Introduction

Transgastric or transduodenal endoscopic ultrasound (EUS)-guided drainage and, if needed, necrosectomy has become the modality of choice in the treatment of pancreatic walled-off necrosis (WON) [1,2,3,4,5,6]. However, some WON may not be in proximity to the upper gastrointestinal tract or may extend into the paracolic gutters, the root of the mesentery, or the pelvis, necessitating multi-gate drainage. In such cases, a percutaneous approach including percutaneous catheter drainage or surgical techniques including video-assisted retroperitoneal debridement (VARD) may be required; however, this is associated with considerable risk of pancreatico-cutaneous fistulas [7]. While EUS-guided transrectal (TR) and transcolonic (TC) drainage of abdominopelvic abscesses has been described elsewhere [8], only one case report has described the use of this technique in managing WON [9].

Procedure

In this paper, we report our experience with EUS-guided TR or TC drainage and necrosectomy in nine consecutive patients with culture-proven infected WON who were admitted to our tertiary referral center. During the study period of January 1, 2020, to December 31, 2022, 91 adult patients (> 18 years) underwent EUS-guided drainage for WON. Permission for this study was granted by the Center for Regional Development, Capital Region of Denmark (ID no.R-20075169). No permission from the Regional Ethics Committee was needed since the study was retrospective.

EUS-guided transcolonic drainage and necrosectomy was needed in seven patients (78%).
ana, United States); 2) insertion of a 0.025- to 0.035-inch/450-cm guidewire (VisiGlide 2, Olympus Medical Systems Europe, Hamburg, Germany or Dreamwire, Boston Scientific Natick, Massachusetts, United States) through the needle; 3) balloon dilatation of the tract over the wire with a 4- to 8-mm balloon (Hurricane, Boston Scientific Natick, Massachusetts, United States); and 4) insertion of one or two 7F double pigtail stents (DPT) of various lengths (Zimmon, Cook Medical, Bloomington, Indiana, United States). Alternatively, a lumen-apposing metal stent (LAMS) (Hot AXIOS 20 × 10 mm, Boston Scientific, Natick, Massachusetts, United States) with a 7F/4-cm coaxial double pigtail stent was used (Fig. 1). Endoscopic necrosectomy was performed through the working channel of either a gastroscope or colonoscope (Olympus Medical Systems Europe, Hamburg, Germany) using forceps, snare or EndoRotator (Interscope Medical, Inc. Worcester, Massachusetts, United States) at the discretion of the endoscopist. During endoscopic debridement, irrigation was performed with 0.3% hydrogen peroxide solution. Bowel cleansing was achieved by administration of a polyethylene glycol (PEG)-based bowel preparation including Plenvu or macrogel (Movicol) before the endoscopic procedures. Between endoscopic procedures, antibiotic and/or antifungal treatment was administered depending on microbiological findings at index drainage procedure and further treatment was adjusted according to subsequent culture findings. The procedures were performed under conscious sedation with midazolam and sufentanil, or under general anesthesia, depending on the clinical condition of the patient. The pigtail stents were removed after 1 year, while the LAMS was removed after clinical resolution and before discharge from the hospital. As for transgastric drainage, indwelling coaxial double pigtail stents were left in place after removal of the LAMS for a year, aiming at minimizing recurrence of pancreatic fluid collections especially in case of disconnected pancreatic duct syndrome.

In all patients the treatment strategy including need for step-up was discussed after thorough review of relevant clinical information and radiological images at a weekly multidisciplinary pancreas team meeting including advanced endoscopists, surgeons, gastroenterologists, microbiologists, and radiologists [6].

