Double-balloon-enteroscopy-based endoscopic retrograde cholangiopancreatography in post-surgical patients

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Abstract

AIM: To evaluate double balloon enteroscopy (DBE) in post-surgical patients to perform endoscopic retrograde cholangiopancreatography (ERCP) and interventions.

METHODS: In 37 post-surgical patients, a stepwise approach was performed to reach normal papilla or enteral anastomoses of the biliary tract/pancreas. When conventional endoscopy failed, DBE-based ERCP was performed and standard parameters for DBE, ERCP and interventions were recorded.

RESULTS: Push-enteroscopy (overall, 16 procedures) reached enteral anastomoses only in six out of 37 post-surgical patients (16.2%). DBE achieved a high rate of luminal access to the biliary tract in 23 of the remaining 31 patients (74.1%) and to the pancreatic duct (three patients). Among all DBE-based ERCPs (86 procedures), 21/23 patients (91.3%) were successfully treated. Interventions included ostium incision or papillotomy in 6/23 (26%) and 7/23 patients (30.4%), respectively. Biliary endoprosthesis insertion and regular exchange was achieved in 17/23 (73.9%) and 7/23 patients (30.4%), respectively. Furthermore, bile duct stone extraction as well as ostium and papillary dilation were performed in 5/23 (21.7%) and 3/23 patients (13.0%), respectively. Complications during DBE-based procedures were bleeding (1.1%), perforation (2.3%) and pancreatitis (2.3%), and minor complications occurred in up to 19.1%.

CONCLUSION: The appropriate use of DBE yields a high rate of luminal access to papilla or enteral anastomoses in more than two-thirds of post-surgical patients, allowing important successful endoscopic therapeutic interventions.

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Key words: Double balloon enteroscopy; Endoscopic retrograde cholangiopancreatography; Choledochojejunostomy; Hepaticojejunostomy; Pancreaticojejunostomy; Percutaneous cholangiopancreatography

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INTRODUCTION

With the technique of push-and-pull enteroscopy by a double balloon endoscope, it is possible to advance much deeper into the small intestine than using a conventional push-enteroscope. Double balloon enteroscopy (DBE) has been successfully applied for diagnosis and treatment of various small intestinal diseases, such as mid-gastrointestinal bleeding, polyposis syndromes, Crohn’s disease, lymphoma, foreign body impaction, or other inflammatory or neoplastic diseases in the jejunum or ileum. Although the introduction of DBE by Yamamoto has brought a significant benefit for the management of various small intestinal diseases, its value in the diagnosis and treatment of biliary or pancreatic diseases in patients after complex abdominal or bilio-pancreatic surgery has recently been reported in some case studies of selected patients. The emerging role of DBE in postoperative endoscopic procedures arises from the fact that conventional endoscopy using side-viewing endoscopes, forward viewing push-enteroscopes, or (pediatric) colonoscopes has often been reported to be unsatisfactory in patients after partial or total gastrectomy (Billroth II, gastrojejunostomy, Roux-en-Y reconstruction), Whipple resection or bilo-pancreatic reconstructions (pancreaticojejunostomy, choledocho-choledochostomy, hepaticojejunostomy). For example, in the pre-DBE era, conventional endoscopic access to the afferent loop and/or choledocho-, hepatico- or pancreaticojejunostomy was extremely difficult because of various lengths of bowel to be traversed, unfortunate locations of low jejunal anastomoses, jejunal loops of differing lengths, fixed jejunal loops, angulation or postoperative strictures and changes.

Failure of endoscopic access and therapy in post-surgical patients with normal papilla, choledocho-, hepatico- or pancreaticojejunostomy often results in more invasive and cost-intensive procedures such as percutaneous transhepatic cholangiography (PTC), computed tomography (CT)-guided pancreatic drainage, or repeated surgery. A training model for balloon-assisted enteroscopy and hepatobiliary interventions has been established by our group to learn, facilitate and adequately perform modern enteroscopic interventions. Therefore, this study describes our clinical results from the prospective use of DBE in performing cholangio- and pancreatoigraphy, including therapeutic interventions of the biliary and pancreatic tract in a group of 37 consecutive post-surgical patients.

MATERIALS AND METHODS

Patient population

Between August 2005 and December 2008, 45 consecutive
anatomy, location of the foot-point anastomosis and the route to the afferent loop were each exactly documented, as well as time requirements for each diagnostic and therapeutic step. Foot-point anastomosis and the afferent loop were marked by India ink. Forward-viewing PE-based ERCP was performed using the typical ERCP technique as described previously\(^{[18-21]}\).

### DBE

DBE was performed using a standard technique, starting in the left lateral position, and thereafter changing to the prone position as described by Yamamoto and other authors\(^{[6-9]}\). At times, manual compression to guide the enteroscope in the abdomen and radiography were necessary. Provided that the anatomical situation and access to papilla or ostium of the enteroanastomoses were clarified, the afferent loop in proximity to the foot-point anastomosis was marked with clips and India ink on retraction of the enteroscope, so that this location would be found quicker in a future examination. Using a standardized protocol, the advance was exactly documented during DBE, and the respective anatomical depth of foot-point anastomosis and papilla and ostium region were determined with the retracted and (as much as possible) straightened enteroscope. The time taken for this procedure and the whole procedure were also recorded. If during enteroscopy, advance failed, the enteroscope slid back, or if pain was experienced by the patient, radiography was applied to avoid kinking, to straighten loops and to retract the enteroscope carefully.

