Endoscopic and Percutaneous Drainage of Symptomatic Walled-Off Pancreatic Necrosis Reduces Hospital Stay and Radiographic Resources

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See related article, Garg PK et al, on page 1089 in this issue of CGH; see Editorial on page 1000.

BACKGROUND & AIMS: Walled-off pancreatic necrosis (WOPN), a complication of severe acute pancreatitis (SAP), can become infected, obstruct adjacent structures, and result in clinical deterioration of patients. Patients with WOPN have prolonged hospitalizations, needing multiple radiologic and medical interventions. We compared an established treatment of WOPN, standard percutaneous drainage (SPD), with combined modality therapy (CMT), in which endoscopic transenteric stents were added to a regimen of percutaneous drains.

METHODS: Symptomatic patients with WOPN between January 2006 and August 2009 were treated with SPD (n = 43, 28 male) or CMT (n = 23, 17 male) and compared by disease severity, length of hospitalization, duration of drainage, complications, and number of radiologic and endoscopic procedures.

RESULTS: Patient age (59 vs 54 years), sex (77% vs 58% male), computed tomography severity index (8.0 vs 7.2), number of endoscopic retrograde cholangiopancreatographies (2.0 vs 2.6), and percentage with disconnected pancreatic ducts (50% vs 46%) were equivalent in the CMT and SPD arms, respectively. Patients undergoing CMT had significantly decreased length of hospitalization (26 vs 55 days, P < .0026), duration of external drainage (83.9 vs 189 days, P < .002), number of computed tomography scans (8.95 vs 14.3, P < .002), and drain studies (6.5 vs 13, P < .0001). Patients in the SPD arm had more complications. CONCLUSIONS: For patients with symptomatic WOPN, CMT provided a more effective and safer management technique, resulting in shorter hospitalizations and fewer radiologic procedures than SPD.

Keywords: Endoscopic Therapy and Percutaneous Therapy of Walled-off Pancreatic Necrosis; Complications of Severe Acute Pancreatitis; Reduction in Hospital Stay; Reduction in Resource Utilization.

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Wallled-off pancreatic necrosis (WOPN), a complication of severe acute pancreatitis (SAP), typically emerges during the second week of SAP. WOPN can become infected, can obstruct or fistulize to adjacent anatomical structures, can compress or erode into vasculature, and can markedly delay a patient’s functional improvement. The computed tomography (CT) scan shows a mixed density peripancreatic solid and liquid mass with a rind of fibrous tissue contiguous with the stomach or duodenum. Emergent drainage and debridement are neces-

Methods

Patients

Patients with symptomatic WOPN who underwent either SPD or CMT between January 2006 and August 2009 were identified retrospectively and included in this analysis. We define symptomatic WOPN as follows: (1) infection unresponsive to parenteral antibiotics evidenced by persisting fevers, leukocytosis, and/or sepsis syndrome; (2) gastric outlet obstruction impeding feeding or causing persistent nausea and vomiting; (3) biliary obstruction as a result of WOPN; (4) fistulous connection between the WOPN and adjacent anatomical structures; (5) clinical deterioration in the face of maximal medical therapy short of drainage.

Patient data were entered into an institutional review board database approved by the Virginia Mason Medical Center Institutional Review Board. Data collected included patient demo-

Abbreviations used in this paper: CMT, combined modality therapy; CT, computed tomography; CTSI, CT scoring index; EROP, endoscopic retrograde cholangiopancreatography; LOH, length of hospitalization; PCF, pancreatic-cutaneous fistula; SAP, severe acute pancreatitis; SPD, standard percutaneous drainage; WOPN, walled-off pancreatic necrosis.

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1542-3565/$36.00
doi:10.1016/j.cgh.2010.09.010
graphics, etiology of SAP, severity of SAP as defined by the CT scoring index (CTSI), number of endoscopic and radiographic procedures performed, length of hospitalization (LOH) from the placement of drainage tubes, complications encountered, and mortality.

