Introduction

Acute pancreatitis is an inflammatory process of the pancreas. It presents with variable severity ranging from a mild transitory form that resolves spontaneously to a severe necrotizing disease with extensive necrosis and hemorrhage that is associated with local and systemic complications. The Atlanta classification defines pancreatic necrosis as diffuse or focal areas of nonviable pancreatic parenchyma, which typically are associated with peripancreatic fat necrosis [1]. With time, these necrotic areas become partially liquefied and contain variable amounts of solid necrotic debris. The term organized pancreatic necrosis was first suggested by Baron et al. [2,3], to distinguish pancreatic necrosis that evolves over several weeks after an episode of severe acute necrotizing pancreatitis. Subsequently, in 2006 Digestive Disease Week during the AGA Clinical Symposium, “Problems and Pitfalls of Atlanta Classification for acute pancreatitis: AGA (American Gastroenterology Association), APA (American Pancreatic Association), and IAP (International Pancreatic Association) to revisit” the term ‘walled off pancreatic necrosis (WOPN)’ was introduced. These collections represent an evolution from the early diffuse pancreatic glandular and retroperitoneal fat necrosis to an encapsulated, loculated form. The evolution of pancreatic collection from an early pancreatic necrosis to a pseudocyst is a continuous process and organized pancreatic necrosis is an intermediate stage between the two. The presence of solid necrotic debris is best documented before intervention by means of magnetic resonance imaging [4] or endoscopic ultrasound. Severe pancreatic necrosis affects 15% of all cases of pancreatitis. 40-70% of these cases later get infected with a mortality up to 50% [5].

Open surgical necrosectomy has been the mainstay of treatment for organized pancreatic necrosis over decades because at a sub acute stage the necrotic tissue is better...
demarcated from the viable pancreas[6]. However, surgical necrectomy[7] is often associated with higher morbidity (13%-53%) and mortality (6.2%-25%)[8-11] and often requires repeated laparotomies (17-71%). Long-term complications are also more[12].

Percutaneous drainage is effective in managing all types of pancreatic fluid collections including infected pancreatic necrosis[13,14]. However, this approach is not effective when thick purulent and necrotic materials are present within the cavity. Percutaneous catheters may leak pancreatic fluid and irrigate onto the abdominal wall. This frequently results in skin breakdown and patient discomfort and prolonged hospital stay[15]. It also carries the disadvantages of need for external catheters and the potential for development of a pancreatico-cutaneous fistula when a pancreatic fluid collection communicates with the main pancreatic duct which often necessitates endoscopic or surgical repair[16,17].

Endoscopic treatment of pancreatic necrosis is an upcoming, less invasive but technically demanding procedure that is associated with lesser morbidity and mortality. Since the first reports of endoscopic management of pseudocyst, technology and expertise have evolved a lot. It includes drainage of abscesses, drainage and now debridement of organized necrosis, not only bulging but also non-bulging and distant collections by using endoscopic ultrasound[18-20]. In this article we present the evolution and an up-to-date review on endoscopic management of pancreatic necrosis, a technique that is still evolving and looking for definitive indications.

**Patient selection / Indications**

Patients who can be taken up for endoscopic necrectomy are those with uncontrolled sepsis associated with persistent pancreatic necrosis on the CT (computed tomography) scan[21,22]. There is no definite evidence that treating sterile necrosis could bring any benefit to patients with necrotizing pancreatitis either surgically or endoscopically[12,23,24]. Infectious complications are common after endoscopic drainage of sterile pancreatic necrosis because of introduction of bacteria during the procedure along with incomplete evacuation of solid debris[25,26]. During the early phase of acute severe necrotizing pancreatitis, the patient should be managed by aggressive intensive medical treatment with intervention delayed if possible[27]. The international guidelines propose surgical intervention only in cases of infected necroses and recommend delayed surgery[7,28]. Surgical series have suggested that postponing surgery until 30 days or more after the onset of acute pancreatitis is associated with an improved outcome. This is because by this time the necrotic tissue is well demarcated and thus limits the extent of surgery to pure debridement and only one intervention[6,12]. Since endoscopic necrectomy is a minimally invasive procedure, whether this interval can be shortened is unknown[25].