### DBE-based ERCP

When papilla or pancreatico-, choledocho-, or hepatopancreaticojejunostomy were needed, ERCP was applied using the push-and-pull enteroscope, a forward-viewing endoscope of 2 m working length, without elevator lever\(^{[19-21]}\). This was assisted by X-rays for radiographic imaging of bile ducts and/or pancreatic ducts or a pancreatic cyst. Appropriate stabilization of the enteroscope with the overtube and/or enteroscope balloon was often required before performance of ERCP.

After administration of contrast medium and diagnostic papillotomy or, an initial bougienage and/or incision of a stenotic ostium of the hepatopancreaticojejunostomy was performed. This was achieved by the use of a 5 and 6 Fr Huibregtse catheter and/or a 6 Fr papillotome (Olympus, intended for SIF Q140 enteroscope), or a snare. Further interventions aided by a 5-m guide wire (Metroguide wire; Cook, Limerick, Ireland) were implantation of endoprostheses (5-8 Fr) or of biliary 7 Fr nasobiliary probes, stone removal, or ostium and papilla dilation using either a CRE-dilation balloon (CRE 8-10 mm balloon; Cook) or a basket.

With regard to prosthesis change, the old prosthesis was at first mobilized with a foreign-body forceps or a loop, and extracted and placed in the afferent loop. After DBE-ERCP implantation of the new prostheses was completed, the old prostheses were fixed again with the loop and extracted from the patient during the final retraction of the double balloon enteroscope.

### RESULTS

#### Patient population

During the period between August 2005 and December 2008, 45 post-surgical patients were admitted to hospital for endoscopy. Eight of these patients with partial gastrectomy (Billroth II, without Roux-en-Y reconstruction) could initially be successfully treated with gastroduodenoscopy or side-viewing duodenoscopy alone, and were therefore excluded from the prospective study. In the remaining 37 patients with complex abdominal surgery, neither a gastroscope nor duodenoscope gained initial access to the papilla or ostium, such that PE, and if it failed, then DBE were necessary.

#### Previous types of abdominal surgery

Previous abdominal surgery of the remaining 37 patients (Table 1) was partial gastrectomy in eight patients (Billroth II-resection, 21.6%), four patients had further resections after B-II-resection, five patients with Roux-en-Y reconstruction; total gastrectomy with Roux-en-Y loop in seven patients (18.9%), and classical or modified Whipple operation with Roux-en-Y loop in seven patients (18.9%). Fifteen patients had normal stomach anatomy after biliary surgery with reconstruction of a choledocho- or hepatopancreaticojejunostomy via Roux-en-Y loop (40.5%).

Thus, 34 patients had previously undergone Roux-en-Y construction (91.8%), whereas only three had an end-to-side gastrojejunostomy that contained an afferent and efferent loop (8.1%).

Among all post-surgical patients, 24/37 patients (64.8%) had a final diagnosis of choledocho- or hepatopancreaticojejunostomy (23 Roux-en-Y, one dorsal gastrojejunostomy), while 13 patients (35.1%) still had a normal papilla. The pancreaticojejunostomy had to be searched additionally in only three of these patients (8.1%) (Table 2).

#### Indications for ERCP and interventional procedures

With regard to the indication, it was necessary to radiograph the bile ducts of 34 patients (91.8%), because these patients were admitted for cholestasis (59.3%), cholangitis (28.1%), or choledocholithiasis (13.3%), with a view to PTCD or re-operation. Radiography of the pancreatic duct was required in only three patients (8.1%), because of the presence of a pancreatic pseudocyst and suspected or advanced chronic pancreatitis, respectively (Table 1).

Due to the complex anatomical situation in seven patients (18.9%) with recurrent disease, 37 PTCDs had already been performed in these individuals before the introduction of DBE-ERCP (Table 2).

#### Access to papilla and entero-anastomoses by PE and DBE

The individual endoscopic accessibility and anatomical
Table 1. Characteristics of post-surgical patients receiving push-enteroscopy or double balloon enteroscopy-endoscopic retrograde cholangiopancreatography

