Original Article

"Wrapping the gastroduodenal artery stump" during pancreatoduodenectomy reduced the stump hemorrhage incidence after operation

Chang Xu*, Xinwei Yang*, Xiangji Luo*, Feng Shen, Mengchao Wu, Weifeng Tan, Xiaoqing Jiang

Eastern Hepatobiliary Surgery Hospital, Second Military Medical University, Chang-Hai road 225, Shanghai 200438, China
*These authors contributed equally to this work.
Correspondence to: Weifeng Tan. Eastern Hepatobiliary Surgery Hospital, Second Military Medical University, Chang-Hai road 225, Shanghai 200438, China. Email: twf1231@263.net; Xiaoqing Jiang. Eastern Hepatobiliary Surgery Hospital, Second Military Medical University, Chang-Hai road 225, Shanghai 200438, China. Email: smmu2009@gmail.com.

Objective: After pancreaticoduodenectomy (PD), the postoperative gastroduodenal artery stump (GDAS) hemorrhage is one of the most serious complications. The purpose of this study is to determine whether wrapping the GDAS during PD could decrease the postoperative GDAS hemorrhage incidence.
Methods: A retrospective review involving 280 patients who underwent PD from 2005 to 2012 was performed. Wrapping the GDAS during PD was defined as "Wrapping the GDAS using the teres hepatis ligamentum during PD". A total of 140 patients accepted the "wrapping" procedure (wrapping group). The other 140 patients didn't apply the procedure (non-wrapping group). Age, sex, preoperative data, estimated intraoperative blood loss, postoperative complications, pathologic parameters and hospitalization time were compared between two groups.
Results: There were no significant differences in patient characteristics between two groups. After wrapping, the incidence of postoperative GDAS bleeding decreased significantly (1/140 *vs.* 9/140, P=0.01). The rates of the other complications (such as intra-abdominal infection pancreatic fistula, billiary fistula, gastrointestinal bleeding, *et al.*) showed no significant differences.
Conclusions: Wrapping the GDAS during PD significantly reduced the postoperative GDAS hemorrhage incidence. And the "wrapping" had no obvious influence on other complications.

Keywords: Pancreaticoduodenectom (PD); wrapping the gastroduodenal artery stump (GDAS); GDAS hemorrhage

Submitted Apr 25, 2014. Accepted for publication Jun 05, 2014.
doi: 10.3978/j.issn.1000-9604.2014.06.08
View this article at: http://dx.doi.org/10.3978/j.issn.1000-9604.2014.06.08

Introduction

Pancreaticoduodenectomy (PD) is a standard surgical procedure for periampullary tumors with very high morbidity. The gastroduodenal artery stump (GDAS) hemorrhage is one of the potentially fatal complications after PD, often occurs 1 to 4 weeks (1-13). GDAS bleeding is usually considered to be correlated with local inflammation and corrosion due to pancreatic leakage (2-4,7-13). Although, as the octreotide and somatostatin widely used and the pancreaticojejunostomy methods gradually improved, the overall incidence of pancreatic fistula (PF) decreased, but now it is still about 2-22% (1-19). PF is difficult to avoid completely (20), thus the risk of GDAS corroded by pancreatic juice is hard to avoid completely.

Maeda *et al*. reported omental flap could be used to cover the vessels during PD, and it was benefit to reduce postoperative intra-abdominal bleeding and infection (21). Sakamoto *et al*. indicated wrapping the GDAS using the falciform ligament during PD is useful for protecting the stump of the gastroduodenal artery from pancreatic juice and for preventing hemorrhages (22). But, recently a new retrospective study revealed that the use of omentum or falciform ligament did not decrease complications after

PD (23).

We designed a retrospective historical cohort study to investigate whether wrapping the GDAS using the teres hepatis ligamentum during PD could decrease the rate of GDAS hemorrhage.

Patients and methods

Group assignment

We retrospectively reviewed complications of 280 patients (175 males and 105 females; age 12 to 76 years, average 55.7±10.4 years) who accepted PD for malignant (n=269) and benign (n=11) diseases in the Biliary Tract One Department of Eastern Hepatobiliary Surgery Hospital from January 2005 to December 2012. According to whether wrapping the stump of gastroduodenal artery, patients were divided into two groups. A total of 140 consecutive patients (85 males and 55 females; average 55.8±10.0 years) accepted the "wrapping" procedure during PD (wrapping group); the other 140 consecutive not wrapping patients (85 males and 55 females; average 55.7±10.8 years) were selected as controls (non-wrapping group). Age, sex, preoperative data, estimated intraoperative blood loss, postoperative complications, pathologic parameters and hospitalization time were compared between two groups.