**Drainage Techniques**

In SPD, symptomatic SAP patients had percutaneous drainage tubes placed into areas of WOPN as described by Freeny et al. Aspirated fluid was sent for amylase and culture. Radiologically placed drainage catheters were positioned within necrotic fluid collections, attempting to avoid pulmonary, hepatic, colonic, and vascular structures. After placement and aspiration of as much fluid as possible, 12F drains were left to gravity and irrigated with 10–20 mL of sterile saline 3 times daily. Percutaneous catheters were sequentially up-sized to a maximum of 28F as patients demonstrated signs of tube occlusion or lack of improvement in WOPN.

In the CMT group, CT-guided percutaneous drains were initially placed into WOPN as in standard therapy, but only 10 mL of fluid was aspirated for culture and amylase. The percutaneous tube was clamped, and the patient was moved immediately to an endoscopy suite, at which point endoscopic drainage of the WOPN was performed by using either a transgastric or transduodenal approach. Endoscopic ultrasound was used when there was no clearly definable luminal bulge from the necrotic fluid collection (Figure 2, radiograph with percutaneous drain in place and 3 endoscopically placed transgastric stents). Endoscopic retrograde cholangiopancreatography (ERCP) was performed to determine whether a pancreatic duct leak existed, and if identified, an endoprosthesis was placed. If not, no endoprosthesis was placed in the pancreatic duct. If a biliary obstruction was found, a biliary endoprosthesis was placed (Figure 3). A nasojejunal feeding tube was inserted.

Regardless of the drainage technique, patients received culture-directed antibiotics. Tube dysfunction or occlusion resulted in exchanges, often preceded by a CT scan of the abdomen. This approach was the same in both groups. Patients were
managed by hospitalists and medical residents, with guidance by the gastroenterology and/or surgical services.

**Patient Selection**

Hospitalists selected patients for SPD or CMT on the basis of consultation with gastroenterologists and interventional radiologists. SPD of WOPN has been the modality used at our tertiary pancreatic center for nearly 20 years; therefore, most patients in 2006 through early 2008 underwent SPD as a result of familiarity with the technique. CMT was introduced in November 2007. As gastroenterologists and radiologists recognized the decreased pancreatic fistula rate in CMT, more patients underwent CMT in late 2008 and 2009. The only qualifying criteria for CMT were that the “necroma” needed to abut the stomach/duodenum and have a well-formed wall. Patients in both groups were discharged from the hospital when they were clinically stable and were followed in the gastroenterology or surgery clinic. Percutaneous drain tubes were removed when the drains no longer produced fluid, did not cause symptoms if closed to gravity drainage, and when there was no residual fluid collection on CT scan (Figure 4, resolution of WOPN and removal of percutaneous drain). Endoscopically placed transenteric stents were removed if the patient had an intact pancreatic duct, had resolved the fluid collection, and removal of the percutaneous tube had not resulted in fluid reaccumulation. If a patient had a disconnected pancreatic duct, then the endoscopically placed transenteric stents were left in place indefinitely.

**Statistics**

Univariate statistical comparisons were performed by using the Student t test or Mann–Whitney U test for continuous or ordinal variables and by the χ² test or Fisher exact test for categorical variables.

**Results**

Forty-three patients (25 male, 18 female) underwent SPD of WOPN, and 23 (18 male, 5 female) had CMT of WOPN. The 2 groups were predominantly male and similar in mean age, 54 years in SPD and 59 years in CMT group. Biliary pancreatitis was the most frequent cause of SAP in both groups, accounting for 56% in SPD and 56% in CMT. Other causes of pancreatitis were similar in the 2 groups (Table 1), with the exception of 6 patients with hypertriglyceridemia in SPD and none in CMT.

CTSI¹²,¹³ was used to evaluate disease severity in both groups. The maximum CTSI after 1 week from the onset of SAP became the severity measure for all patients. CTSI were comparable in CMT and SPD, 8.0 versus 7.2, respectively (P = NS). The size and complexity of fluid collections were equivalent in each arm of therapy, as were the percentage of leukocytes and positive Gram stains in WOPN (Supplementary Table 1). Clinical measures predictive of severity such as Ranson, Glasgow, and Acute Physiology, Age, and Chronic Health Evaluation II were inconsistent, often unobtainable, and not used because a

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**Figure 4.** Same patient 4 months after CMT for WOPN: resolution of fluid collections and areas of necrosis. Percutaneous drain was removed 1 month earlier. Resolved WOPN with necrogastrostomy stents in place (large white arrow). Insert demonstrates residual pancreatic parenchyma (small white arrow).