Results
Overall, nine patients with WON, all with culture-proven infection, according to the Revised Atlanta classification [10] were included in the study (Table 1). In all but two of the patients, the TR/TC drainage was performed in addition to transgastric drainage and necrosectomy (Table 1). Drainage was performed through the colon in seven patients and through the rectum in two patients. Double pigtail stents were used in six patients and LAMS was used in three patients. TR/TC necrosectomy was needed in seven patients (78%) (Video 1). Drainage was successfully performed in all patients and clinical resolution was achieved in eight of the nine patients at follow-up (89%). In one patient, a small, isolated remnant of the WON recurred as a psoas abscess and was first drained percutaneously at the referring hospital and subsequently in our center through the colon. The overall adverse event rate was 11% (n = 1). A transverse colonic perforation occurred in a patient after faulty insertion of double pigtail stents into what was believed
### Table 1 Overview of patients with WON who underwent transrectal/transcolonic EUS-guided drainage and necrosectomy.

<table>
<thead>
<tr>
<th>ID</th>
<th>Age, sex</th>
<th>Etiology</th>
<th>Comorbidity</th>
<th>WON size and location</th>
<th>Puncture site</th>
<th>Index intervention, days since index intervention</th>
<th>Indication for transcolonic/transrectal necrosectomy</th>
<th>Transcolonic/transrectal necrosectomy Stent, type and size</th>
<th>Adverse events</th>
<th>Clinical success</th>
<th>Number of transcolonic procedures before resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27, M</td>
<td>Gallstones</td>
<td>Diabetes</td>
<td>10 × 12 cm, splenic flexure, medial to the descending colon</td>
<td>Descending colon</td>
<td>Transgastric drainage followed by necrosectomy, 15 days</td>
<td>Remnant necrotic collection at the splenic flexure not accessible by transgastric drainage</td>
<td>No</td>
<td>7F DPT stent</td>
<td>Yes, colonic perforation¹</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>28, M</td>
<td>Alcohol</td>
<td>None</td>
<td>15 × 4 cm, pelvic cavity</td>
<td>Rectum</td>
<td>Transgastric drainage followed by necrosectomy and VARD, 104 days</td>
<td>Slow clinical progression and poor infection control why a multi-gate technique was used (concomitant transgastric necrosectomy and transrectal drainage)</td>
<td>No</td>
<td>7F DPT stent</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>63, M</td>
<td>Alcohol</td>
<td>None</td>
<td>7 × 3 cm, splenic flexure, medial to the descending colon</td>
<td>Descending colon</td>
<td>Transgastric drainage followed by necrosectomy, 13 days</td>
<td>Remnant necrotic collection at the splenic flexure not accessible by transgastric drainage</td>
<td>Yes</td>
<td>7F DPT stent</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>50, F</td>
<td>Post-ERCP</td>
<td>Primary biliary cholangitis and liver transplantation</td>
<td>26 × 4 cm, pelvic cavity</td>
<td>Rectum</td>
<td>Transrectal, N/R</td>
<td>Transrectal drainage and necrosectomy used as single-therapy due to WON location</td>
<td>Yes</td>
<td>7F DPT stent</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>40, F</td>
<td>Ischemic pancreatitis following newly liver transplantation</td>
<td>Neuroendocrine tumor with previous Whipple procedure</td>
<td>24 × 16 cm, at the left paracolic gutter extending medially to the mesenteric root</td>
<td>Transverse colon</td>
<td>Concomitant transgastric and transcolonic drainage and necrosectomy at index procedure</td>
<td>Refractory septic shock in an immunocompromised patient</td>
<td>Yes</td>
<td>LAMS (Hot AXIOS stent, 20 mm x 10 mm)</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>ID</td>
<td>Age, sex</td>
<td>Etiology</td>
<td>Comorbidity</td>
<td>WON size and location</td>
<td>Puncture site</td>
<td>Index intervention, days since index intervention</td>
<td>Indication for transcolonic/transrectal intervention</td>
<td>Transcolonic/transrectal necrosectomy</td>
<td>Stent, type, and size</td>
<td>Adverse events</td>
<td>Clinical success</td>
</tr>
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<td>6</td>
<td>33, F</td>
<td>Post-ERCP</td>
<td>None</td>
<td>9 × 7 cm, at the mesenteric root, infero-medial to the transverse colon</td>
<td>Transverse colon</td>
<td>Transcolonic</td>
<td>Collection not accessible by transgastric approach</td>
<td>None</td>
<td>LAMS (Hot AXIOS stent, 20 mm x 10 mm)</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>73, F</td>
<td>Gallstones</td>
<td>Hypertension</td>
<td>11 × 6 cm, at the splenic flexure, extending medially to the descending colon</td>
<td>Descending colon</td>
<td>Transgastric drainage and necrosectomy, 39 days</td>
<td>Remnant necrotic collection at the splenic flexure not accessible by transgastric drainage</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>46, M</td>
<td>Gallstones</td>
<td>None</td>
<td>24 × 7 cm, at the left paracolic gutter extending medially to the mesenteric root</td>
<td>Descending colon</td>
<td>Transgastric drainage and necrosectomy, 62 days</td>
<td>Remnant collection at left paracolic gutter not accessible by transgastric approach</td>
<td>None</td>
<td>LAMS (Hot AXIOS stent, 20 mm x 10 mm)</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>35, M</td>
<td>Alcohol</td>
<td>None</td>
<td>8 × 4 cm, at the splenic flexure extending medially to the descending colon</td>
<td>Descending colon</td>
<td>Transgastric, 32 days</td>
<td>Remnant collection at the splenic flexure not accessible by transgastric drainage</td>
<td>None</td>
<td>7F 8 cm DPT stent</td>
<td>None</td>
<td>Yes</td>
</tr>
</tbody>
</table>

