

# Pancreatic duct stones in patients with chronic pancreatitis: surgical outcomes

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**BACKGROUND:** Pancreatic duct stone (PDS) is a common complication of chronic pancreatitis. Surgery is a common therapeutic option for PDS. In this study we assessed the surgical procedures for PDS in patients with chronic pancreatitis at our hospital.

**METHOD:** Between January 2004 and September 2009, medical records from 35 patients diagnosed with PDS associated with chronic pancreatitis were retrospectively reviewed and the patients were followed up for up to 67 months.

**RESULTS:** The 35 patients underwent ultrasonography, computed tomography, or both, with an overall accuracy rate of 85.7%. Of these patients, 31 underwent the modified Puestow procedure, 2 underwent the Whipple procedure, 1 underwent simple stone removal by duct incision, and 1 underwent pancreatic abscess drainage. Of the 35 patients, 28 were followed up for 4-67 months. There was no postoperative death before discharge or during follow-up. After the modified Puestow procedure, abdominal pain was reduced in patients with complete or incomplete stone clearance ( $P>0.05$ ). Steatorrhea and diabetes mellitus developed in several patients during a long-term follow-up.

**CONCLUSIONS:** Surgery, especially the modified Puestow procedure, is effective and safe for patients with PDS associated with chronic pancreatitis. Decompression of intraductal pressure rather than complete clearance of all stones predicts postoperative outcome.

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**KEY WORDS:** pancreatic duct stone;  
chronic pancreatitis;  
surgical management;  
modified Puestow procedure

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## Introduction

Pancreatic duct stone (PDS) is a common complication during the natural course of chronic pancreatitis (CP) and contributes to the pathogenesis and complications of CP. A survey showed that the prevalence of PDS in patients with CP is 8.5% (171/2008) in China.<sup>[1]</sup> Abdominal pain, one of the principal symptoms of CP, is believed to be caused by obstruction of the pancreatic duct with increasing intraductal pressure and parenchymal ischemia either by stones or stricture.<sup>[2]</sup> The standard intervention for CP with obstructing duct stones is stone retrieval and duct drainage by endoscopic, extracorporeal shockwave lithotripsy or surgery, depending upon the size and location of stone(s).<sup>[3-5]</sup> A recent randomized trial revealed a better 2-year outcome after surgery compared with endoscopic treatment to drain the obstructive pancreatic duct in patients with CP.<sup>[6]</sup> For patients with failed nonsurgical treatments, surgery is the only option to relieve symptoms. In this study we investigated the outcomes of surgical procedures to treat PDS in patients with CP.

## Methods

Between January 2004 and September 2009 years, 35 patients were diagnosed with CP associated with PDS, and underwent surgery at our hospital. Patients with PDS treated by conservative therapy and those with any pancreatic neoplasm were excluded. All patients met the diagnostic criteria of CP issued by the Pancreas Study Group, the Chinese Society of Gastroenterology.<sup>[7]</sup> PDS was preoperatively diagnosed by imaging and confirmed operatively.

Reviewed data included demographics, symptoms and signs, results of blood tests, image findings, surgical approaches, pathological results, and short-term postoperative complications. The patients were followed by telephone interview and mail, and the data collected included patients' pain level and post-

discharge medical events including PDS recurrence, pancreatic carcinogenesis, acute pancreatitis, steatorrhea and, if relevant, onset of diabetes mellitus. All patient comments were confirmed by clinical presentation, imaging studies, and laboratory tests.

If the stones found during surgery were removed and no sign of stone was found in the first postoperative imaging examination, complete stone clearance was defined; otherwise incomplete stone clearance was considered. The statistical significance of postoperative pain relief between complete and incomplete stone clearance was assessed by Fisher's exact test. A *P* value less than 0.05 was considered statistically significant.

## Results

### Clinical characteristics

The demographic data showed that there were more men than women, and nearly half of them were drank or smoked (Table 1). The most significant symptom was abdominal pain, followed by diabetes mellitus, steatorrhea, and jaundice. Two patients without abdominal pain presented with hyperglycemia and dyspepsia, for which

tenderness in the upper abdomen was the most common sign. Twenty-four patients had a history of acute pancreatitis, 11 had a prior gall stone, whereas none of the patients had a family history of CP.