**Table 1. Patient Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>SPD</th>
<th>CMT</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (M/F)</td>
<td>43 (25/18)</td>
<td>23 (18/5)</td>
<td>.13</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>54 ± 17</td>
<td>59 ± 14</td>
<td>.23</td>
</tr>
<tr>
<td>% male</td>
<td>58</td>
<td>77</td>
<td>.13</td>
</tr>
<tr>
<td>Etiology, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choledocholithiasis</td>
<td>24 (56)</td>
<td>13 (56)</td>
<td>.21</td>
</tr>
<tr>
<td>Alcohol</td>
<td>6 (14)</td>
<td>4 (17)</td>
<td>.65</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>3 (7)</td>
<td>4 (17)</td>
<td>.17</td>
</tr>
<tr>
<td>Pancreas divisum</td>
<td>2 (4)</td>
<td>2 (9)</td>
<td>.48</td>
</tr>
<tr>
<td>Hypertriglyceridemia</td>
<td>6 (14)</td>
<td>0</td>
<td>.07</td>
</tr>
<tr>
<td>Post ERCP</td>
<td>1 (2)</td>
<td>0</td>
<td>.47</td>
</tr>
<tr>
<td>Trauma</td>
<td>1 (2)</td>
<td>0</td>
<td>.47</td>
</tr>
<tr>
<td>Mean CTSI</td>
<td>7.2 ± 2.0</td>
<td>8.0 ± 1.4</td>
<td>.06</td>
</tr>
<tr>
<td>Definable fluid collection</td>
<td>2.7 ± 1.2</td>
<td>2.13 ± 1.2</td>
<td>.1</td>
</tr>
<tr>
<td>Mean interval from SAP onset until drain placement (d)</td>
<td>33.3 ± 27.2; median, 22</td>
<td>44.5 ± 11.3; median, 26.5</td>
<td>.24</td>
</tr>
<tr>
<td>No. of patients with disconnected pancreatic ducts</td>
<td>16/35 (46%)a</td>
<td>12/23 (52%)</td>
<td>.75</td>
</tr>
</tbody>
</table>

aEight patients without pancreatograms in standard group; therefore, unable to assess integrity of pancreatic duct.
The majority of patients were transferred into our institution at differing times during the course of SAP.

Initial drains were placed into WOPN an average of 33.3 days after onset of SAP in SPD and 44.5 days in CMT (P = NS). In the CMT group, the mean time until removal of the final percutaneous drain was significantly shorter, 84 days versus 189 days in the standard group (P < .006). Three SPD patients developed pancreatic cutaneous fistulae (PCFs) requiring surgery, whereas no CMT patient developed a PCF or needed surgery. Three patients undergoing SPD died during the course of therapy with drainage catheters in place, 2 of respiratory failure and 1 of multisystem organ failure. One CMT patient died 6 months after completing therapy for WOPN as a result of complications of esophageal carcinoma.

Mean LOH from placement of drains to discharge was significantly less in CMT, 26 days versus 55 days (P < .0005). LOH was computed from the time of drain placement until discharge. Readmissions for any problem while having percutaneous drains were added to the total. Occluded percutaneous drains accounted for the majority of readmissions. In SPD, the average number of percutaneous drains per patient was significantly more in CMT, 2.0 versus 1.2 (P < .0005). Five SPD patients developed splenic artery pseudoaneurysms that bled. No pseudoaneurymsmal bleeding was observed in the CMT group.

Mean number of abdominal CT scans in CMT from time of drain placement until final drain removal was significantly reduced from SPD, 8.9 compared with 14.3 (P < .002). Drain exchanges were reduced by 50% in CMT over SPD, 6.5 versus 13.0 (P < .0001). The reduction in radiologic resources used in CMT occurred in spite of equivalent patients in both groups having disconnected ducts, CMT with 52% and SPD with 46%. Eight patients (18%) in SPD did not have definitive pancreatograms. The mean number of ERCPs and other endoscopies was equivalent between the 2 groups (Table 2).

