Chapter 9
Pancreatic and Duodenal Injuries (Sleep When You Can…)

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Deployment Experience:

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BLUF Box (Bottom Line Up Front)

1. The indication for a trauma Whipple is rarer than hen's teeth. You don't want to go there.
2. A trauma laparotomy is not the time to learn to do a complex pancreatic surgery.
3. For both pancreatic and duodenal trauma, drains are your best friends in the world.
4. You have to look at both the stability of the patient and the complexity of the injury to make a good decision.
5. Keep in mind that the majority of injuries involving the head of the pancreas and the duodenum will either require no direct repair or multiple operations to correct.
6. Beware the trauma sins of omission – every trauma exploration should include a look at the pancreas and duodenum. These injuries kill if missed.
7. Assume your duodenal repair will leak, so see point 3 above.
8. Primary repair and wide drainage of the duodenum usually beats any of the complex reconstruction methods you may have read about.
9. A stapled distal pancreatectomy is usually your simplest option for significant injuries to the body and tail of the pancreas.
10. Para-duodenal hematomas are duodenal or vena cava injuries until proven otherwise. Explore them – but be prepared for both blood and guts.

For pancreatic trauma: treat the pancreas like a crawfish, suck the head … eat the tail.

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I have a unique perspective here. I am a surgical oncologist who has the benefit of being exposed to the intense trauma surgery of war. I take trauma call in a level 2 trauma Center and I have been deployed to the busiest combat support hospital's in Iraq as well as being deployed to a desolate forward surgical team in Afghanistan where the only help I had was the skills I possess. I remember saying to the editor of this book (and good friend), "Any surgical oncologist can be a trauma surgeon because we are comfortable operating anywhere in the body and we routinely operate on the pancreas and the liver." Obviously, that was an incorrect statement because the trauma patient has a very distinct physiology requiring attention to much more than just the technique of how to do a complex surgery. This was a lesson that I learned the hard way. On the flip side, pancreatic and duodenal injuries can be very difficult to manage if you do not routinely operate in this area. For a surgeon who does not have experience in complex operations and those involving the pancreas and the duodenum, the midst of the acute trauma is not the time to try to learn. To this end, there are excellent bail-out options available to ensure the safety of the patient and bring about the best chances of long-term survival. If you are a surgeon then you know the saying "Eat when you can, sleep when you can and don't mess with the pancreas." Another wise Army surgeon has also told me "I don't fear the pancreas as much as I fear the duodenum". This has never been as true as in the combat trauma patient with an injury in that dreaded right upper quadrant. The goal here is to get an overview of the most appropriate treatment beginning with the simple injuries of the pancreas and duodenum and progressing to the more complex injuries, always keeping in mind the stability of the patient in selecting the best management of each of these injuries.

Making the Diagnosis

Most often in the combat scenarios, you will discover these injuries during abdominal exploration for penetrating trauma and massive blast injury. No diagnostic studies are required in these cases, just a thorough exploration. However, you may also encounter patients that are more analogous to civilian trauma, with primarily blunt trauma to the abdomen and no obvious indication for emergent exploration. You should approach these patients similar to a civilian blunt trauma, with the exception of having a much lower threshold for exploration if an injury is in question. This is particularly important for soldiers or other patients that you are putting into the evacuation chain and who will not be closely observed by a surgeon over the next 24–48 h. In addition, there is now a large body of civilian literature on nonoperative management of pancreatic injuries. This usually relies on having a variety of advanced adjuncts available (angiography, ERCP, interventional radiology) and adequate resources and personnel to provide the long term care that is often required. This will not be the situation at a forward combat medical facility, so in many cases the "conservative" approach to these injuries is to operate and take care of it with one procedure.

You should suspect a blunt pancreatic or duodenal injury in any patient with a direct blow to the upper abdomen, blast trauma, or blunt abdominal trauma with a lumbar spine fracture. These injuries are notoriously difficult to diagnose due to the retroperitoneal location which may limit or delay the development of peritoneal signs, as well as the limitations of imaging studies. CT scan is great for almost all serious abdominal injuries – except the pancreas and duodenum. It has a sensitivity of between 40 and 70%, and cannot delineate the presence of a pancreatic duct injury, particularly when performed early. Admission enzyme levels (amylase, lipase) are also of limited value in the early diagnosis, but typically will rise over the first 24 h if there is a significant injury; if you suspect an injury, then trend the enzymes over the first 24–48 h. Suggestive signs to look for on CT scan are a peri-pancreatic hematoma, free fluid in the lesser sac, or the development of a cystic fluid collection involving the pancreas. If you suspect the diagnosis but are unsure, or have an equivocal initial CT scan, I would recommend performing a delayed CT (12–24 h) scan with a small amount of oral contrast delivered immediately prior to the scan to opacify the c-loop of the duodenum. Also follow enzyme levels (which should rise), the abdominal exam, and the urine output. If your clinical evaluation and imaging studies are suspicious, then you are usually better off exploring the patient. The longer the patient sits with an undrained pancreatic or duodenal injury, the fewer options you will have for successfully repairing it due to tissue damage from leakage of enzymes or enteric contents.