Surgical approach

All of 280 patients underwent the conventional pancreaticojejunostomy. PD extent: distal-end stomach (more than 50% of whole stomach), duodenum, pancreatic head and uncinate process of pancreas, gallbladder and common bile duct were resected. Lymph node dissection extent: routine dissection at number 3, 4, 5, 6, 8, 9, 12 13 series of lymph nodes were performed. GDAS treatment: stitch ligature with 1-0 silk suture with needle, followed by number 4 silk suture ligation to strengthen was conducted. GDAS was exposed in non-wrapping group, but wrapped in wrapping group. Pancreatic-enteric anastomosis: end-to-side reconstruction, rather than duct-to-mucosa was performed. Silica gel tube was detained in the pancreatic duct to drain the pancreatic juice. Hepatic duct jejunum anastomosis: end-to-side anastomosis between common hepatic duct stump and jejunum side wall was performed and T tube was detained to drain the bile. Gastroenteric anastomosis: anastomosis between posterior wall of remnant stomach and side wall of jejunum was performed. The interval between gastrointestinal stomas and chol-intestinal stomas was about 40 cm. Jejunum side to side anastomosis (Braun anastomosis): side-to-side anastomosis was performed between input and output jejunums at about 10 cm away from gastrointestinal stomas. Peritoneal cavity drainage tube placement: one drainage tube was put in front of pancreas-intestinal stomas and another one was put behind chol-intestinal stomas.

Postoperative treatment

All patients received intensive care for at least 12 hours in ICU wards. Somatostatin was infused into patients at 4 mL/h (6 mg dissolved in 100 mL physiological saline) by minipump or 0.1 mg octreotide once per 8 hours was injected subcutaneously to inhibit pancreatin secretion until hemodiastase level dropped to normal (medication should be extended in pancreas leakage patients).

Complications criteria

PF criteria: Bassi (19) grade B and C was defined as PF, and grade A was excluded due to its light manifestation and non-special treatment. Biliary fistula criteria: bile-like liquid was observed in abdominal cavity drainage tube among the first 3 days after operation, and flow discharge was above 50 mL/d in 3 continuous days. Postoperative abdominal cavity or alimentary tract hemorrhage criteria: we referred to International Study Group of Pancreatic Surgery (ISGPS) definition (24). Postoperative infection criteria: hemogram was above upper normal level, combining with body temperature higher than 38.5 centigrade, meanwhile, positive outcome in body fluid cultivation, such as blood, abdominal fluid, sputum or bile. Delayed gastric emptying criteria (25): nasogastric tube was detained more than 10 days, and combining with at least one of the following conditions: (I) vomiting after pulling out gullet; (II) using propulsives more than 10 days after operation; (III) inserting nasogastric tube again to decompress; (IV) not able to resume oral intake; patients whose nasogastric tube was detained less than 10 days but suffered at least two of the above conditions, and were confirmed by alimentary tract iodine visualization or upper abdominal CT were also diagnosed gastric emptying disorder.

Statistical analysis

Continuous data were expressed as mean ± SD. Comparison

of categorical and continuous variables were performed using χ^2 test (or Fisher exact test where appropriate) and Student's *t*-test, respectively. Univariate and multivariate sequential analysis of risk factors for GDAS hemorrhage were performed using the binary logistic regression analysis. A P value<0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 18.0 (SPSS inc., Chicago, IL., USA).

Results

Perioperative comparison of two groups

Before operations, there were 26 (9.3%) patients without overt symptom, 220 (78.6%) with obstructive jaundice, 147 (52.5%) with abdominal pain, 113 (40.4%) jaundice combining with abdominal pain, and 34 (12.1%) with obvious weight loss (≥5 kg). Before operations, there were 67 (23.9%) hepatitis B infectors, 27 (9.6%) patients with type 2 diabetes, 22 (7.9%) patients with hypertensions, 5 (1.8%) patients with hepatic cyst, 3 (1.1%) patients with hepatic haemangioma, 3 (1.1%) patients with chronic superficial gastritis and ulcers, two (0.7%) patients with gallbladder stones, 2 (0.7%) patient with renal cyst, 1 (0.4%) patient with intrahepatic bile duct stone, 1 (0.4%) patient with schistosomiasis hepatic cirrhosis, 1 (0.4%) patient with chronic pancreatitis, 1 (0.4%) patient with bronchopneumonia, 1 (0.4%) patient with asthma, 1 (0.4%) patient with gout, 1 (0.4%) patient with depression, 1 (0.4%) patient with neuroma and 1 (0.4%) patient with left eye blindness. A total of 25 (8.9%) patients had upper abdominal surgery history. There were no significant differences between wrapping group and non-wrapping group on age, sex, preoperative manifestations and examination results, preoperative jaundice treatment, size of tumor, pathological diagnosis, main concomitant diseases, upper abdominal operation history, intra-operative hemorrhage volume and hospitalization time (Detailed in *Table 1*).

