Acute pancreatitis results in over 210,000 hospital admissions in the United States each year. Approximately three-quarters of these patients will have a self-limited clinical course characterized by rapid resolution of their symptoms with conservative treatment measures including bowel rest, pain management, and fluid resuscitation. Ideal management for patients with uncomplicated acute, biliary pancreatitis includes same admission cholecystectomy as this approach has been shown to be safe, has been associated with the lowest recurrence rates and to be the most cost effective.

A complicated clinical course ensues in approximately one-quarter of patients. The presence of pancreatic necrosis and multisystem organ failure are associated with 17% and 47% mortality rates, respectively. Patients destined to this severe clinical course must be identified early to be appropriately managed with regard to nutritional support, infectious risks, and operative intervention. Numerous randomized clinical trials have identified which interventions provide the best outcomes for patients with severe acute pancreatitis (SAP), and this literature is the basis of published, best practice, treatment guidelines. These recommendations address the timing and modality of imaging, the use of prophylactic antibiotics, and the introduction and modality of nutritional support. We recently reported that compliance with these recommendations remains poor, with fewer than one-quarter receiving optimum, evidence-based evaluation and management.

The data also provides guidance for other interventions including the use of endoscopic retrograde cholangio-pancreatography (ERCP) and percutaneous drainage or other operative procedures but these recommendations are not as broadly applicable. Furthermore, modern imaging, percutaneous drainage, advanced endoscopy, and minimally invasive surgery all are currently applied in the management of complications resulting from SAP. Little, if any, data exist comparing these various modalities. The approach taken is often based upon local expertise in a setting where all current options are not equally available. Our current surgical approach to certain clinical scenarios is as follows:

**Abdominal Compartment Syndrome**

A rare, but lethal complication of SAP is abdominal hypertension. Immediate recognition of this condition and surgical intervention are essential. ACS typically presents in the first week of the disease process and is manifested by respiratory failure requiring high pressure ventilation, renal failure despite evidence of adequate intravascular volume, and hypotension resistant to inotropic support. Treatment is emergent decompressive laparotomy. A vacuum dressing is then applied. This can be done in the ICU to avoid transfer of these critically ill patients. In our published series, we found that fewer than 10% of patient with severe pancreatitis will develop ACS, half of the patients with ACS requiring decompression do not require additional surgical management other than closing the complex abdominal wall defect and approximately 50% of affected patients survive.

**Necrosis**

After identifying a patient with severe pancreatitis and adequately resuscitating them and assessing renal function, a contrast-enhanced, pancreatic protocol computerized tomography scan is essential to assess for pancreatic necrosis and/or peripancreatic fluid collections and necrosis. This is ideally obtained 48-72 hours after the initiation of symptoms as necrosis develops over this time and will often not be apparent on CT scans obtained at the time of admission. The extent and region of the pancreas affected by necrosis drives prognosis and surgical management.

The pancreatic neck is a watershed region with respect to blood supply and thus is most frequently affected by necrosis. Unfortunately, this also translates to significant, further complications even when only this small percentage of the gland has undergone necrosis. Disrupted pancreatic duct syndrome and symptomatic peripancreatic fluid collections often result. The risk of subsequent infection or other indication for surgical intervention is otherwise directly proportional to the percent of the pancreas that has undergone necrosis. This can also serve as a rule of thumb for patients with peripancreatic necrosis without evidence of pancreatic necrosis; the volume of peripancreatic adipose tissue with CT changes of necrosis/phlegmon as it relates to the volume of pancreas correlates with the risk of subsequent infection.

Once necrosis is confirmed, the need for invasive intervention is the norm. Early intervention has been shown to result in inferior outcomes compared to a delayed approach (4-6 weeks). Furthermore, the process will evolve over time. Thus, we routinely perform weekly CT scans on all patients where the index scan reveals necrosis, extensive phlegmon, or a fluid collection.
Infection, typically by enteric organisms, will ensue with a risk proportional to the extent of necrosis. Evidence of infection can be identified as soon as 2-3 weeks after the onset of symptoms, the incidence peaks approximately 4 weeks after onset and significant risk persists for up to 2-3 months. This timeline is important in the context of clear data demonstrating that the value of surgical intervention can be determined 4 weeks into the course of severe pancreatitis complicated by necrosis; delay only prolongs the duration of disability and increases the risk of sepsis producing a “second hit.”

Thus, patients who will require surgical intervention can be identified within the first 2 weeks of their disease process and intervention planned at 4 weeks. The exceptions are patients with multi-organ dysfunction or who clinically deteriorate during this time frame. Percutaneous drains play a role in these patients. Specimens for microbiologic analysis can be obtained with this intervention and clinical improvement is often observed once these drains are placed.

The intervention is dependent upon the extent of necrosis and the anatomy.