| Pts. | Age/sex | Indication | Previous surgery | Access by G/T/P |
|------|---------|------------|------------------|-----------------|
| 1    | 72 f    | Recurrent cholangitis | LTX, Roux Y, hepaticojejunostomy | No |
| 2    | 76 m    | Malignant cholestasis | Partial gastrectomy (B II) | No |
| 3    | 60 m    | Liver abscesses | Whipple resection, Roux Y, hepaticojejunostomy | P |
| 4    | 66 m    | Benign cholestasis | CHE, Roux Y, hepaticojejunostomy | P |
| 5    | 52 f    | Benign cholestasis | Complicated CHE, Roux Y, hepaticojejunostomy | No |
| 6    | 79 f    | Postsurgical bile duct leakage | Complicated CHE partial gastrectomy (B II) | P |
| 7    | 38 m    | Recurrent cholangitis | Congenital bile duct atresia Roux Y, hepaticojejunostomy | No |
| 8    | 66 m    | Pancreatitis with pseudocyst | Pylorus preserving pancreatic head resection, Roux Y, hepatico- & pancreaticojejunostomy | No |
| 9    | 58 f    | Benign cholestasis abdominal pain | Total gastrectomy, Roux Y, hepaticojejunostomy | No |
| 10   | 64 f    | Benign cholestasis with cholangitis | CHE, right hemihepatectomy, Roux Y, hepaticojejunostomy | No |
| 11   | 50 f    | Benign cholestasis, bile duct stones | Dorsal gastroenterostomy with hepaticojejunostomy | G |
| 12   | 51 f    | Benign cholestasis | CHE, partial gastrectomy (B II) with Roux Y | No |
| 13   | 81 f    | Malignant cholestasis | CHE, partial gastrectomy (B II) with Roux Y | No |
| 14   | 52 f    | Benign cholestasis | Complicated CHE, Roux Y, hepaticojejunostomy | No |
| 15   | 71 m    | Malignant cholestasis | Complicated CHE, partial gastrectomy (B II), Roux Y | No |
| 16   | 69 f    | Recurrent cholangitis | CHE, Roux Y, hepaticojejunostomy | No |
| 17   | 47 f    | Cholangitis, malignant cholestasis | Total gastrectomy, Roux Y, hepaticojejunostomy | T |
| 18   | 67 m    | Benign cholestasis | LTX, bile duct revision, Roux Y, hepaticojejunostomy | No |
| 19   | 51 f    | Benign cholestasis, bile duct stones | LTX, bile duct revision, Roux Y, hepaticojejunostomy | No |
| 20   | 68 f    | Benign cholestasis, chronic pancreatitis | Total gastrectomy, Roux Y | No |
| 21   | 71 m    | Recurrent cholangitis | Modified Whipple resection, Roux Y, hepaticojejunostomy | No |
| 22   | 68 m    | Malignant cholestasis | Partial gastrectomy (B II) with Roux Y | No |
| 23   | 64 f    | Malignant cholestasis | CHE, small bowel & colon resection, Roux Y, hepatico-jejunostomy | No |
| 24   | 61 m    | Suspected malignant cholestasis | Modified Whipple resection, Roux Y, hepaticojejunostomy | No |
| 25   | 62 m    | Malignant cholestasis | Total gastrectomy, Roux Y | P |
| 26   | 73 m    | Benign cholestasis | Pylorus preserving pancreatic head resection, Roux Y, hepatico- & pancreaticojejunostomy | No |
| 27   | 76 m    | Benign cholestasis | Total gastrectomy, Roux Y | No |
| 28   | 76 f    | Malignant cholestasis | Total gastrectomy, Roux Y | No |
| 29   | 84 m    | Malignant cholestasis | Partial gastrectomy (B II) with Roux Y | No |
| 30   | 54 m    | Choleodocholithiasis, cholangitis | Complicated CHE, Roux Y, choledochojejunostomy | No |
| 31   | 74 m    | Choleodocholithiasis | Total gastrectomy, Roux Y | No |
| 32   | 61 m    | Recurrent cholangitis | LTX, bile duct revision, Roux Y, choledochojejunostomy | P |
| 33   | 55 m    | Suspected malignant cholestasis, chronic pancreatitis | Whipple resection, Roux Y, hepato- & pancreato-jejunostomy | No |
| 34   | 34 f    | Biliary colic, benign cholestasis hepatitis C | LTX, Roux Y, hepaticojejunostomy | P |
| 35   | 64 m    | Suspected malignant cholestasis, chronic pancreatitis | Whipple resection, Roux Y, hepato- & pancreato-jejunostomy | No |
| 36   | 51 f    | Suspected choleodocholithiasis, right abdominal pain | LTX, Roux Y, choledochojejunostomy | No |
| 37   | 61 m    | Recurrent cholangitis | Complicated CHE, Roux Y, hepaticojejunostomy | No |

*Only after previous double balloon enteroscopy; †Only after previous double balloon enteroscopy and by use of a short-specialised, large caliber overtube (16.8 mm); Patients indicate initial failure of DBE-based ERCP. G: Gastroscope; T: Side-viewing duodenoscope; P: Push-enteroscope; CHE: Cholecystectomy; B II: Billroth II resection; LTX: Liver transplantation; DBE: Double balloon enteroscopy; ERCP: Endoscopic retrograde cholangiopancreatography.

The push-enteroscope could reach the papilla or the enterostomoses in only 6/37 cases (16.2%), while DBE had to be applied in 31 post-surgical patients (83.7%).

With DBE, access to papilla, choledocho-, hepatico- or pancreaticojejunostomy could be successfully and repeatedly achieved in 23 out of 31 patients (74.1%).

A total of 86 DBE-ERCPs were undertaken in those 31 patients, who failed to be successfully examined by PE. Seventy-five of the 86 DBE examinations (87.2%) were successfully carried out as a diagnostic or therapeutic

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depth of the anastomoses, as well as of the papilla and the ostium of the choledocho- or hepaticojejunostomy and of the pancreaticojejunostomy using PE and DBE are described in Tables 1 and 2. The average depth of all anastomoses (three Billroth II gastrojejunostomy, 34 foot-point anastomoses jejunoojenostomy) was 71 ± 21 cm, and the length of the afferent loop to the papilla or enteroa-anastomosis measured a further 53 ± 26 cm.

In total, a median of four (2-19, 25th-75th percentile) balloon-assisted enteroscopic cycles had to be performed after the passage of the anastomosis to the papilla or ostium were reached by DBE. Manual compression to guide the enteroscope was necessary in most patients.