Complications of two groups

A total of 133 (47.5%) patients suffered from postoperative complications: 47 (16.8%) patients got two or more kinds of complications. There was no significant difference between wrapping group and unwrapping group in the incidence of total complications (69/140 *vs.* 64/140, P=0.550). The gastroduodenal stump massive hemorrhage rate was significantly lower in wrapping group than that in non-wrapping group (1/140 *vs.* 9/140, P=0.010); Meanwhile, no significant difference was observed between two groups on other complications, for example, other reasons intra-abdominal massive hemorrhage (except GDAS bleeding) (4/140 *vs.* 1/140, P=0.370), gastrointestinal massive hemorrhage (14/140 *vs.* 10/140, P=0.393), intra-abdominal infection (37/140 *vs.* 26/140, P=0.115), PF (7/140 *vs.* 14/140, P=0.112), billiary fistula (2/140 *vs.* 3/140, P=0.652) and delayed gastric emptying (7/140 *vs.* 13/140, P=0.164).

Table 1 Patient characteristics of the two groups

	Total (n=280)	Wrapping group (n=140)	Unwrapping group (n=140)	P value
Age (y)	55.7±10.4	55.8±10.0	55.7±10.8	0.995
<60	170	85	85	1.000
≥60	110	55	55	
Gender				
Male	175	85	90	0.537
Female	105	55	50	
HBV infection				
Yes	67	36	31	0.484
No	213	104	109	
Diabetes				
Yes	27	16	11	0.311
No	253	124	129	

Table 1 (*continued*)

Table 1 (*continued*)

	Total (n=280)	Wrapping group (n=140)	Unwrapping group (n=140)	P value
Hypertension				
Yes	22	15	7	0.076
No	258	125	133	
Upper abdominal surgery history				
Yes	25	11	14	0.530
No	255	129	126	
Obvious weight loss (kg)				
Not obvious (<1)	213	104	109	0.696
1-5	33	19	14	
5-10	24	11	13	
≥10	10	6	4	
Abdominal pain				
Yes	147	70	77	0.402
No	133	70	63	
Preoperative TBil grades (μmol/L)				
1: <34.2	85	41	44	0.337
2: 34.2-171	93	52	41	
3: 171-342	77	38	39	
4: ≥342	25	9	16	
Preoperative serum albumin level (g/L)				
1: <35	23	12	11	0.828
2: ≥35	257	128	129	
Preoperative prothrombin time grades (s)				
1: ≤14	275	136	139	0.370*
2: >14	5	4	1	
Preoperative biliary drainage				
Yes	107	53	54	0.902
No	173	87	86	
Diameter of tumor (cm)	2.5±1.5	2.5±1.9	2.4±1.1	0.156
Pathologic diagnosis				
Pancreatic cancer	47	21	26	0.192
Distal common bile duct cancer	87	45	42	
Ampulla of vater cancer	39	19	20	
Duodenal cancer	80	41	39	
Other malignancies	16	5	11	
Benign diseases	11	9	2	
Estimated intraoperative blood loss (mL)				
1: ≤800	269	134	135	0.758
2: >800	11	6	5	

*, Fisher exact test.

