installed. Three-dimensional image reconstruction was performed, which included volume-rendering and multiplanar or curved planar reformation along or across the venous segments of interest. Small in-stent low-density areas, such as the ones observed after carotid stenting^[12], were observed between the stent wall and a contrast-filled PV on follow-up CT scans. Extent, location, and relative time of discovery were recorded.

Statistical analysis

Portal venous pressure gradient was analyzed before and after stent placement using the Wilcoxon rank test; cumulative stent patency rates were calculated using the Kaplan-Meier estimation. Statistical analysis was conducted using the SPSS software (version 18.0); a $P < 0.05$ indicates a statistically significant difference.

RESULTS

Stenting was successful in 21 out of 22 patients (technical success rate: 95.5%). Guidewire selection failed in 1 patient due to severe PV stenosis (Figure 1). All patients in whom PV stenting was successful ($n = 21$) showed improvement of clinical manifestations (*e.g.*, disappearance of intestinal angina, ascites, and abnormal LFT, and decreased JP drain output). Remarkably, 6 patients showed increased JP drain output during the early follow-up periods after surgery, with JP drain output decreasing rapidly within 1 wk after stenting. Therefore, the clinical success rate was of 100%. The used stents were 37-80 mm long and 8-14 mm in diameter. In 1 patient, 2 stents were used due to stent misplacement. Twenty-one self-expandable and 1 balloon-expandable stents were used, including the Smart (Cordis, Cordis, Inc.; Miami Lakes, FL, United States; $n = 8$), Zilver (Cook; Bloomington, IN, United States; $n = 7$), Protégé (Covidien; St. Paul, MN, United States; $n = 3$), Hercules (S&G Biotech Inc.; Seongnam, South Korea, $n = 2$), Complete SE (Medtronic Inc.; Minneapolis, MN, United States, $n = 1$), and Express LD (Boston Scientific; Natick, MA, United States; $n = 1$).

Stents were positioned as follows: through main PV and SMV ($n = 13$), through main PV ($n = 2$), through right PV and main PV ($n = 1$), through left PV and main PV ($n = 4$), and through main PV and splenic vein ($n = 1$).

The transhepatic parenchymal track was embolized with coils ($n = 15$), gelfoam slurry ($n = 6$) or n-butyl cyanoacrylate ($n = 1$) to prevent bleeding. There were no procedure-related complications, such as perihepatic hematoma, hemobilia, hemoperitoneum,

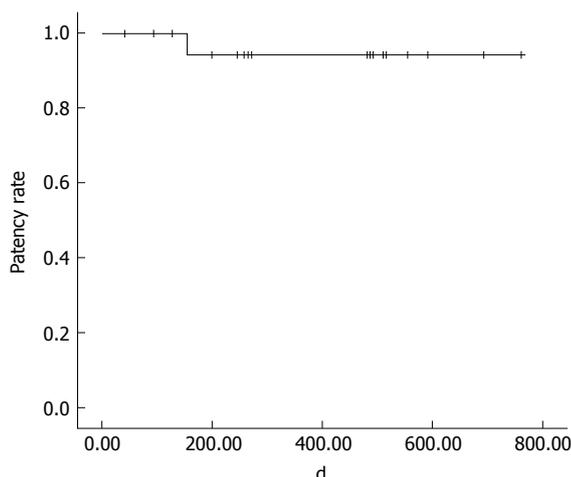


Figure 2 Kaplan-Meier results for cumulative patency rates among 22 patients who underwent portal vein stenting. Initial decrease in patency rate occurred within 155 d after procedure. Further decrease in patency rate was not observed during the entire follow-up period. The cumulative patency rate for PV stent was 95.7%. PV: Portal vein.

or pneumoperitoneum.

Pre- and post-stenting pressure gradients across the stenosis (measured in 14 patients) were 8.7 ± 3.4 mmHg (range: 5-16 mmHg) and 2.1 ± 1.1 mmHg (range: 1-5 mmHg), respectively. The decrease in pressure gradient after the procedure was statistically significantly (Wilcoxon rank test; $P < 0.05$).