Four complications of therapy in CMT have been identified. One abscess occurred after drainage of a large fluid collection that did not communicate with an adjacent smaller fluid collection. The abscess resolved after placement of a second drain into the smaller collection. Two percutaneous drains dislodged before completion of therapy, requiring a new drain through the mature fistula. Both drains were removed successfully 1 month later without consequence. One patient had intermittent duodenal edema causing partial gastric outlet obstruction. He was admitted and managed conservatively with fluids, antibiotics, but no endoscopic intervention. Duodenal edema and obstruction resolved with conservative management. Complications were less easily determined in the SPD patients because tube occlusion and spontaneous drain passage before WOPN resolution were considered part of the natural history of treatment.

Discussion

Treatment of symptomatic WOPN has changed during the past 40 years from surgical debridement as the sole accepted therapy to nonoperative modalities such as percutaneous drainage with frequent drain exchanges, minimally invasive surgical procedures such as transcatheter debridement by using small-caliber scopes through fistula tracts, and combinations of endoscopic and percutaneous drainage. The current study demonstrates that combining endoscopic and percutaneous drainage reduces LOH as well as decreasing use of both CT scans and radiologic tube studies. These advantages are coupled with equivalent or better clinical outcomes and the elimination of PCF.

Percutaneous management of symptomatic WOPN has been the standard of care at our institution for almost 20 years. Patients with WOPN require long hospitalization, use substantial amounts of health care resources, and are exposed to large

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Table 2. Endoscopic and Radiologic Studies and Clinical Outcomes

<table>
<thead>
<tr>
<th>Endoscopic and radiologic studies</th>
<th>SPD</th>
<th>CMT</th>
<th>P value</th>
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<tbody>
<tr>
<td>Mean no. of CTs from time of placement of drain until removal of last percutaneous drain</td>
<td>14.3 ± 7.2; median, 13</td>
<td>8.95 ± 3.5; median, 7</td>
<td>.002</td>
</tr>
<tr>
<td>Mean drainage studies until removal of last drain</td>
<td>13.0 ± 6.9; median, 13</td>
<td>6.5 ± 2.8; median, 6</td>
<td>.0001</td>
</tr>
<tr>
<td>Mean no. of drainage/patient</td>
<td>2.02 ± 0.96</td>
<td>1.18 ± 0.96</td>
<td>.0005</td>
</tr>
<tr>
<td>Mean no. of ERCPs/patient</td>
<td>2.56 ± 1.9; median, 3</td>
<td>2.04 ± 0.95; median, 2</td>
<td>.24</td>
</tr>
<tr>
<td>Other endoscopies, mean</td>
<td>1.1 ± 1.2</td>
<td>1.3 ± 1.0</td>
<td>.52</td>
</tr>
<tr>
<td>Median</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0–4</td>
<td>0–3</td>
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</table>

Clinical outcomes

| Mean LOH, median (d) | 55.2 ± 41.8, 39 | 25.6 ± 19.9, 19 | .0026 |
| Mean interval until final drain removed, median (d) | 189 ± 164, 142 | 83.9 ± 14.2, 59.5 | .006 |
| Successful completion of drainage (no external drains) | 35/43, 81% (3 deaths, 3 surgeries, 2 lost to follow-up) | 22/22, 100% | .03 |
| Need for surgery | 3/43 (6.9%) | 0 | .20 |
| Pseudoaneurysms with bleeding | 5/43 (11.6%) | 0 | .10 |
| Deaths | 3/43 (6.9%) | 1/22 | .70 |

NOTE. Two patients in the standard group were lost to follow-up.

*A drain study was considered as 1 for a given day, even if multiple drains were in position and injected.

*The last day of drainage for 3 patients who went to surgery was the day of surgery.

*Died of methicillin-resistant Staphylococcus aureus pneumonia during treatment for esophageal cancer 6 months after removal of percutaneous drain.
quantities of ionizing radiation. The idea for CMT for WOPN arose from the clinical observation that patients with WOPN who spontaneously fistulized into the duodenum during SPD had shorter, less complicated hospital courses and no PCFs. The goal of CMT, therefore, was to create a controlled fistula between the necrotic fluid collection and the lumen of the bowel at the beginning of percutaneous drainage. The external drains were still necessary to lavage WOPN.