Table 2 Postoperative complications of two groups

Complications	Total (n=280) No. (%)	Wrapping group (n=140) No. (%)	Unwrapping group (n=14) No. (%)	P value
Total complication	133 (47.5)	69 (49.3)	64 (45.7)	0.550
GDAS bleeding	10 (3.6)	1 (0.7)	9 (6.4)	0.010
Intra-abdominal massive bleeding (Except GDAS bleeding)	5 (1.8)	4 (2.9)	1 (0.7)	0.370
Left gastric artery bleeding	1 (0.4)	1 (0.7)	0 (–)	
Left hepatic artery bleeding	1 (0.4)	1 (0.7)	0 (–)	
Retroperitoneum bleeding	1 (0.4)	1 (0.7)	0 (–)	
For unknown reasons	2 (0.7)	1 (0.7)	1 (0.7)	
Gastrointestinal massive bleeding	24 (8.6)	14 (10.0)	10 (7.1)	0.393
Intra-abdominal infection	63 (22.5)	37 (26.4)	26 (18.6)	0.115
Delayed gastric emptying	20 (7.1)	7 (5.0)	13 (9.3)	0.164
Pancreatic fistula	21 (7.5)	7 (5.0)	14 (10.0)	0.112
Billiary fistula	5 (1.8)	2 (1.4)	3 (2.1)	1.000
Billiary infection	8 (2.9)	6 (4.3)	2 (1.4)	0.282
Respiratory infection	28 (10.0)	18 (12.9)	10 (7.1)	0.111
Delayed wound healing	10 (3.6)	6 (4.3)	4 (2.9)	0.735
Pleural effusion	7 (2.5)	2 (1.4)	5 (3.6)	0.447
Urinary tract infection	2 (0.7)	1 (0.7)	1 (0.7)	1.000
Atrial fibrillation	1 (0.4)	1 (0.7)	0 (–)	1.000
Reoperation	7 (2.5)	5 (3.6)	2 (1.4)	0.447
GDAS massive bleeding	1 (0.4)	0 (–)	1 (0.7)	
Left gastric artery massive bleeding	1 (0.4)	1 (0.7)	0 (–)	
Retroperitoneum hemorrhage	1 (0.4)	1 (0.7)	0 (–)	
Gastrointestinal bleeding	2 (0.7)	2 (1.4)	0 (–)	
Delayed wound healing	2 (0.7)	1 (0.7)	1 (0.7)	
Postoperative death	5 (1.8)	2 (1.4)	3 (2.10)	1.000*
GDAS hemorrhage	2 (0.7)	0 (–)	2 (1.4)	
Gastrointestinal bleeding	2 (0.7)	1 (0.7)	1 (0.7)	
Heart failure	1 (0.4)	1 (0.7)	0 (–)	
Hospital time (days)	32±14	32±14	32±13	0.645

*, Fisher exact test. GDAS, gastroduodenal artery stump.

Complications relating with teres hepatis ligamentum wrapping GDAS, such as hepatic arteriostenosis, hepatophyma etc. didn't occur to all patients in wrapping group. Seven patients (2.5%) accepted reoperation: one for GDAS hemorrhage, one for left gastric artery hemorrhage, one for retroperitoneum hemorrhage, two for gastrointestinal hemorrhage and two for delayed wound healing. Six patients (6/7) recovered after reoperation, and one patient (1/7) who accepted reoperation for gastrointestinal bleeding died. There was no significant difference between wrapping group and unwrapping group on the reoperation rate (5/140 *vs*. 2/140, P=0.447). Five (3.11%) patients died within 60 days after operations. Two patients died of postoperative GDAS hemorrhage, two patients died of postoperative gastrointestinal bleeding, and one patient died of postoperative heart failure. The rate of postoperative mortality (2/140 *vs*. 3/140, P=1.000) was unanimous statistically (Detailed in *Table 2*).

Table 3 Patients complicated with gastroduodenal artery stump hemorrhage

Patient no	Age/gender	Interval* (d)	Management	Outcomes
1	66M	15	DSA + TAE	Death
2	53M	8	DSA + TAE	Alive
3	55M	12	DSA + TAE	Alive
4	68F	13	DSA + TAE	Death
5	65M	26	DSA + TAE	Alive
6	61M	22	DSA + TAE	Alive
7	46F	20	DSA + TAE	Alive
8	59M	22	DSA + TAE	Alive
9	61M	12	DSA + TAE + Reoperation	Alive
10	47M	43	DSA + TAE	Alive

*, Interval between pancreaticoduodenectomy and gastroduodenal artery stump hemorrhage.

Treatment and prognosis of GDAS hemorrhage

The GDAS hemorrhage occurrence time of ten patients were at least one week (range from 8 to 43 days) after operations. Digital selective angiography (DSA) and transcatheter arterial embolization (TAE) were performed to stanch bleeding for all of ten GDAS hemorrhage patients, and seven (7/10) of them got successful hemostasis. One patient got hemorrhage volume decreased, and underwent emergent surgical hemostasis successfully after his shock was eased, but the other two kept bleeding after DSA + TAE, and shock were even aggravated, thus emergent surgical hemostasis could not be performed and these two patients died as a result (Detailed in *Table 3*).