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DBE-ERCP (Tables 1-3), while 11 examinations (12.7%) in eight patients were unsuccessful.

After the initial, successful DBE-ERCP in two patients, the papilla and ostium of the hepaticojejunostomy, respectively, could be reached afterwards with the side-viewing endoscope or gastroscope. However, both treatments only worked after previous DBE, during which a large caliber overtube (17 mm, length 110 cm; Fujinon Europe) was inserted as a guide bar and the hepaticojejunostomy, located in an intestinal loop, was made visible through an inserted prosthesis.

Failure of PE and DBE to reach papilla or enterooanastomoses

In 8/31 patients (25.8%), despite DBE application, access to the bile ducts could not be achieved for a number of reasons (Tables 1 and 2): the anastomosis region was considerably swollen (one patient); the afferent loop was technically not intubatable (one patient); the papillary or ostial region was infiltrated or covered by a tumor (four patients); or the ostium of the hepaticojejunostomy could not be found (one patient). Seven of these 8 patients (87.5%)...
Table 3  Results of push-enteroscopy and double balloon enteroscopy-endoscopic retrograde cholangiopancreatography: therapeutic measures and (means ± SD) of sedation, X-rays and procedure time

| Pts. | Push ERCP-/DBE-ERCP | Sedation | X-ray | Procedure Time (min) |
|------|---------------------|----------|-------|----------------------|
|      | Procedures          | Therapy  | Dose (mg) | Drug | Time (min) | Dose (10³ cGy/cm²) |
| 1    | 7                   | Ostium incision (snare, papillotome) dilation, 2 stents inserted, regular change of 2 stents/1 yr | 12.8 ± 3 | Midazolam | 19 ± 11 | 3.4 ± 2 | 122 ± 158 |
|      |                     |          | 132 ± 31 | Pethidine |      |    |     |
|      |                     |          | 10.0    | Midazolam | 3.3    | 1.0  | 82  |
|      |                     |          | 100     | Pethidine | 120    | Butylscopolamine |      |  |
| 2    | 1                   | Not successful, re-operation | 15.0 ± 1 | Midazolam | 7.5 ± 7 | 1.8 ± 1.9 | 115 ± 79 |
|      |                     |          | 125 ± 35 | Pethidine | 40     | Butylscopolamine |      |  |
| 3 P  | 3                   | Ostium incision (papillotome), dilation, stent insertion, regular change of stent/1 yr | 12 ± 2 | Midazolam | 20 ± 29 | 3.1 ± 1.6 | 110 ± 171 |
|      |                     |          | 137 ± 25 | Pethidine |      |    |     |
|      |                     |          | 5       | Diazepam | 2.8 ± 1 | 4.0 ± 0.2 | 77 ± 11 |
| 4 P  | 4                   | Stent insertion, regular change of stent/1 yr | 12 ± 1 | Midazolam | 10.0 | 7.8 ± 0.4 | 5.1 ± 0.5 | 30 ± 71 |
|      |                     |          | 150     | Pethidine | 169 ± 38 | Butylscopolamine |      |  |
|      |                     |          | 40      | Diazepam | 10.1 | 1.0 | 91  |
| 5    | 2                   | Not successful, PTCD | 11.2 ± 5 | Midazolam | 12.6 ± 9 | 0.6 ± 0.4 | 61 ± 12 |
|      |                     |          | 133 ± 28 | Pethidine | 115 ± 74 | Butylscopolamine |      |  |
|      |                     |          | 9.5 ± 1  | Midazolam | 8.1 ± 2 | 0.7 ± 0.4 | 61 ± 22 |
| 6 P  | 2                   | Stent insertion, closure of bile duct leakage | 1082 ± 476 | Propofol | 14 ± 8 | 3.1 ± 1.8 | 113 ± 97 |
|      |                     |          | 156 ± 77 | Pethidine | 11.6 ± 11 | 2.5 ± 2.6 | 178 ± 98 |
| 7    | 9                   | Ostium incision (papillotome), 2 stents inserted, regular change of stents/1 yr | 1691 ± 867 | Midazolam | 13 ± 4 | 5.9 ± 2.9 | 77 ± 61 |
|      |                     |          | 163 ± 74 | Pethidine | 16.8 ± 4 | 2.0 ± 0.2 | 161 ± 92 |
| 8    | 4                   | Bougienage pancreaticojejunoanostomy, stent insertion into pancreatic duct and pseudocyst; normal hepatico-jejunoanostomy | 13.3 ± 2 | Midazolam | 11.8 ± 9 | 2.0 ± 2.5 | 161 ± 92 |
|      |                     |          | 138 ± 30 | Pethidine | 140 ± 28 | Butylscopolamine |      |  |
| 9    | 1                   | Normal hepaticojejunoanostomy | 14 | Midazolam | 10.1 | 0.5 | 91  |
|      |                     |          | 150 | Pethidine | 126 ± 9 | 0.6 ± 0.4 | 61 ± 12 |
| 10   | 4                   | 3 stents inserted, one change of 2 stents | 11.2 ± 5 | Midazolam | 12.6 ± 9 | 0.6 ± 0.4 | 61 ± 12 |
|      |                     |          | 133 ± 28 | Pethidine | 116 ± 33 | Butylscopolamine |      |  |
| 11   | 4                   | Insertion nasobiliary probe, dilation, stone extraction, insertion of stent | 125 ± 35 | Midazolam | 8.1 ± 2 | 0.7 ± 0.4 | 61 ± 22 |
|      |                     |          | 20 | Pethidine | 14 ± 8 | 3.1 ± 1.8 | 113 ± 97 |
| 12   | 8                   | Bougienage, papillotomy, papilla dilation 8-10mm, stent insertion, regular change of stents/18 months | 1082 ± 476 | Midazolam | 13 ± 4 | 5.9 ± 2.9 | 77 ± 61 |
|      |                     |          | 156 ± 77 | Pethidine | 11.6 ± 11 | 2.5 ± 2.6 | 198 ± 98 |
| 13   | 3                   | Stent insertion, regular change of stent unsuccessful due to progreident papilla tumor, PTCD | 10.8 ± 3 | Midazolam | 14 ± 8 | 3.1 ± 1.8 | 113 ± 97 |
|      |                     |          | 91 ± 52 | Pethidine | 114 ± 11 | 2.5 ± 2.6 | 198 ± 98 |
|      |                     |          | 40 ± 29 | Butylscopolamine |      |    |     |
| 14   | 2                   | Not successful, PTCD | 25 ± 7 | Midazolam | 5.4 ± 1 | 0.8 ± 0.1 | 155 ± 21 |
|      |                     |          | 175 ± 35 | Pethidine | 5.9 ± 2 | 1.5 ± 0.3 | 122 ± 46 |
| 15   | 2                   | Not successful, PTCD | 7.8 ± 3 | Midazolam | 5.4 ± 1 | 0.8 ± 0.1 | 155 ± 21 |
|      |                     |          | 100 ± 25 | Pethidine | 5.9 ± 2 | 1.5 ± 0.3 | 122 ± 46 |
| 16   | 1                   | Ostium incision (papillotome), 2 stents inserted (perforation) | 125 ± 35 | Midazolam | 15.7 | 1.7 | 155 |
|      |                     |          | 20 | Pethidine | 125 ± 35 | Butylscopolamine |      |  |
| 17   | 5                   | Papillotomy*, bougienage, nasobiliary probe; insertion of 2 stents, regular change of 2 stents/9 mo | 16.8 ± 4 | Midazolam | 11.6 ± 11 | 2.5 ± 2.6 | 198 ± 98 |
|      |                     |          | 210 ± 74 | Pethidine | 16.7 ± 10 | 2.5 ± 2.6 | 198 ± 98 |
|      |                     |          | 30 ± 11 | Diazepam | 16.7 ± 10 | 2.5 ± 2.6 | 198 ± 98 |
| 18   | 1                   | Stone extraction | 13 ± 1 | Midazolam | 9.7 ± 9 | 2.0 ± 1.8 | 82 ± 31 |
|      |                     |          | 116 ± 28 | Pethidine | 9.7 ± 9 | 2.0 ± 1.8 | 82 ± 31 |
|      |                     |          | 5 ± 5 | Diazepam | 9.7 ± 9 | 2.0 ± 1.8 | 82 ± 31 |
| 19   | 4                   | Extraction sludge & blood coagel, insertion nasobiliary probe, extraction of percutaneous drainage & insertion of 2 stents (rendezvous), regular change of 2 stents/9 mo | 695 ± 275 | Propofol | 8.7 ± 1 | 0.7 ± 0.4 | 61 ± 13 |
|      |                     |          | 75 ± 50 | Pethidine | 12 ± 1.8 | 4.5 ± 1.9 | 185 ± 32 |
| 20   | 4                   | Papillotomy, stent insertion pancreatic duct, regular change of stent/6 mo, hemostasis with injection therapy | 70 ± 14 | Butylscopolamine |      |    |     |
| 21   | 3                   | Insertion of 2 stents, regular change of 2 stents/6 mo | 138 ± 62 | Midazolam | 15 ± 7 | 4.5 ± 1.9 | 185 ± 32 |
| 22   | 1                   | Papillotomy, insertion of 2 stents | 19 | Midazolam | 17.2 | 4.5 | 113 |
|      |                     |          | 200 | Pethidine | 17.2 | 4.5 | 113 |