Other indications of intervention includes biliary and/or gastric outlet obstruction, persistent pain that requires narcotics, inability to eat and/or failure to thrive[29].

**Evaluation before endoscopic drainage**

As the pancreatic necrosis contains a lot of necrotic solid debris, the endoscopic approach for its drainage is different from the techniques of endoscopic drainage of other pancreatic fluid collections. Endoscopic drainage of pancreatic necrosis is a highly complex procedure with limited experience and no randomized studies comparing it with different techniques. It should be undertaken only by an experienced endoscopist at a centre with a good surgical and radiological back up. Once the decision to drain pancreatic necrosis endoscopically has been made, the endoscopist should answer these questions before proceeding for intervention. i) Is it central or peripheral necrosis? Central pancreatic necrosis is confined almost entirely to the pancreatic parenchyma and immediately adjacent peripancreatic tissue. As the body of the pancreas is close to the stomach and duodenum, patients with central pancreatic necrosis are suitable candidates for transmural drainage. Peripheral pancreatic necrosis is not in the immediate vicinity of the pancreas and is less amenable to endoscopic therapy alone. ii) Is it organized or early necrosis? iii) Is there any contraindication to puncturing the stomach wall (e.g., fixed coagulopathy, cyst wall >1 cm thick, gastric varices or a complex cyst)? iv) Is endoscopic ultrasound (EUS) available? v) Is surgical and/or radiological backup available[30]?

**Technique**

Intravenous contrast enhanced computed tomography (CECT) should be obtained before attempted transmural drainage to identify major vascular structures or pseudoaneurysms between the gastric or duodenal wall and the collection. Endoscopic ultrasound can help in better delineating the vascular structures between the cyst wall and the stomach. The procedure can be performed under non intubated deep propofol sedation[31], only benzodiazepine and opioid sedation[32], or general anesthesia with intubation[33]. Endoscopy is performed with a therapeutic, side viewing video duodenoscope. Extrinsic compression of the gastric or duodenal lumen by the walled off pancreatic necrosis (WOPN) is determined endoscopically. A pancreatogram can be obtained when possible at the index endoscopy either before or after drainage to assess the integrity of the pancreatic duct.

Entry into the collection is achieved by several methods. For non–EUS-guided drainage, either needle-knife electrosurgery or needle aspiration is used as described previously[34,35]. In patients undergoing EUS, cyst puncture is performed under direct EUS guidance using 19
Agrawal indicated and percutaneous and/or operative management is discontinued when resolution or near resolution of the end of first procedure. Endoscopic procedures can be repeated if there was persistent or recurrence of necrotic cavity at the end of first procedure or persistence of necrotic cavity at the end of first procedure and/or mortality. Radiological (morphological) success is defined as complete if there is no cyst/fluid collection and partial if there is some cystic cavity remaining (<3 cm), not requiring further interventional treatment. Radiologically, endoscopic treatment is said to be failed if the collection remains unchanged.

Role of EUS

Endoscopic ultrasound guided puncture has been found to be safe for non-bulging collections. It has the advantage of excellent visualization of pancreas and peripancreatic areas and provides direct passage of the needle into the cavity avoiding inadvertent puncture of interposed blood vessels. When the distance between the pseudocyst and bowel lumen exceeds 1 cm, complications may increase. It remains to be determined whether the distance between the enteral lumen and the pancreatic collection is related to the complication rate when EUS is employed. In a study comparing conventional transmural drainage with EUS guided drainage by Kahaleh et al, no significant difference in efficacy or safety was observed between the two methods. EUS guided drainage is considered in patients with non-bulging fluid collections, high pretest probability of bleeding, prior failed transmural entry using non-EUS guided technique, collections inaccessible by gastroduodenoscopy, i.e., those located at the tail or extending into the porta hepatitis. EUS is however, less useful for monitoring the resolution of necrotic tissue because the resultant cavity does not provide good EUS images because of presence of excessive air.