The first follow-up CT examination was performed 1-162 d (mean: 40.1 d) after the procedure; sequential follow-up CT were performed in all patients. The interval between procedure and final follow-up CT was 41-761 d (mean: 374.5 d). Twenty stents remained patent during the entire follow-up period. One stent obstruction was identified on a follow-up CT scan 155 d after the procedure; this obstruction was caused by invasion of the PV stent by a recurrent tumor. In a study population, 8/17 patients with malignant tumors showed local recurrence of tumors, but 7 stents that were not directly invaded by the tumor remained patent during the entire follow-up period. The cumulative stent patency rate was 95.7% (Kaplan-Meier estimation; Figure 2). Follow-up CT performed 83-409 d (mean: 180.6 ± 99.5 d) after the procedure revealed small in-stent low-density areas in 11 patients (55%). In all cases, these areas were visualized in patients in whom the stents were placed through PV and SMV, within 25% of the luminal diameter. During consecutive follow-up CT, the extent of these areas slightly decreased (Figure 3). These low-density areas were located in the proximal and distal edge ($n = 9$) or mid portion ($n = 2$) of stents.

DISCUSSION

Postoperative PV stenosis is a surgical complication usually observed after concurrent resection and anastomosis of the PV after hepatobiliary and pancreatic surgery^[7,13], and LT^[1,9]. Percutaneous intervention

through transhepatic approach was firstly introduced in LT patients by Olcott *et al.*^[14]. This technique has gained worldwide acceptance for the treatment of PV stenosis after LT due to their minimal invasiveness, low number of complications, and high success rate^[15,16]. Nonetheless, the reported stenosis recurrence rate following balloon angioplasty alone has been relatively high (28.6%-36.8%). Stents have usually been used to treat recurrent and elastic portal venous stenoses following balloon angioplasty, as this procedure presents several potential complications, such as PV rupture or recoil^[15,17,18]. Therefore, Ko *et al.*^[11] suggested performing primary stent placement rather than balloon angioplasty in the early post-transplantation period (< 1 mo) to minimize the potential need of repeat surgery and the risk of anastomotic rupture during balloon angioplasty. In our study, primary stenting was performed in all patients in the same way as done in the study by Ko *et al.*^[11], given that the interval between operation and stenting was relatively short. PV stent placement success in non-transplant populations was similar to that in the LT population^[7,19,20].

In our study, all patients showed minor symptoms and signs of portal hypertension, such as nausea, intestinal angina-like pain, abnormal LFT, ascites, and increased JP drain output (no variceal bleeding was recorded). PV stenosis symptoms were identified after relatively short postoperative follow-up periods (within 2 mo, with the exception of 2 patients). Conservative management and follow-up was performed in patients presenting with intestinal angina only ($n = 5$, Table 1); however, PV stenosis in these cases was not improved during the follow-up period. Six patients presenting JP drains showed serosanguineous drainage output increase; these findings were different manifestations of ascites. Considering these observations, patients with significant PV stenosis presenting only minor symptoms, such as intestinal angina, ascites, or increased JP drain output, were recommended to be treated early. Woodrum *et al.*^[20] reported on a patient that presented with intestinal angina symptoms, with a mesenteric venogram showing near occlusion of the splenic vein and SMV. After PV stent placement, the patient's symptoms were completely relieved, which is in accordance with the results of our study.

The long-term patency of PV stents has been previously investigated. Reported stent patency was of 60%-100% during 1-2 years follow-up periods^[5,7,10,11]. Kim *et al.*^[7] performed a stent patency comparison between groups of patients presenting benign and malignant stenosis and observed that the mean patency period in the benign stenosis group was higher than that of the tumor recurrence group. The shorter patency period in the tumor recurrence group seemed to be caused by a shorter survival period rather than by tumor ingrowth into the stent due to tumor recurrence. In our study, even in those cases in which local tumor recurrence was observed, the stent remained patent unless direct tumor invasion to the stent occurred; however, further follow-up was needed