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underwent subsequent PTCD or surgery (one patient, 12.5%).

**Diagnosis, results and interventions at normal and malignant choledocho- and hepaticojejunostomy**

In choledocho- or hepaticojejunostomies, 14 out of 24 (58.3%) were cicatricially changed, three were infiltrated by malignant tissue (12.5%), and seven (29.1%) appeared normal in width and were intact (Table 2).

DBE was able to achieve access to 15 of the 24 choledocho- or hepaticojejunostomies (62.5%), while PE reached only four out of 24 (16.6%), and the remaining five patients with failure of the enteroscopic approach (20.8%) had to undergo PTCD.

Among the seven normal appearing ostium of the choledocho- or hepaticojejunostomies (29.1%), sludge and

| Pts overall | Total number PE/DBE | Mean sedation dose per examination | Total x-ray dose | Total examination time |
|-------------|---------------------|-----------------------------------|-----------------|-----------------------|
| 37          | 16 PE 86 DBE        | Midazolam 11.7 ± 2.8               | 9.0 ± 5.5       | 111 ± 54              |
|             |                     | Pethidine 124 ± 45                 | 2.5 ± 1.3       |                       |
|             |                     | Butylscopolamine 20 ± 20           |                 |                       |
|             |                     | Propofol 1156 ± 593                |                 |                       |

P: Push-enteroscopy; ERCP: Endoscopic retrograde cholangiopancreatography; DBE: Double balloon enteroscopy; PTCD: Percutaneous transhepatic cholangiography; PE: Push-enteroscopy.
concrements had to be removed from one normal choledocho- and three normal hepaticojejunostomies in one patient suffering from cholangitis and choledocholithiasis, and three patients with hepaticolithiasis, respectively. In addition, endoprosthesis and/or nasobiliary probe insertion via the normal choledocho- or hepaticojejunostomy were necessary in two of these patients and in one with hilar and hepatic duct strictures, respectively.