Site of drainage

When compared with the transgastric approach, the transduodenal approach had a higher success rate, although statistically significant difference was not found. Papachristou et al also showed that there was no significant difference between the transgastric and the transduodenal approach in terms of procedure-related complications, number of endoscopic procedures, final outcome of endoscopic treatment and time for the WOPN to resolve. The only difference was that there was an increased need for concomitant radiologic drainage in transduodenal approach. Selection of a site about 5 cm from the gastroesophageal junction on the posterior wall/lesser curvature of the stomach is valuable because this location allows straight positioning of the scope, allowing easy entrance into the cystic collection.

Debridement is performed under direct endoscopic vision by entering into the necrotic cavity with a standard or therapeutic channel, forward-viewing gastroscope. Devitalized pancreatic tissue can be removed with the combination of several different accessories, including 15-mm biliary stone retrieval balloons, Roth retrieval net baskets, lithotripsy stone retrieval baskets, tripod retrieval forceps, rat-toothed and pelican forceps and 10-Fr irrigation probes. All devitalized tissue that can be visualized and easily dissociated from the wall of the cavity, without causing significant bleeding is removed into the stomach or the duodenum. The degree of necrosectomy is performed at the discretion of the therapeutic endoscopist, with the goal of uncovering the pink granulation tissue lining the wall of the collection. Removed tissue is collected within the gastric or duodenal lumens or can be removed en bloc via the mouth by using a Roth retrieval net.

During each intervention, all patients should receive intravenous antibiotics, which are continued for at least 3 days after the endoscopy. Serial CTs are performed every 1 to 2 weeks to evaluate the status of the WOPN until resolution. Timing of repeat endoscopic procedure is variable. In some studies, it was performed daily, in some studies procedure was repeated if there was persistent or recurrent fever or evident remaining necrotic material at the end of first procedure or persistence of necrotic cavity at the end of first procedure. Endoscopic procedures can be discontinued when resolution or near resolution of the collection is documented, or if endoscopic treatment failed and percutaneous and/or operative management is indicated.

Seifert et al defined clinical success as complete if the patient is symptom-free and no further interventions are required. Clinically failure is defined as failure to resolve the collection, requiring other interventions, and/or failure to significantly improve the patient’s symptoms, and/or complications necessitating a switch to other therapies (mostly surgery), and/or mortality. Radiological (morphological) success is defined as complete if there is no cyst/fluid collection and partial if there is some cystic cavity remaining (<3 cm), not requiring further interventional treatment. Radiologically, endoscopic treatment is said to be failed if the collection remains unchanged.
Use of intracystic irrigation catheters and pancreatic drainage tubes:

The choice of stents after initial access to the necrotic cavity is not standardized. Often two or more 10 Fr double pigtail plastic stents are used. For endoscopic necrosectomy, the choice of stents is of lesser importance, since they mainly serve to keep the access open for dilatation and subsequent sessions of necrosectomy. A 7-Fr, nasobiliary pigtail tube is positioned into the necrotic collection to perform aggressive irrigation. However, Mathew et al[45] didn’t put nasocystic catheter in their 2 cases after necrotic material was completely removed and both of them improved.

Baron et al[15] described for the first time placement of percutaneous endoscopic gastrostomy (PEG) tube with a jejunal extension into the collection for continuous irrigation and debridement for patients who do not tolerate nasally placed irrigation lavage tubes. This was later modified by Racynski et al[46] who innovated double PEG approach with one tube into the necrotic cavity and another having jejunal extension for normocaloric enteral nutrition. This had the advantage of high volume irrigation of retroperitoneal necrosis, continuous normocaloric enteral nutrition and no need of transnasal drainage or feeding tubes[46]. But PEG placement is a technically demanding procedure and is associated with procedure related complications, infection, patient discomfort and peristomal skin irritation[47,48].

Use of SEMS

The removal of necrotic debris depends upon the size of gastro-retroperitoneal track. Wider diameter track enable the debridement of large pieces of necrotic retroperitoneal tissue. Antillon et al[49] described transmural placement of a fully covered self-expanding metallic stent in a patient not responding to frequent sessions of endoscopic necrosectomy. SEMS allowed intensive irrigation and better drainage. Patient showed prompt improvement and resolution of infected pancreatic necrosis. However, such treatment is associated with risk of stent migration and bleeding and therefore has not been routinely recommended[50].

