Ultrasound-guided extracorporeal shock wave lithotripsy of pancreatic ductal stones: Six years’ experience

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Pancreatic calcification is found in 50% to 90% of patients with advanced chronic pancreatitis (1,2). Two patterns of distribution can be distinguished: calcification of the secondary branches and acini; and calculi in the main pancreatic duct (3). Combinations of the two forms are common. The postulated pathophysiological mechanism is precipitation of proteins, which become calcified by calcium carbonate crystals (4). Reduced levels of pancreatic stone protein, which acts as calcium stabilizer in the pancreatic juice, are thought to play a role (5-7).

Pancreaticolithiasis with duct obstruction is a serious complication of chronic pancreatitis (Figure 1). Experience with anastomotic surgery and endoscopic drainage has shown that removal of the obstruction in the main pancreatic duct can produce immediate pain relief and prevent further inflammatory episodes (8-11).

Endoscopic-operative measures (papillotomy, stone extraction) are of limited use for large or impacted stones or ductal strictures. We used pancreatic extracorporeal shock wave lithotripsy (ESWL) as an alternative to surgical intervention to treat patients with symptomatic pancreaticolithiasis and ultrasonographically identifiable duct dilation (Fig-
Our aims were clearance of ductal stones and consequent reduction of patient complaints.

**PATIENTS**

Thirty-five patients (17 men, 18 women) suffering from chronic pancreatitis complicated by an obstruction of the pancreatic duct system resulting from pancreaticolithiasis who were treated by ESWL were included in this six-year study. Average age of patients was 48 years (range 14 to 61). Nineteen patients (54%) suffered from chronic alcoholic pancreatitis; in 15 patients (43%) the etiology of the pancreatitis was not evident and in the case of a 13-year-old, idiopathic juvenile pancreatitis was assumed. All patients complained of upper abdominal pain, mostly with radiation to the back, which was classified as recurrent pain attacks in 24 (69%) and as continued pain in 11 (31%). Average history of symptoms was five years (range three to 12). Nine patients (26%) had solitary stones, 16 (46%) had one to five stones and 10 (29%) had multiple stones, in some cases completely filling Wirsung’s duct (Figures 3, 4a). Mean average diameter of the largest stone was 11 mm (range 5 to 25). In conventional abdominal ultrasound the mean average diameter of the dilated pancreatic duct was 9 mm (range 5 to 28).

Each patient underwent endoscopic retrograde pancreatography (ERP), which showed moderate to marked chronic inflammatory ductal changes. Significant strictures at the main pancreatic duct were found in 15 patients (43%). In 30 patients (86%) ERP confirmed pancreatic duct system dilation as observed by ultrasound; in five patients (14%) stone impaction prevented contrasting of the distal part of the duct. Two cases of pancreatic pseudocysts (4 and 5 cm in diameter) showed communication with the pancreatic ductal system.

Shock wave treatment was administered because the stones were not extractable by applied endoscopic measures. A total of 29 patients (83%) presented with exocrine pancreatic dysfunction (reduced fecal chymotrypsin, steatorrhea) and weight loss; 28 of them had enzyme replacement. Five patients had overt diabetes mellitus and two presented with impaired glucose tolerance.

**METHODS**

Pancreatic ductal stones were fragmented using an electrohydraulic lithotripter (MPL 9000, Dornier Medizintechnik, Germany) (12, 13) after exact sonographic targeting. All patients were treated in a prone position. Up to 2000 electrocardiogram-triggered shock waves were delivered per session under continuous ultrasound monitoring. If fragmentation
was not successful, i.e., insufficient disintegration of the stone(s) visible in the ultrasound examination, shock wave lithotripsy was repeated. The average shockwave energy was 18 kV (range 14 to 22). Patients were given piritramide (available only in Europe through Janssen Pharmaceutica Inc) and midazolam for analgesia and sedation. Endoscopic sphincterotomy (EST) of the pancreatic portion of the sphincter was done during ERP in 34 patients. In the 13-year-old, presumably presenting with idiopathic juvenile pancreatitis, EST was not done. Pancreatic duct diameters and stone fragmentation were controlled ultrasonographically. Fragments not passed spontaneously after ESWL were extracted as completely as possible using Dormia baskets (Schadlowsky; Voerde, Germany).

Average follow-up was 23 months (range three to 70). Patients were asked about their conditions and examined clinically and by ultrasonography every three months in the first year of follow-up, and thereafter at intervals of up to 12 months. If there was any doubt about fragment migration or impaction, or stone recurrence, an ERP was performed.

RESULTS

Targetting of pancreatic stones within the shock wave focus and complete therapeutic monitoring were possible in all treatment sessions under ultrasonographic control.