Out of three tumor-induced malignant ostium stenoses (12.5%), the precise location of the enteroanastomosis could be identified twice, but in neither case could the stenosis be passed by a flexible hydrophilic guidewire and successfully treated. All three patients with tumorous hepaticojejunostomies required PTCD.

Diagnosis and results in post-surgical stenotic choledocho- and hepaticojejunostomy

Eight patients out of 14 (57.1%) with cicatricial ostial stenosis at the choledocho- or hepaticojejunostomy were treated successfully via DBE-ERCP, and a further four via PE (28.5%), while the remaining two patients (14.2%) required PTCD (Tables 2 and 3).

In one case with stenotic hepaticojejunostomy and previous PTCD (suspected hepaticolithiasis) at an outlying hospital, DBE-ERCP revealed blood in the afferent loop, bile duct bleeding from PTCD, and obstruction of the stenotic ostium including bile ducts due to blood clots. Thus, extraction of sludge and blood clots was performed, and insertion of a temporary nasobiliary drainage for irrigation of the bile duct. Then, after 3 d, a first DBE-based rendezvous technique was applied via the PTCD with successful extraction of the percutaneous drainage and endoscopic insertion of two internal stents.

Of note, a successful rendezvous technique was further achieved in three patients with non-malignant disease who were admitted to our hospital after construction of a PTCD, and in one patient with initial failure of DBE. (Table 3).

Thus, these four patients had most significant benefit from DBE-ERCP because they had endoscopically inserted endoprotheses and lost their percutaneous drainage within 1 wk.

Ostium incision and dilation and endoprosthesis insertion at post-surgically strictured choledocho- and hepaticojejunostomy

Initial endoscopic interventions at the non-malignant post-surgical biliary anastomosis (choledocho- or hepaticojejunostomy), which could not be cannulated by a flexible guidewire, included a careful, 1-3-mm ostium incision (by snare and/or 6 Fr papillotome) of each narrowed ostium in 6 out of 12 cases (50.0%) during DBE-ERCP. Five ostial incisions were made during DBE-ERCP, and one during PE-based ERCP. All incisions resulted in significant widening of the ostium with subsequent successful cannulation and intervention in the biliary system. Perforation occurred in one of the 5 patients treated with ostial incision by DBE-ERCP (20.0%), which had to be treated surgically. None (0%) of the ostial incisions caused relevant bleeding, but in two cases (40.0%), pus was discharged from the opened ostium (Figures 1 and 2).

The other six patients (50.0%) with post-surgically strictured choledocho- or hepaticojejunostomy were initially cannulated using a guidewire and were treated either with a bougienage via a papillotome or nasobiliary probe, to widen the ostium ready to implant subsequently a prosthesis, or by dilation using a colonic CRE balloon.

Overall, in patients with cicatricial changed choledocho- or hepaticojejunostomies, on average 1.5 ± 0.7 endoprotheses were implanted per DBE-ERCP examination.
the latter case, for the first time a 7 Fr double pigtail pros-
ted side branches, duct irregularities, but no acute strictures).

DBE-ERCP with interventions via the afferent loop at the papilla

Thirteen (41.9%) of the 31 patients still had a normal papilla. In 11 out of 13 patients (84.6%), the papilla was accessible via a Roux-en-Y loop, and only in two patients (15.3%) was it directly accessible from the Billroth II stomach anastomosis via the afferent loop (Table 1).

The papilla could be reached with conventional PE in two of these 13 (15.3%) cases, and ERCP could be successfully performed with this forward-viewing enteroscope.

In the remaining 11 patients (84.6%) with normal papilla and prior abdominal surgery, the papilla had to be searched by push-and-pull-enteroscopy. DBE-ERCP could only be performed after appropriate stabilization of the enteroscope in front of the papilla, partly by use of the balloons. The DBE-ERCP and treatment was successful in eight of the 11 cases (72.7%; Tables 2 and 3), while in three cases (27.2%), DBE-based endoscopic retrograde cholangiography (ERC) failed because of tangential position to the papilla, or because of a papillary tumor (re-operation in one patient, and PTCD in two).

In the eight successful DBE-ERCs, seven patients (87.5%) had papillotomies of 3-7 mm in length using a 6 Fr papillotome, whereby moderate pancreatitis and bleeding (14.2% for each) occurred as side effects. In total, 1.2 ± 0.4 endoprotheses were successfully placed via the forward-viewing enteroscope (four double pigtail 7 Fr prostheses, one double pigtail 8 Fr prosthesis, seven straight 7 Fr endoprosthesis, and one 7 Fr nasobiliary probe).