Role of ERCP

The endoscopic approach has the added advantage of performing ERCP during the procedure. By performing ERCP during the procedure, several pathologies such as biliary stones, pancreatic fistulas, and pancreatic duct strictures can be diagnosed and treated. Fistulas and strictures being the possible causes of recurrence of peripancreatic collections[51,52]. However, in spite of not performing routine ERCP, Voerman’s et al[53] showed a low recurrence rate, thus doubting the utility of routine ERCP. Based on the findings of several other studies, routine performance of ERCP can be suggested[29,31,33].

Number of sessions

Mean number of sessions has varied from single session to a maximum of 7. Number of sessions required to achieve the end-point depends upon the operator expertise and type of drainage procedure and the duration of endoscopic sessions. Single session necrosectomy has been performed by Mathew et al[45] in 6 patients with a success rate of 83%. Decreasing the number of necrosectomy sessions requires prolonged procedure which often requires general anesthesia which is associated with its own complications[33,45].

Complications

Endoscopic therapy of pancreatic necrosis is associated with a lot of complications. Most of these are local and are easily manageable. These include bleeding at the stoma site, perforation of necrosis into the peritoneal cavity. Others include fistula formation, air embolism, transient aggravation of sepsis, perforation of the adjacent organ, etc. Complications which are not directly related to necrosectomy may also occur. Mortality has occurred in only a few studies and has always been less than 10%. In most of the cases not directly related to necrosectomy[36,54].

Results of endoscopic necrosectomy (Table 1)

Baron et al in 1996[25], for the first time described endoscopic therapy in organized pancreatic necrosis when they performed endoscopic drainage in eleven patients out of which 8 had sterile necrosis. Initially the tract was dilated by 8 mm hydrostatic balloon and only 10 Fr stents were placed but when infection was observed in all the initial 3 patients, they started placing intrapancreatic nasocystic drain for continuous lavage. Complete resolution of necrosis was found in 9 out of 11 patients after a follow up of 1 year, with complications in the form of bleeding or infection in 5 patients.

The above strategy was modified later by Seifert et al[2000] when no response was observed after transmural stenting and surgical intervention was found to be risky. The fenestration was dilated with a 16 mm balloon through the endoscope. A therapeutic gastroscope was inserted into the cavity and debridement of large coherent masses was done with a stone-retrieval basket. All 3 patients improved and successfully discharged.

After two years, Baron et al[44] compared the outcome after endoscopic drainage of acute and chronic pseudocyst and pancreatic necrosis. It was found that patients with necrosis had a poor outcome as compared to acute and chronic pseudocyst. The resolution rate was 72% in patients with necrosis and 74% in patients with pseudocyst. The hospital stay was longer in patients with necrosis (20 days) than patients with acute and chronic pseudocyst (9 and 3 days respectively). There was 29% recurrence rate in necrotic group after a follow up of 2.1 years compared with 9% and
12% in acute and chronic pseudocyst groups. Complications were more frequent in necrosis group (37%) compared with chronic (17%) and acute pseudocyst (19%). Pancreatic necrosis was found to be an independent predictor of complications. Subsequently, Hookey et al. also compared the endoscopic drainage outcome of various pancreatic fluid collections. They also found that drainage of organized necrosis was associated with a significantly higher failure rate than other collections. However, no significant differences were observed regarding success when disease, drainage technique, or site of drainage was considered. Subsequently, a number of studies came in last 5 years which have shown successful outcome after endoscopic management of necrosis.

Seewald et al.[31] subsequently modified Seifert’s[55] technique in their 5 cases who were unfit for open necrosectomy. They dilated the stoma up to 20 mm with the intention of insertion of therapeutic gastroscope with a 6 mm working channel directly into the cavity to ensure rapid removal of necrotic debris. Although minor bleeding was noted, no free perforation occurred. Necrosectomy was performed on daily basis followed by lavage until all the necrotic material was completely removed. Success was noted in all except one case in whom surgery was required because of extension of cavity in the paracolic gutter. Fistula closure with N-butyl-2-cyanoacrylate was also done in cases with pancreatic fistula but only in case with pancreatic abscess.