### Preoperative diagnosis

The diagnosis of PDS associated with CP was made by evaluating preoperative images including transabdominal ultrasonography (TAUS), computed tomography (CT), endoscopic retrograde cholangiopancreatography (ERCP), or magnetic resonance cholangiopancreatography (MRCP). Similar to other reports,<sup>[8,9]</sup> 30 (85.7%) of the 35 patients in our study were confirmed with a diagnosis of PDS associated with CP either by TAUS, CT, or both.

### Characteristics of pancreatic stones

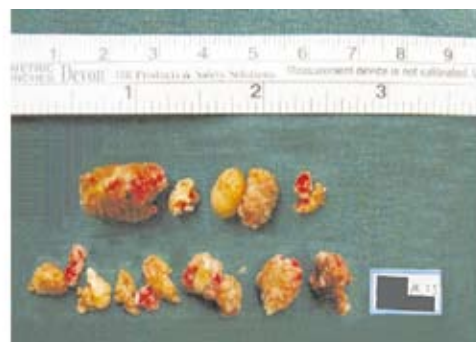
PDSs were present throughout the pancreas. 40.0% were totally confined at the head of the pancreas, and 45.7% were at but not limited to pancreatic head in head-tail or diffuse pattern (Table 1). The stones were round in shape and usually appeared lemon-yellow in color (Fig.).

### Surgical considerations

All patients underwent surgery (Table 1). In 3 patients ERCP was done but failed to extract PDS before surgery, and in 2 patients a pancreatic stent was placed. A modified Puestow procedure was performed to form an artificial passage connecting the pancreas to the jejunum. Pancreaticojejunostomy was performed by a Roux-en-Y loop procedure posterior to the transverse colon. Before incising the main pancreatic duct, the surgeon felt for calculi and a dilated duct, and reconfirmed the dilated pancreatic duct using a syringe. A full-length incision was then made to complete the side-to-side pancreaticojejunostomy. Two patients could not be excluded from the involvement of pancreatic head neoplasm and underwent a Whipple procedure. One of them underwent simple stone extraction via a simple

**Table 1.** Patient characteristics

Characteristics	<i>n</i> (%)
Demographics	
Age (range, yrs)	44 (16-32)
Male	32 (91.4)
Alcoholic	15 (42.9)
Smoker	16 (45.7)
BMI (median, range)	19.1 (16.7-22.0)
Presenting symptoms	
Abdominal pain	33 (94.3)
Diabetes mellitus	13 (37.1)
Steatorrhea	3 (8.6)
Jaundice	2 (5.7)
Location of PDS	
Head	14 (40.0)
Body	3 (8.6)
Tail	2 (5.7)
Head-tail	4 (11.4)
Diffuse	12 (34.3)
Number of PDS	
Single	9 (25.7)
Multiple	26 (74.3)
Surgical procedures	
Modified Puestow procedure	31 (88.6)
Whipple procedure	2 (5.7)
Simple duct incision and suturing	1 (2.9)
Pancreatic abscess drainage	1 (2.9)



**Fig.** Multiple PDSs obtained from a 23-year-old male patient.

## Pancreatic duct stones in patients with chronic pancreatitis

duct incision and suturing and the other underwent an external drainage of pancreatic abscess. Dilation of the main pancreatic duct was seen in 33 patients at surgery (mean duct diameter 9.3 mm). A pancreatic stent was placed in 5 patients during surgery, and in one patient the stent was positioned out of the abdominal cavity through the small intestine. The overall operative time ranged from 3 to 14 hours (mean 4.6 hours); the operative time for the modified Puestow procedure ranged from 3 to 6 hours (mean 4.3 hours).

The rate of incomplete stone clearance after the modified Puestow procedure (31 patients) was 37.5% (3/8) in patients with a single stone and 56.5% (13/23) in patients with multiple stones. The three single stones that were incompletely extracted during surgery were all confined in the pancreatic head. The multiple stones of incomplete extraction in 13 patients were mostly associated with the pancreatic head, whereas some were also in the pancreatic tail (3 patients) or in the whole pancreas (7). In the remaining 4 patients, incomplete stone clearance occurred in one patient with multiple stones who received external drainage for a pancreatic abscess because the stone was inaccessible.