In addition, apart from bougienage with the 6 Fr papil-
lotome, dilatations using a CRE dilation balloon (8-10 mm, Cook) and removal of 5 ± 11 concrements and sludge using baskets were carried out in cases of papillary or distal bile duct stenoses. For treatment of purulent cholangitis with concrements, a nasobiliary drainage for irrigation was also placed via the enteroscope and left for 3 d to perform endoscopic shockwave lithotripsy and clean the bile system.

Laboratory results before and after DBE-ERCP with interventions

Before intervention, laboratory testing determined that the patients presented with distinct cholestasis and bilirubin elevation (2.8 ± 3.1 mg/dL) and/or inflammatory symp-
toms (leukocytes 12800 ± 10200/μL, C-reactive protein 51 ± 37 mg/L). By performing DBE-ERCP with ostial incisions, papillotomies and/or implantation of biliary endoprostheses, a clear reduction of cholestasis and chol-
angitis parameters was obtained. Values for bilirubin (1.6 ± 2.0 mg/dL), leukocytes (6800 ± 4000/μL) and C-reactive protein (18 ± 21 mg/L) decreased significantly (P < 0.05).

Complications of DBE-ERCP with interventions
Among 86 DBE-ERCPs, post-interventional cholangitis was not observed in any of the 31 patients treated by DBE-ERCP. However, after six of 86 examinations (6.9%) in 31 patients (19.3%), a lipase increase of more than twice the norm was seen on the day after DBE, whereas clinically significant post-ERCP pancreatitis (one mild and one moderate) was only seen after two examinations (2.3%) in two patients.

Post-interventional bleeding occurred in one of 86 examinations (1.1%) in 31 patients (3.2%) after papilotomy, which required emergency endoscopy, intensive care treatment, and blood transfusion.

Post-interventional stomach pain was experienced after six of 86 examinations (6.9%) in 31 patients (19.3%), whereas perforation occurred in two DBE-ERCPs (2.3%). One perforation developed immediately after ostial incision, while the second became evident 8 h later, with ileal perforation. Both perforations could be treated surgically, and no patient died due to complications of DBE-ERCP. No other fatalities following DBE-ERCP were recorded.

After two of 86 examinations (2.3%), two patients complained of abdominal pain that lasted > 24 h, and raised temperature developed on the day after the examination. Of note, one patient developed tonsillitis after DBE-ERCP (1.1%). No other serious side effects occurred.

Examination and radiography times and premedication during DBE-ERCP
The average duration of all DBE-ERCPs was 111 ± 54 min, and radiography took 9.0 ± 5.5 min with a dose of 2465 ± 1295 cGy/m². The individually required examinations for each patient are listed in Table 3, which included the exact therapeutic procedures, time measurements, and premedication.

With regard to premedication, an average of 11.7 ± 2.8 mg midazolam and 124.9 ± 45 mg pethidine or 1156 ± 593 mg propofol was needed per patient undergoing DBE-ERCP. In addition, butylscopolamine was administered at an average dose of 44.8 ± 20 mg. During conscious sedation for DBE-ERCP, one patient each developed hypoxia induced by midazolam/pethidine or propofol, which led in each case to abortion of the examination.

DISCUSSION
The difficulties involved with endoscopic access to the bile ducts and the pancreas in patients with prior abdominal surgery before the introduction of DBE have been described previously.[4,6,10,19-21] The success rate of ERCP with a side-viewing endoscope, push-enteroscope or pediatric colonoscope in patients with previous surgery depends on a number of factors, e.g. type of previous surgery, length of afferent loop, post-surgical changes, or experience of the endoscopist. Usually, results tend to be very variable (e.g. success rate of Billroth II gastrojejunostomy up to 92%, Roux-en-Y reconstruction, 33%, and pancreaticojunostomy, 8%) accompanied by high complication rates.[4,6,19-21]

Access through conventional endoscopy was particularly difficult in our patients after several rounds of complex abdominal surgery (91.8% Roux-en-Y reconstruction, 8.1% gastrojejunostomy), and initially, access or treatment by gastroscopy or duodenoscopy was not possible. As recently outlined by several other investigators in small patients series,[4,10,22-24] our stepwise approach with PE and DBE in 37 non-selected, consecutive post-surgical patients found that DBE-ERCP was clearly more efficient than PE. By the appropriate use of DBE in over two-thirds of cases, enteroanastomoses or papilla could be repeatedly reached, identified and satisfactorily visualized. The enteroscope could be stabilized also for biliary-pancreatic intervention. DBE-ERCP could be successfully conducted in 74.1% of the cases via the enteroscope, while PE reached biliary anastomoses or papilla in only 16.2% of the patients, which resulted in successful ERCP in only a minority of patients. Both results are in good agreement with recently published data for the approach by double- or single-balloon enteroscopy,[4,10,22-24] as well as for earlier published data on postoperative or PE-based ERCP[4,11,19-21].

However, until a successful DBE-ERCP was achieved, several balloon-assisted enteroscopic cycles over an average length of 124 ± 47 cm of the small intestine, application of X-rays, and manual guidance of the enteroscope were necessary. In addition, a substantial effort in time, staffing and sedation had to be afforded. Compared with PE, the push-and-pull method by DBE proved to be markedly more effective, because pushing and stretching of small intestinal loops is reduced by regular retractions of the DBE cycle. The threading of the small intestine onto the DBE and the option to block the balloons at the enteroscope provides the enteroscope tip with a greater possibility of movement for identifying the biliary or pancreatic anastomoses or the papilla. In addition, sliding back of the enteroscope may be prevented by inflated balloons, which, compared with PE, explains the significantly higher effectiveness of interventions during DBE-ERCP.