Charnley et al.[32] later showed a success rate of 92% after endoscopic necrosectomy having a median APACHE 2 score of 8 (range 8-18) on admission. They suggested that this technique can be considered in all patients with localized infected necrosis and not necessarily in those patients unfit for surgery[31]. Several factors may be predictive of successful outcome after endoscopic therapy. Papachristou et al.[24] demonstrated a success rate of 81% out of 53 cases. 40% cases required concurrent radiologic-guided catheter drainage of associated or subsequent areas of peripancreatic fluid and/or walled off pancreatic necrosis. Three factors which were found to be predictive of poor outcome after endoscopic necrosectomy and need of subsequent open operative therapy were extension of necrosis into the paracolic gutters, size of necrotic cavity more than 15 cm and presence of diabetes mellitus as a co-morbid illness. Necrosis extending into the paracolic gutters are remote and not contiguous from the transgastric or transduodenal entry areas, thereby precluding adequate debridement. Presence of diabetes may allow poor wound healing or because of some undefined factors may be associated with poor outcome after endoscopic therapy. Alcohol induced pancreatitis has also been found to have a poorer outcome after surgical necrosectomy compared with biliary pancreatitis.

Voermans et al.[53] showed a higher success rate (93%) with fewer numbers of endoscopic sessions in 25 cases with pancreatic necrosis. Additional treatment modalities were required in only 2 cases. Thus, with increasing expertise and experience, treatment duration can be shortened. Hocke et al.

### Table 1: Outcome of various studies in the endoscopic management of pancreatic necrosis

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Author</th>
<th>Year</th>
<th>n</th>
<th>Drainage/Debridement</th>
<th>Interval between pancreatitis and intervention</th>
<th>No. of sessions</th>
<th>Hospital Stay (days)</th>
<th>Follow up (months)</th>
<th>Success rate (%)</th>
<th>Complications (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baron[25]</td>
<td>1996</td>
<td>11</td>
<td>Drainage</td>
<td>7.2 wks</td>
<td>2.7</td>
<td>14.9</td>
<td>12</td>
<td>82%</td>
<td>45%</td>
</tr>
<tr>
<td>2</td>
<td>Seifert[33]</td>
<td>2000</td>
<td>3</td>
<td>Debridement</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Baron[44]</td>
<td>2002</td>
<td>43</td>
<td>Drainage</td>
<td>-</td>
<td>2</td>
<td>20</td>
<td>25</td>
<td>72%</td>
<td>37%</td>
</tr>
<tr>
<td>4</td>
<td>Seewald[31]</td>
<td>2005</td>
<td>5</td>
<td>Debridement</td>
<td>-</td>
<td>7</td>
<td>46</td>
<td>9.5</td>
<td>80%</td>
<td>30%</td>
</tr>
<tr>
<td>5</td>
<td>Hookey[56]</td>
<td>2006</td>
<td>8</td>
<td>Drainage</td>
<td>23 days</td>
<td>1</td>
<td>18</td>
<td>7</td>
<td>50%</td>
<td>11%</td>
</tr>
<tr>
<td>6</td>
<td>Charnley[32]</td>
<td>2006</td>
<td>13</td>
<td>Debridement</td>
<td>24 days</td>
<td>4</td>
<td>-</td>
<td>16</td>
<td>92%</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Papachristou[45]</td>
<td>2007</td>
<td>53</td>
<td>Debridement</td>
<td>49 days</td>
<td>3</td>
<td>13</td>
<td>6</td>
<td>81%</td>
<td>21%</td>
</tr>
<tr>
<td>8</td>
<td>Voermans[43]</td>
<td>2007</td>
<td>25</td>
<td>Debridement</td>
<td>84 days</td>
<td>1.8</td>
<td>5</td>
<td>16</td>
<td>93%</td>
<td>8%</td>
</tr>
<tr>
<td>9</td>
<td>Hocke[44]</td>
<td>2008</td>
<td>30</td>
<td>Debridement</td>
<td>-</td>
<td>2.7</td>
<td>16.1</td>
<td>16</td>
<td>96.7%</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>Escourrou[33]</td>
<td>2008</td>
<td>13</td>
<td>Debridement</td>
<td>27.5 days</td>
<td>1.8</td>
<td>30</td>
<td>19.5</td>
<td>100%</td>
<td>46%</td>
</tr>
<tr>
<td>11</td>
<td>Mathew[45]</td>
<td>2008</td>
<td>6</td>
<td>Debridement</td>
<td>4-6 weeks</td>
<td>1</td>
<td>8.5</td>
<td>3.5</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>12</td>
<td>Seifert[45]</td>
<td>2009</td>
<td>93</td>
<td>Debridement</td>
<td>43 days</td>
<td>6</td>
<td>46</td>
<td>50</td>
<td>81%</td>
<td>26%</td>
</tr>
<tr>
<td>13</td>
<td>Gardner[37]</td>
<td>2009</td>
<td>25</td>
<td>Debridement</td>
<td>74 days</td>
<td>3.6</td>
<td>15.4</td>
<td>13.6</td>
<td>88%</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>Drainage</td>
<td>42 days</td>
<td>3.1</td>
<td>38.4</td>
<td>13.6</td>
<td>45%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Agrawal et al[54] also showed a technical success rate of 93% in their 30 patients with just 2.7 sessions per patient. However, they observed mortality in 2 cases (6.6%) due to procedure-related complications. Escourrou et al[33] also performed endoscopic necrosectomy in 13 cases with 100% success rate. Minor complications were noticed in 46% cases in the form of bleeding and transient aggravation of sepsis which were managed with adrenaline injection and antibiotics. Mean time taken per procedure was 3.5 hours with a mean number of sessions 1.8.