Discussion

"Wrapping" reduced the GDAS hemorrhage incidence after PD

Traced back to the 20th century, with the invention and widely utilization of somatostatin and octreotide, the incidence of PF and postoperative intra-abdominal hemorrhage relating to PF have been decreased obviously (26,27). In recent years, retrospective or RCT researches on improving pancreatic juice drainage (28-32) and pancreatic-enteric anastomosis (33-42) have been done all over the world, in order to further reduce the PF incidence. However, none of these methods have been demonstrated significant superiority (43), and Peng *et al*. (20) considered that due to the injuries on pancreatic parenchyma and minor ductus pancreaticus caused by needle and thread during pancreatic-enteric anastomosis, PF is inevitable, and slight PF evokes severe PF. Now the overall incidence of PF is still about 2-22% (1-19), and the incidence of PF who need clinical treatment according to Bassi grading criteria in this study is 7.5%, which is correspondent with former reports. After hepatoduodenal ligament lymph node dissection during PD, GDAS is exposed nearby pancreas-intestinal stomas, and is easily got corroded by pancreatic juice, thus causing a high risk of hemorrhage. Although PF is not the direct death cause, GDAS hemorrhage is possibly fatal. The intra-abdominal hemorrhage rate after PD is approximately 5-16% according to report (44), among which GDAS is a frequent bleeding locus (3-6,8-13,22), and PF and intra-abdominal infection are key risk factors of intra-abdominal hemorrhage (2-4,7-13). In our study, the total postoperative intra-abdominal hemorrhage rate was 5.4% (15/280), but GDAS hemorrhage took up 66% (10/15) of them, which is similar to former results by other scholars.

PF is difficult to avoid completely (20), thus the risk of GDAS corroded by pancreatic juice can not be avoided completely. Some scholars (21,22,45) began to use the omentum or falciform ligament to cover/wrap the exposed major blood vessels, in order to protect the vessels from pancreatic juice and reduce the incidence of postoperative intra-abdominal bleeding. For example, Maeda *et al*. indicated only one patient (1/100) occurred postoperative intra-abdominal bleeding after covering the vessels using omental flap during PD (21); Abe *et al*. reported none patient (0/36) developed late post-pancreatectomy hemorrhage after the pedicled falciform ligament was used to cover the major exposed vessels, and was fixed to the surrounding retroperitoneal connective tissue (45); Sakamoto *et al*. reported just one patient (1/136) developed GDAS hemorrhage after

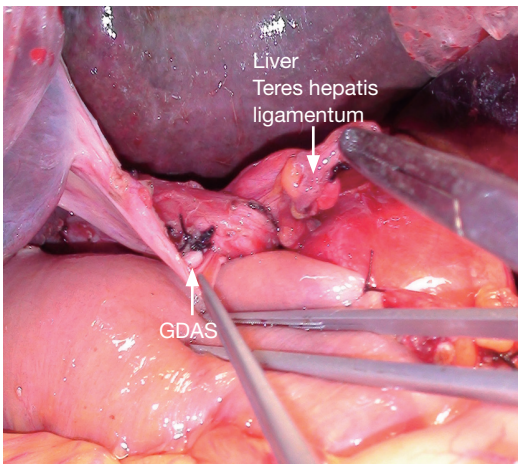

Figure 1 GDAS was wrapped by the teres hepatis ligamentum from the rear. GDAS, gastroduodenal artery stump.

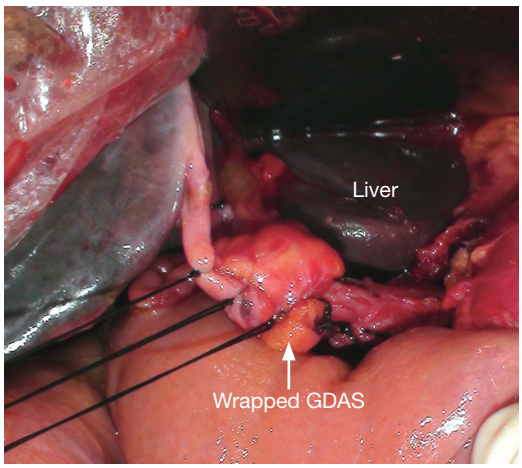

Figure 2 GDAS was entirely wrapped by the teres hepatis ligamentum with using thread fixed. GDAS, gastroduodenal artery stump.