Out of the 37 post-surgical patients with significant cholestasis and cholangitis, PE achieved a successful bile duct drainage in six (16.2%), whereas, before DBE was introduced, a far more invasive procedure, either PTCD or surgery, would have been carried out in the remaining 31 patients. PTCD carries a significantly higher morbidity and mortality risk compared to the endoscopic procedure,[12,14,17,22-24] therefore, all consecutive patients with previous abdominal surgery were included in this prospective treatment protocol after DBE had been introduced in August 2005 at the University of Erlangen–Nuremberg. Of note, DBE facilitated successful ERCP with biliary
The key benefits of DBE-ERCP in the care of postsurgical patients with cholestasis/cholangitis and patients with installed percutaneous drainage are somewhat limited by the small caliber of bile duct prostheses that are applied via the enteroscope. According to the present state of technology, only an implantation of 5-8 Fr prostheses through an operating channel of 2.8 mm is possible. Consequently, several prostheses (1.5 ± 0.7) were implanted in our patients. In the case of strongly soiled bile ducts and concurrent cholangitis or sump syndrome, it is recommended first to apply a nasobiliary probe for irrigation of the bile ducts (Figure 4) to prevent rapid clogging of the small caliber bile duct prostheses.

The sequential coupling of two examinations (DBE and ERCP) explains the lengthy examination times, high doses of sedation, and applied fluoroscopy dosage. Considering the enormous benefit of DBE-ERCP with an approximately 74% successful biliary drainage and a significantly smaller complication rate than PTCD[11,12,14-17,27-29], the effort involved in such an examination seems justified.

In comparison to the more frequent cholestatic patients, only three of 37 patients also required radiography and interventions of the pancreatic duct after pancreatic resection. Overall, only a limited view could be gained as to which role DBE-ERCP might play in this area. In all three patients, the position of the pancreaticojejunostomy was only reached by DBE and was located deeper in the small intestine or considerably closer to the blind end of the afferent loop than was the choledocho- or hepatojejunostomy. The technical conduction of the endoscopic retrograde pancreatography via DBE was undertaken in the same manner as described for ERCP. The ostium, however, was smaller, but in none of the cases stenotic. The main pathological changes of chronic pancreatitis were limited to the remaining pancreatic duct in the corpus area. During DBE-based pancreatography, a cystic lesion (pseudocyst) could be successfully drained via insertion of a 7 Fr double pigtail prosthesis for the first time, which led to a noticeable improvement of the patient, and regression of the pseudocyst within a week. Therefore, DBE offers also a novel option for pseudocyst drainage in postsurgical patients.

In conclusion, this prospective study from a single university tertiary referral center confirms that DBE-ERCP has considerable potential to treat successfully benign (postoperative) or malignant biliary and papillary stenoses, bile duct concrements, and cholangitis, even in non-selected postsurgical patients[5-10,22-26,29], and it helps to reduce the number of percutaneous approaches. Only in eight of 31 patients (25.8%), in whom the biliary or pancreatic anastomoses or papilla could not be found via DBE, was PTCD finally achieved. By the use of DBE, was PTCD finally achieved. By the use of DBE-ERCP, however, the external drainage could be extracted from all four patients after 1 wk. Practically, methylene blue injected externally through the PTCD helps to identify the afferent loop and/or biliary anastomoses or papilla, so that these are more easily and quickly detected by the subsequent DBE.

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Innovations and breakthroughs

Before the era of balloon-assisted endoscopy, only 20%-30% of patients with diseases of the biliary tract or pancreas (e.g., tumor, stones, inflammation, stenosis) could be effectively managed by conventional endoscopy, whereas the other 70%-80% had to be treated by more invasive percutaneous puncture techniques, external tube insertion, drainage procedures, and more cost-intensive computed tomography (CT)-based therapies, or even re-operation. This paper describes, in a large number of consecutive patients, successful use of DBE to perform effective endoscopic treatment in a majority (74%) of post-surgical patients with biliary-pancreatic diseases.

Applications

DBE-based examination of the biliary tract or pancreas represents a further important endoscopic treatment modality for postoperative patients after complex abdominal resections. It allows successful application and interventions in post-surgical patients with bile duct stenosis, obstruction, stones or pancreatic diseases (chronic inflammation, tumor) in terms of performing incision of the bile duct ostium, or papillotomy, endoprosthesis insertion, or stone extraction.

Terminology

DBE-based examination of the biliary tract and pancreas is achieved by forward-viewing optics in post-surgical patients, and requires examination of the small bowel by DBE, and includes endoscopic-radiological examination of the bile duct and/or pancreatic duct, with the aim of performing interventions in the case of bile duct, liver or pancreatic disease. This whole procedure is called DBE-based retrograde cholangiopancreatography and is indicated only when conventional endoscopy fails to reach the biliary tract or pancreas.

Peer review

This study describes the utility of modern enteroscopy, especially DBE, in symptomatic patients with cholestasis and cholangitis after complex abdominal surgery. A high rate of enteroscopic access and successful biliary interventional procedures, with a new intervention, ostial incision at biliary anastomosis is presented, which resulted in a substantial reduction in more invasive procedures such as transcatheter percutaneous biliary interventions or CT-guided punctures.

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