Recently two large studies have been published showing a good outcome after endoscopic treatment of pancreatic necrosis. In a retrospective study by Gardner et al[29], that compared endoscopic necrosectomy with transmural endoscopic drainage for the treatment of walled-off pancreatic necrosis, successful resolution was accomplished in 88% who underwent direct endoscopic necrosectomy versus 45% who received standard drainage. Operative or percutaneous intervention was necessary in 50% of the patients treated with standard endoscopic drainage but in only one patient in the endoscopic necrosectomy group. The number of endoscopic re-interventions, the use of intracystic irrigations tubes, complication rates and the time for resolution of the cavity were although similar in both the groups. Thus, direct endoscopic debridement is superior in resolving WOPN without increasing patient risk or delaying time to resolution. Seifert et al[36] in the multicentre retrospective study, showed a success rate of 81% in 93 cases who underwent endoscopic necrosectomy. They described the long term outcome in these patients over a mean follow up of 50 months. Of the 68 survived cases, clinical success was maintained in only 57 and 11 cases had secondary recurrence/failure. Detailed quality-of-life (QOL) data for the long-term survivors showed that about 80% of the endoscopically and surgically treated patients reported a fairly good quality of life. In the endoscopic group, nearly all patients who reported a poor general condition and a reduced QOL index also had reasons other than pancreatitis.

In another study, Gluck et al[57] compared the standard percutaneous drainage therapy for walled off pancreatic necrosis with the combined modality therapy (CMT) [percutaneous drainage along with endoscopic transenteric stenting]. The only qualifying criteria for CMT were that the necroma needed to abut the stomach/duodenum and have a well formed wall. Patients undergoing CMT had significantly decreased length of hospitalization, duration of external drainage and, number of computed tomography scans than patients with standard percutaneous drains alone. Also patients who underwent percutaneous drain alone had more complications than the patients who underwent CMT.

Conclusion

The present role of minimal access, transoral/transmural endoscopic drainage/debridement in the management of patients with necrotizing pancreatitis still remains uncertain. Comparative trials between these treatment modalities compared with operative and percutaneous methods are lacking. However, with increasing expertise and evolving technology, endoscopic therapy stands as a strong contender for the preferred modality of treatment for pancreatic necrosis with decreased hospital stay and morbidity.

References

Endotherapy in Pancreatic Necrosis

Agrawal et al


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**ERRATIUM**

“Guidelines for Reuse of Endoscopic Accessories”  
*J Dig Endos* 2011;3:192-4

**Method of Reprocessing**

Single use endoscopic accessories

After use

ultrasonic cleaner

Reused

Manual cleaning

enzyme detergent

Sterilization

Flush 70% alcohol & dry with air

Autoclaving, Gas

**Figure 1:**

Source of support: Nil; Conflict of interest: none declared