Necrosectomy, Debridement, and External Drainage
This approach is utilized for patients with extensive necrosis associated with complex fluid collections that extend beyond the lesser space. Pre-operative assessment of a viable segment of pancreatic tail is essential. If this viable pancreas is not also resected, these patients will develop a chronic pancreatic fistula and require subsequent surgical resection. A combination gastrojejunostomy feeding tube is also placed. Cholecystectomy should also be performed regardless of the etiology of the pancreatitis. This procedure can occasionally be performed via the laparoscopic approach but loss of abdominal domain and access to complex retroperitoneal fluid collections limits this approach in many of these patients.

Transgastric Debridement with Enteric Drainage
This approach is utilized for patients with extensive necrosis where the process is confined to the lesser space. An endoscopic approach should be considered in institutions where this expertise is available and cholecystectomy is not necessary. Alternatively, this procedure can be performed laparoscopically in a significant percentage of patients and a laparoscopic cholecystectomy performed simultaneously.

Percutaneous Drainage Alone
Percutaneous drainage as a “step-up” approach has been compared in a randomized, controlled trial to open necrosectomy and it was concluded to be superior. This approach has subsequently been broadly applied but often misunderstood. Sixty percent of the patients in the step-up approach arm subsequently underwent open necrosectomy a mean of 10 days after percutaneous drainage. Thirty-five percent of the patients underwent percutaneous drainage alone. Importantly, the duration of disability was not considered in this study. At our institution, we pursue percutaneous drainage alone as a treatment strategy for patients with limited necrosis, ideally of the tail of the gland – a situation where disrupted pancreatic duct syndrome is unlikely.

Symptomatic Fluid Collection or Walled-off Pancreatic Necrosis
These clinical scenarios are typically encountered more than 6 weeks after the initial onset of symptoms. However, maturation of peripancreatic fluid collections may evolve over considerably greater period of time. Recent imaging is essential to determine when the inflammatory process has resulted in adequate apposition of the collection to the posterior wall of the stomach or to determine that the collection cannot be safely accessed via the stomach. Communication of the collection with the pancreatic duct should be assumed. In our experience, magnetic resonance pancreatography often fails to define pancreatic duct communication adequately and ERCP is associated with the risk of inducing infection.

Endoscopic Drainage of Peripancreatic Fluid Collections
These patients are often ideal candidates for endoscopic management. The principle decision point is anatomy – what is the relationship of the collection to the stomach? Surgical management of mature fluid collections with or without a component of necrosis is reserved for patients in whom an endoscopic approach is deemed technically infeasible or if additional procedures not amenable to endoscopic management are also indicated (i.e., cholecystectomy).

Laparoscopic Cyst Gastrostomy or Roux-en-Y Cyst Jejunostomy
The majority of patients with delayed indications for surgical management can be approached laparoscopically. As above, decision making for the surgical approach hinges on anatomy and the need for additional procedures such as cholecystectomy. Thus, patients will either require additional procedures and a cyst gastrostomy or anatomy dictates that the collection be managed via a Roux-en-Y cyst jejunostomy.

Disrupted Pancreatic Duct Syndrome (DPDS)
If the potential for DPDS is considered at the time of presentation, this unfortunate clinical entity can be largely avoided. Most affected patients present for surgical therapy more than one year after the initial episode of acute pancreatitis. Virtually all have a persistent pancreatic fistula. Most are malnourished and financially devastated. Surgical options include:
Enteric Drainage via a Roux Limb
Occasionally, when the remnant is large and the pancreatic duct dilated, a modified Peustow procedure can be performed providing drainage of pancreatic effluent into the enteric tract. While this is always our first intention to surgically manage DPDS, the procedure is not technically feasible in the majority of patients.

Resection of the Disconnected Remnant (Distal Pancreatectomy/Splenectomy)
This procedure is often the only option for patients with a disconnected remnant and is technically very demanding given the fibrosis from the previous inflammation. Splenic vein thrombosis and sinister portal hypertension are also frequently encountered. Consideration of the impact of the procedure on endocrine insufficiency must be taken as up to one-third of patients who are not diabetic will become so following the procedure. Nonetheless, preservation of the remnant tail is often not technically feasible. In the recent past, we have performed splenic artery embolization prior to the procedure to reduce blood loss and need for transfusion. Other than exocrine insufficiency, these patients do very well with few other complications.

Summary
Surgical care plays an important role in uncomplicated biliary pancreatitis and severe pancreatitis. Modern imaging, advanced endoscopic techniques, and laparoscopic approaches are emerging as valuable strategies in the management of complicated acute pancreatitis but there remains a lack of good comparative data. A state-of-the-art treatment algorithm based on the current literature should selectively apply all of these modalities.

SELECTED REFERENCES