M, male; F, female; ASA, American Society of Anesthesiology; WON, walled-off pancreatic necrosis; ERCP, endoscopic retrograde pancreatography; DPT, double pigtail; VARD, video-assisted retroperitoneal debridement; PBC, primary biliary cholangitis; LAMS, lumen-apposing metal stent.

1 A transverse colon perforation occurred during insertion of double pigtail stents, necessitating surgery (explorative laparotomy with suture repair); however, a further transcolonic drainage procedure was performed successfully.
to be a WON. This was treated with laparotomy and suture repair, followed by an uneventful recovery (Patient ID 1, ▶ Table 1). A successful transcolonic drainage was later performed in this case.

Discussion
No patient in our cohort developed pancreatico-cutaneous fistula, a complication associated with substantial morbidity and more commonly encountered in patients drained through percutaneous routes or surgical approaches including VARD and open necrosectomy [4, 7]. We believe that endoluminal drainage and necrosectomy minimize that risk. Moreover, necrotic collections extending into the root of the mesentery may be challenging to drain sufficiently with percutaneous techniques including VARD due to a central location in the abdomen. We find that transcolonic drainage in collections inaccessible to a transgastric or transduodenal route may serve as a minimally invasive alternative to percutaneous or surgical techniques.

EUS-guided TR/TC drainage may be performed both with DPT and LAMS. However, when puncturing from the transverse colon, which is intraperitoneally located, the use of LAMS is preferred to seal the trajectory.

Conclusions
While our study is limited by its small number of patients, it is the first to demonstrate the technical feasibility of EUS-guided TR/TC drainage and necrosectomy in patients with WON. TR/TC drainage of WON appears to be safe and practical, and the combination of transgastric and transcolonic drainage may be recommended for multi-gate treatment of WON extending to the paracolic gutters, the root of the mesentery, or in the presacral space. Hypothetically, bacterial translocation from the colon and subsequent superinfection of the WON may be an issue. However, the WON in our cohort were already infected, as confirmed by culturing findings. Finally, it remains to be explored in a prospective setting whether EUS-guided TR/TC drainage improves clinical outcomes.

Conflict of Interest
ME, SN, PNS, and EFH have no conflicts of interest to declare. JGK is a consultant for Boston Scientific, Ambu, and SNIPR Biome.

References