wrapping the GDAS using the falciform ligament (22). In our study, only one patient (1/140) developed GDAS hemorrhage after GDAS wrapping by teres hepatis ligamentum, which was similar with the outcome in single arm, non-control group clinical research by Maeda *et al*., Sakamoto *et al*. and Abe *et al*. (21,22,45). We adopted the non-wrapping patients as control, and found that GDAS hemorrhage incidence was significantly lower in wrapping group than in non-wrapping group (1/140 *vs*. 9/140, P=0.010), which indicated that wrapping GDAS is beneficial to reduce GDAS bleeding incidence. On the contrary, a recent retrospective study of the Japanese Society of Pancreatic Surgery indicated that using omentum or falciform ligament did not decrease the incidence of intra-abdominal hemorrhage after PD (23). On one hand, the study adopted polycentric retrospective data, while statistical bias may occur for the fact that the operation standard differed from each center and researchers cumulated the data from different centers directly; on the other hand, whether wrapping GDAS can intrinsically reduce GDAS hemorrhage incidence is still under debate, and RCT study is an urgent need in order to find out the value of wrapping GDAS.

"Wrapping" had no obvious influence on other complications

For instance, no significant difference was observed on the postoperative PF incidence in two groups (7/140 *vs*. 14/140, P=0.112), which is similar to former results (21-23,45). Maeda *et al*. advocated that wrapping porta hepatic blood vessel by omentum majus could reduce the incidence of postoperative intra-abdominal infection after PD (21), while our data did not show significant difference on intra-abdominal infection between two groups (37/140 *vs*. 26/140, P=0.115). There were no such complications as hepatic artery stenosis, hepatic function recovery disorder, and hepatophyma that relating to the wrapping procedure in the wrapping group, which was similar to the results obtained by Maeda *et al*. (21) and Abe *et al*. (45).

GDAS should be entirely "wrapped" with gentle approach

The approach we adopted to wrap GDAS is similar to that reported by Sakamoto *et al*. (22) (*Figure 1*). However, they wrapped GDAS by the pedicled falciform ligament, and we chose the pedicled teres hepatis ligamentum. Although the procedure of wrapping GDAS is simple and low time-consuming, there are two key points that should be noticed: (I) GDAS should be wrapped entirely to separate from the site of pancreatojejunostomy; (II) wrapping should not be too tight to affect the hepatic artery blood supply (*Figures 1,2*). Our data showed: there were no significant differences between wrapping group and non-wrapping group on the other postoperative complications (except GDAS hemorrhage incidence).

DSA + TAE was useful for early stage of GDAS hemorrhage, but once hemodynamic instability occurred emergency surgical hemostasis might be more profitable

Due to the fact that gastroduodenal artery (GDA) has a

crude caliber, and once hemorrhea happens, it arouses shock and life-threatening result if bleeding cannot be controlled promptly and effectively. Now that medical treatment cannot stop bleeding effectively, DSA + TAE or emergent surgical hemostasis are the possible approaches to rescue lives. Sato *et al*. considered it is vital to perform early angiography in patients with intra-abdominal hemorrhage (13). Choi *et al*. indicated TAE provides not only a basic treatment, but also a temporary hemostatic effect that makes it easy to reoperate if necessary (4). But, Tien *et al*. considered that TAE could not be safely performed after hemodynamic instability occurred, so they performed surgical hemostasis on 70% GDAS hemorrhage patients (46). According to this study we performed DSA + TAE treatment in all of ten GDAS bleeding patients. Seventy percent (7/10) of them got successful hemostasis. One patient (10%) got hemorrhage volume decreased, after his shock was eased, emergent surgical hemostasis performed successfully. But 20% (2/10) of them failed, both of them accepted DSA + TAE treatment with unstable hemodynamics and died (shock was even aggravated after DSA + TAE treatment, and the chances of the emergent surgical hemostasis were lost. Thus, we considered that DSA + TAE treatment might be extremely useful for early stage of GDAS hemorrhage patients, but once hemodynamic instability occurred DSA + TAE treatment might not be profitable and emergency surgical hemostasis should be taken as soon as quickly.

Acknowledgements

This study was funded by A new round of the Shanghai Health System outstanding young talent training plan (XYQ2011030).
Disclosure: The authors declare no conflict of interest.

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Cite this article as: Xu C, Yang X, Luo X, Shen F, Wu M, Tan W, Jiang X. "Wrapping the gastroduodenal artery stump" during pancreatoduodenectomy reduced the stump hemorrhage incidence after operation. Chin J Cancer Res 2014;26(3):299-308. doi: 10.3978/j.issn.1000-9604.2014.06.08