Combining endoscopic and percutaneous drainage significantly reduced LOH from 55 days in SPD to 26 days in CMT. This reduction compares favorably with other published series. Gardner et al.\textsuperscript{27} reported a reduction in LOH by using endoscopic necrosectomy from 38 to 15 days in comparison with standard drainage; however, this was not a statistically significant change. Van Santvoort et al.\textsuperscript{3} recently reported a comparison of surgical debridement to a step-up approach; LOH was reduced by 10 days from 60 to 50 days in those in the minimally invasive arm. In our study, percutaneous drainage catheters were placed approximately 4–6 weeks after onset of SAP, slightly earlier than described by Gardner et al in patients treated with endoscopic necrosectomy for WOPN. Notable in our series is that patients with either CMT or SPD who had percutaneous drains before 3 weeks had a more prolonged course and more drain exchanges, suggesting that a well-defined wall was advantageous and should be sought if the patient could sustain conservative management until maturation of the WOPN. Duration of percutaneous drainage was significantly decreased in CMT compared with SPD from 189 to 84 days, partially explained by providing a luminal exit for pancreatic secretions in those patients with disconnected pancreatic ducts.

The number of CTs and tube checks in the CMT group decreased in part as a result of shorter LOH. Fewer drains were required in CMT, and the drains occluded less frequently, presumably as a result of an internal fistula through which necrotic debris could pass. It is not clear why providing dual drainage facilitates passage of necrotic debris. Conceivably, motility of the gastrointestinal tract assists in pumping debris out of the WOPN, or enteric fluids beneficially irrigate it. Another unexpected favorable result of CMT was the reduction in pseudoaneurysmal bleeding, apparently as a result of improved drainage of pancreatic fluid from necrotic tissue surrounding vascular structures and smaller drains, and with fewer drain exchanges.

Using CMT reduced the total dose of ionizing radiation that patients receive. Treatment of WOPN by using percutaneous drainage depends on contrast-enhanced CT scans to diagnose, determine severity, and direct drains.\textsuperscript{1,2,7–13} CT scanners are ubiquitous at large medical centers and can perform highly detailed studies rapidly, but at the expense of substantial exposure to ionizing radiation. Morgan et al.\textsuperscript{31} demonstrated that SAP patients undergo more abdominopelvic CTs than patients with less severe pancreatitis, independent of age. Their study recommended alternate imaging techniques to reduce future cancer risk, especially in younger patients. A series of articles has heightened both physician and public awareness of the risks associated with radiologic procedures and future cancer risk.\textsuperscript{32–35} Our current study significantly decreased patient exposure to ionizing radiation over conventional treatment with SPD, but we hope in the future to reduce it further by using other imaging modalities without sacrificing resolution and accuracy.

By reducing LOH and radiologic procedures, CMT appears to reduce the cost of managing symptomatic patients with WOPN. This study did not determine total hospital and outpatient costs of both treatment modalities. In spite of comparable patient demographics and CTSI, the study groups might vary in ways not measured or recognized. Also, CMT was not compared with surgery or endoscopic necrosectomy because those treatment modalities for WOPN are rarely used in our institution. The study by Van Santvoort et al.\textsuperscript{3} convincingly demonstrated that minimally invasive therapy for WOPN reduced complications and mortality.

The current study is limited by its retrospective nature. CMT for WOPN represents an evolution of a technique that we have used for many years, SPD. During the past 15 years, we have instituted early enteral feedings, improved nursing protocols, and intensified physical therapy, but the modification that most dramatically decreased LOH and fistula formation was introduction of CMT. To state with certainty that CMT is more efficacious, cost-effective, and/or associated with lower morbidity than minimally invasive surgery or endoscopic necrosectomy, a large multicenter, randomized trial would need to be undertaken. Until then, the current study adds another seemingly effective and safe management technique for symptomatic WOPN, with the added benefit of reducing LOH, PCFs, and use of radiologic resources.

### Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org and at doi:10.1016/j.cgh.2010.09.010.

### References


Reprint requests
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Conflicts of interest
The authors disclose no conflicts.