The mean postoperative hospital stay for all 35 patients was 14.3 days (8-83 days), and 12.3 days for those surgically treated by the modified Puestow procedure. Somatostatin was administered to suppress pancreatic juice secretion in 30 of the 35 patients. There were no postoperative deaths, and the overall postoperative morbidity rate was 5.7% (2/35). Of the two patients with complications, one had a pancreatic fistula and the other, who had undergone Whipple procedure, had abdominal bleeding 36 hours after surgery and abdominal infection on postoperative day 12. The 31 patients who had received the modified Puestow procedure showed no postoperative pancreatic fistula, bleeding, acute pancreatitis, or hyperglycemia.

### Long-term follow-up

Twenty-eight of the 35 patients were followed up for 4-67 months (median 37 months); among them 27 underwent the modified Puestow procedure

and 1 was subjected to the Whipple procedure. No deaths or evidence of pancreatic cancer was observed during the follow-up. Complications included new-onset steatorrhea (6 patients), diabetes mellitus (2), and recurrent acute pancreatitis (1). The correlations between complete stone clearance and pain after the modified Puestow procedure are shown in Table 2. Pain relief was found in 100% of the patients with complete clearance and 81.3% in those with incomplete clearance ( $P=0.25$ ).

## Discussion

PDS, first reported in 1667,<sup>[10]</sup> is a common pathologic event in cases of CP. In western countries, the incidence of PDS associated with CP may be as high as 50%-90%,<sup>[11]</sup> whereas in China, it is 8.5%.<sup>[1]</sup>

Passing a pancreatic stone spontaneously is rare.<sup>[12]</sup> ERCP and extracorporeal shockwave lithotripsy are effective and safe in clearing stones from the pancreatic duct and in relieving pain, with an overall complication rate of 0-43%.<sup>[4, 13, 14]</sup> The outcomes of endoscopic treatment were reported to be equivalent to those of surgery; in the present study the indications for endoscopic treatment were  $\leq 3$  stones, stones confined in the head and body of the pancreas, absence of restricted pancreatic duct, PDS diameter  $\leq 10$  mm, and noncompacted stone(s).<sup>[15]</sup> Additional and larger stones were retrieved successfully using a modified metallic stent.<sup>[16]</sup> For patients who need treatment but do not meet the aforementioned indications, or for whom conservative therapy fails, surgery is extremely necessary.

In 1883 the first case of surgical removal of PDS was reported.<sup>[10]</sup> A randomized controlled trial indicated that during a 2-year follow-up, surgery is superior to endotherapy for pain relief (75% vs. 32%) in patients with painful obstructive CP,<sup>[6]</sup> a finding similar to the result of another trial.<sup>[17]</sup> Fang et al<sup>[8]</sup> reported a symptom remission rate of 65%-94%, a mortality of 0-5%, and a morbidity of 20%-40%, based on their studies. In our study, 88.9% patients reported pain relief after the modified Puestow procedure with complete or incomplete stone clearance (Table 2).

Selection of surgical approach should be guided by the size, number, and type of PDS. Depending on the location of stones, four types of PDS have been established: type I in the head of the pancreas, type II in the body, type III in the tail, and type IV in the whole pancreas.<sup>[18]</sup> Drainage by pancreatic ductotomy is generally applicable for patients with a dilated pancreatic duct ( $\geq 6$  mm); the drainage includes the Puestow, modified Puestow, and Frey procedures.<sup>[19]</sup> The Berger

**Table 2.** Pain after modified Puestow procedure ( $n=27$ )

Stone clearance	Pain relief ( <i>n</i> , %)	More intense pain ( <i>n</i> , %)
Complete	11 (100)	0 (0)
Incomplete	13 (81.3)*	3 (18.8)
Total	24 (88.9)	3 (11.1)

\*:  $P=0.25$ , compared with complete stone clearance.

procedure, in which the pancreatic head is removed but the duodenum is preserved, and the Whipple procedure are suitable for type I stones, however distal pancreatectomy is suitable for type III stones. For patients with type II stones, the modified Puestow procedure or segmental resection of the pancreas is suitable. For patients with type IV stones, an alternative to drainage is a subtotal pancreatectomy, which allows 95% removal of the pancreas, preserving only a thin layer of pancreatic tissue attached to the duodenum.