Figure 3 A 68-year-old woman (patient No. 8) presenting with main portal vein stenosis after pylorus-preserving pancreatoduodenectomy for duodenal gastrointestinal stromal tumor. She presented with anorexia and increased JP drain output during the follow-up period. A: Axial CT image 13 d after surgery showing stenosis at junction between the PV and SMV (arrowheads); B: Curved planar reformatted (CPR) image from abdominal CT 13 d after surgery showing stenosis at junction between the PV and SMV (arrow); C: Percutaneous transhepatic portogram showing severe stenosis (> 50%) at the PV-SMV junction. The pressure gradient was not measured because of definite stagnation of the contrast medium. The contrast medium injected at the distal SMV is clearly stagnant; D: Portogram showing metallic stent in the main PV and SMV and the elimination of stenosis. After the procedure, the patient's symptoms and signs improved; E: CPR image from abdominal CT 2 d after stenting showing patent stent with small in-stent low-density area (arrow); F: The extent of small in-stent low-density area decreased on CPR image from abdominal CT scan 555 d after stenting (arrow). CT: Computed tomography; PV: Portal vein; SMV: Superior mesenteric vein.

for these patients.

A pressure gradient > 5 mmHg across a stenosis has been considered "significant" in some reports^[3,18,21]. However, no standard definition regarding a significant pressure gradient currently exists. In our study, the pressure gradient in 3 patients was < 6 mmHg. We observed aggravation of stenosis in one of these patients, kinking of PV in another, and diffuse stenosis (> 50%) in the third one. Several researchers have also reported clinically successful cases of stent placement following balloon angioplasty for the treatment of PV stenosis, using a pressure gradient < 6 mmHg^[2,15,22]. Therefore, we consider that treatment is beneficial in patients who have symptoms related to PV inflow abnormalities or portal hypertension, even when the change in pressure gradient is not significant.

In some cases, small in-stent low-density areas were identified on follow-up CT scans, such as after carotid stenting^[12]. The size of these areas decreased during consecutive follow-up CT. The exact pathology of these lesions was not fully understood but did not alter the patency of the stents. Additional studies are needed to clarify these observations.

The main limitations of this study are its retrospective nature and the small number of patients. Another limiting factor is that all procedures were

usually performed based on clinical manifestations observed on CT and PV pressure gradient, not on clinical manifestations, such as intestinal angina and ascites; however, risk reduction of PV hypertension should also be considered in cases in which early intervention was recommended.

In conclusion, percutaneous transhepatic stent placement can be safe and effective in the treatment of PV stenosis developed after hepatobiliary and pancreatic surgery. Importantly, stents show excellent patency in follow-up abdominal CT scans, despite the development of small in-stent low-density areas.

COMMENTS

Background

Acquired portal vein (PV) stenosis is sometimes observed after hepatobiliary and pancreatic surgery, but treatment options for patients with PV stenosis or occlusions are limited. Surgical management of these complications has been limited by technical difficulties due to the development of postsurgical fibrosis and the lengths of the involved venous structures.

Research frontiers

Percutaneous interventional procedures have gained worldwide acceptance for their ability to alleviate the symptoms of portal hypertension because of their minimal invasiveness and high success rates, with low number of complications.

Innovations and breakthrough

This study aimed to evaluate the therapeutic efficacy and patency of PV stenting after hepatobiliary and pancreatic surgery, using abdominal CT.

Applications

Percutaneous transhepatic stent placement can be safe and effective for the treatment of PV stenosis after hepatobiliary and pancreatic surgery.

Terminology

Pressure gradient: pressure changes in two different vessels (e.g., the PV and superior mesenteric vein). This can be checked between anatomical stenoses.

Peer-review

The authors report their experience with PV/SMV stenting in patients who had previous HPB surgical resections. The study is well written and interesting as there is very little in the medical literature on this topic.

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P- Reviewer: Fusai G, Garcia-Olmo D, Tarazov PG
S- Editor: Gong ZM **L- Editor:** A **E- Editor:** Zhang FF





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ISSN 1007-9327



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