Stone disintegration was achieved in all patients; 13 (37%) required one treatment session, nine (26%) required two, eight (23%) required three, and five (14%), with multiple stones completely filling the duct of Wirsung, required between four and seven. A total of 5000 (range 500 to 13,500) shock waves were used per patient. Under analgesia and sedation with piritramide and midazolam ESWL was well tolerated. There were no cardiopulmonary complications.

After sufficient stone fragmentation, controlled by ultrasound examination (Figure 4b), follow-up ERP was performed. Based on ultrasound and ERP, 16 patients (46%) were shown to be completely stone-free. Nineteen patients (54%) had small residual fragments in the main ductal system, mostly located in the tail portion of the pancreatic duct (Table 1). Complete endoscopic extraction of these fragments was not possible because of strictures, kinking of the...
ESWL Extracorporeal shock wave lithotripsy

Results of extracorporeal shock wave lithotripsy (ESWL) and endoscopic stone extraction for pancreatic ductal stones

| Before ESWL | Stone-free | Obstruction cleared |
|-------------|------------|---------------------|
| Solitary stone (n=9) | 6 | 9 |
| 2 to 5 stones (n=16) | 6 | 16 |
| ≥6 stones (n=10) | 4 | 10 |
| Total | 16 | 35 |

Clinical course as a function of duct morphology and stone clearance

| Stone-free (n=16) | Pain-free | Pain-reduced | No change |
|------------------|-----------|--------------|-----------|
| With stricture | 2 | 3 | 1 |
| Without stricture | 6 | 3 | 1 |

Residual stones (n=19)

| With stricture | 1 | 6 | 2 |
| Without stricture | 3 | 5 | 2 |
| Total | 12 | 17 | 6 |

Number of stones and clearance of stones in patients with strictures of the pancreatic duct

| After ESWL | Stone-free | Obstruction cleared |
|------------|------------|---------------------|
| Solitary stone (n=4) | 2 | 4 |
| 2 to 5 stones (n=3) | 1 | 3 |
| ≥6 stones (n=8) | 3 | 8 |
| Total | 6 | 15 |

DISCUSSION

Because of high perioperative mortality and generally poor long-term results of surgical resection or drainage procedures in patients with chronic calcific pancreatitis (1,14-16), alternative forms of treatment are needed. Endoscopic procedures involving division of the pancreatic sphincter and extraction of ductal stones are often unsuccessful due to the incongruity between the size of the stone and the anatomy of the pancreatic duct. Stone fragmentation by ESWL permits clearance of the duct by spontaneous passage or endoscopic extraction of stone fragments (11,12,17-24).

Fragmentation of the occluding pancreatic ductal stones, with reduction of the stone volume and clearance of the obstruction, was achieved in all patients. In 16 patients (46%) treatment resulted in complete stone clearance. Twelve patients (34%) were free from complaints after treatment and pain diminished considerably in 17 (49%). The diameter of Wirsung’s duct was reduced by more than 50% of the baseline value, indicating the clearance of obstruction with a decrease of pressure in the pancreatic duct system, in 29 patients (83%) (25) (Figures 4b,4c,5).

Therapeutically, five of six patients who complained of unchanged symptoms after ESWL and who subsequently required pancreatic surgery had a filiform stenosis in the distal portion of the main pancreatic duct. In patients with fragments not endoscopically extractable, these fragments were primarily located behind strictures or in especially narrow segments of the duct. However, there were some patients with a large stone volume, a stricture of the pancreatic duct or both, who became stone-free and asymptomatic (Tables 1-3). Thus, neither stone characteristics nor pancreatic duct morphology seems to be of predictive value regarding the therapeutic outcome.
We found that complete stone clearance was not necessary for complete abolition of symptoms. Remaining residual fragments were small, caused no obstruction and were usually situated in the tail portion of the gland. Four patients who suffered a further episode of pain due to fragment migration after initial success of ESWL were pain-free after repeated ESWL. Stone recurrence was observed in three patients after 18 to 28 months, and they were again treated successfully with ESWL.

Results equivalent to or better than those discussed have been reported by others (18,19,21,22,26,27) using hydraulic or electromagnetic lithotripters with radiographic stone location. Three groups used ultrasonography alone (28,29) or in combination with radiography (24) for targeting pancreatic ductal concrements; freedom from stones and complete freedom from pain were achieved in up to 70% of patients.

The success of ultrasonography in indication, therapeutic monitoring and follow-up examination renders it the method of choice in our opinion in pancreatic ESWL. By using ultrasonic to locate stones, patients avoid exposure to radiation (12,20). With continuous treatment monitoring by real-time ultrasound, we can also spare the patients the nasopancreatic tube necessary for administration of contrast medium during x-ray-guided ESWL.

Our complication rate was low, which is similar to results from other groups (18,19,21-24,26-29). In close temporal association with ESWL we observed mainly mild episodes of pancreatitis.

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