Side-to-side pancreaticojejunostomy is effective for most PDSs. At our institution, 88.6% of the 35 patients underwent the modified Puestow procedure, greater than the percentage of other case series because in all 31 patients the main pancreatic duct diameter was  $\geq 6$  mm, indicating a drainage procedure rather than resection. The modified Puestow procedure was found to be safe and suitable for unobstructed pancreatic juice drainage.<sup>[20]</sup> In the 14 patients with stones only in the head of the pancreas, 12 underwent pancreatic ductotomy for stone removal and decompression. In these patients, a full-length and wide incision throughout the dilated duct was necessary and, if necessary, the anterior wall of the pancreatic head was partially resected to expose enough area for adequate drainage. Although the mortality due to the Whipple procedure is below 5% in large pancreatic centers,<sup>[21]</sup> the procedure is complex and time-consuming, and carries the risk of additional postoperative complications, thus limiting its wide application. In our study, one patient experienced abdominal bleeding and infection after the Whipple operation, necessitating an 83-day postoperative hospital stay. The Whipple procedure is not always necessary for pancreatic head stones if they can be removed and the interductal pressure decreases after pancreaticojejunostomy, but the procedure is required when a pancreatic head tumor is suspected.

The incompletely removed stones were either within or partly within the pancreatic head, and they showed dot-like calcification or were compacted into the pancreatic parenchyma. Sometimes it is difficult to widely unroof the pancreatic duct within the pancreatic head and uncinata to clear dot-like calculi due to the vessel complexes. In addition, forced removal of the compacted stones may lead to massive postoperative bleeding and pancreatic leakage. Furthermore, the size of the pancreatic tail usually decreases in cases of CP, and the duct within the tail is sometimes not dilated for pancreaticojejunostomy, especially when it is adjacent to the spleen. Therefore, stones or fragments are deliberately left at the site where removal is difficult. In our patients, although some stones were not completely removed, we adequately decompressed the pancreatic

duct by opening the dilated duct as much as possible.

Studies on obstructive CP showed that after ERCP and extracorporeal shockwave lithotripsy, pain recurs more frequently in patients with incomplete stone removal than in those with complete removal.<sup>[22]</sup> Additional stenting for the main pancreatic duct after extracting pancreatic stones may reduce the risk of recurrence of pancreatic symptoms.<sup>[23]</sup> In our study, there was no difference in pain relief between the patients with complete and incomplete stone removal after the modified Puestow procedure. This demonstrates that good decompression rather than complete clearance of all stones is the decisive factor for postoperative outcome. Decompression promotes longitudinal anastomosis that ensures drainage over the full length of the pancreas and also opens the pancreatic capsule to alleviate interstitial pressure.<sup>[6]</sup> In our study, 2 of 3 patients who experienced more intense pain after the modified Puestow procedure were treated with plastic stents before surgery, but the stents were removed during surgery. It is uncertain that there is any correlation between preoperative stenting and postoperative pain relief, however, Sasahira et al<sup>[23]</sup> suggested that endoscopic stenting may worsen pancreatic duct morphologic abnormalities and lead to the risk of less pain relief.

Steatorrhea and diabetes mellitus are indications for pancreatic exocrine and endocrine dysfunction. Postoperative dysfunction in exocrine and endocrine glands was seen in 21.4% and 7.1% of the 28 patients we followed up respectively, indicating that surgical drainage could not have prevented pancreatic damage over the long-term follow-up. In this study, no pancreatic carcinogenesis was observed after surgery, but longer follow-up was necessary.

In conclusion, the modified Puestow procedure has fewer complications than other procedures and is the most widely used procedure for PDS in patients with CP at our institution. Good decompression rather than complete clearance of all stones is the most important factor for postoperative outcome, after which abdominal pain is reduced in most of patients during a long-term follow-up.

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