Anatomy: The Key to the Battle Plan

The heat of battle in the operating room is not the time to be trying to remember your medical school anatomy, or whipping out an atlas. You should know the basic maneuvers to expose the pancreas and the critical *surgical* anatomy of the pancreas and duodenum (Fig. 9.1). This is an area that is often relatively unfamiliar to general surgeons so spend some time reviewing it and mentally rehearsing maneuvers before you deploy.

Exposure of the head of the pancreas and the 2nd/3rd portion of the duodenum is done by first mobilizing the hepatic flexure of the colon inferiorly and medially (Fig. 9.2a). Sharply open the white line of Toldt along the ascending colon and continue this around the flexure, retracting the colon inferiorly and the gallbladder superiorly. Once that first layer is opened, the rest can usually be rapidly done with blunt finger dissection and bovie. Follow the colon mesentery to the base and this will lead directly to the c-loop of the duodenum. Now you have the anterior surface of the duodenum and pancreatic head exposed. If this appears completely normal, no further mobilization is required. If complete visualization or mobilization is required, then divide the postero-lateral attachments of the duodenal c-loop as you retract it anteriorly and medially (Kocher maneuver). Beware that the c-loop is sitting on top of the vena cava as you begin this maneuver. Slide your hand behind the head of the pancreas and bluntly mobilize and palpate. Exposure of the body

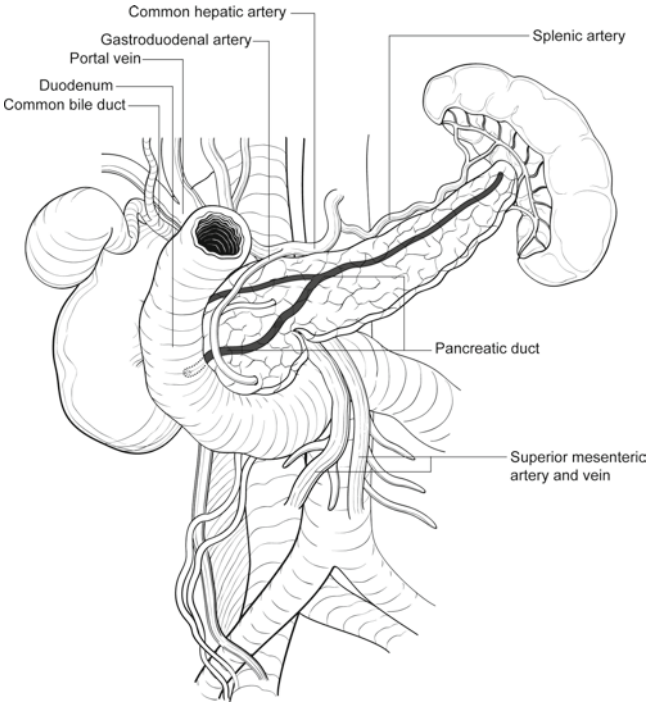

Fig. 9.1 Surgical anatomy of the pancreaticoduodenal complex

of the pancreas is easily obtained by opening the gastro-colic ligament and retracting the stomach superiorly and anteriorly (Fig. 9.2b). You can also visualize most of the tail through this window in the lesser sac. To fully mobilize the tail and splenic hilar vessels, the lateral attachments of the spleen are divided and the spleen and pancreas are mobilized to the midline together (Fig. 9.2c). Further exposure of the posterior pancreas and the fourth portion of the duodenum can be obtained by opening the retroperitoneum along the inferior border of the pancreas, and dividing the ligament of Treitz.

Figure 9.1 demonstrates the critical anatomy in this area. The vena cava and right renal vein will be immediately posterior to the duodenal c-loop. The first major vessel you encounter when exposing the body of the pancreas will be the splenic artery running (often tortuous) along the superior pancreatic border. The splenic vein is *posterior* to the pancreas, so additional mobilization will be required to expose this vessel and you must take great care when dissecting circumferentially around the body of the pancreas. There are multiple small pancreatic branches entering the splenic vein, and these will be the usual sources of bleeding during mobilization. The splenic vessels and the tail of the pancreas will then converge in the hilum of the spleen, with a wide variety of anatomic variants. Beware that the pancreatic tail may be intimately associated with the spleen, and that the splenic vessels may enter the hilum as multiple smaller branches rather than single large trunks.

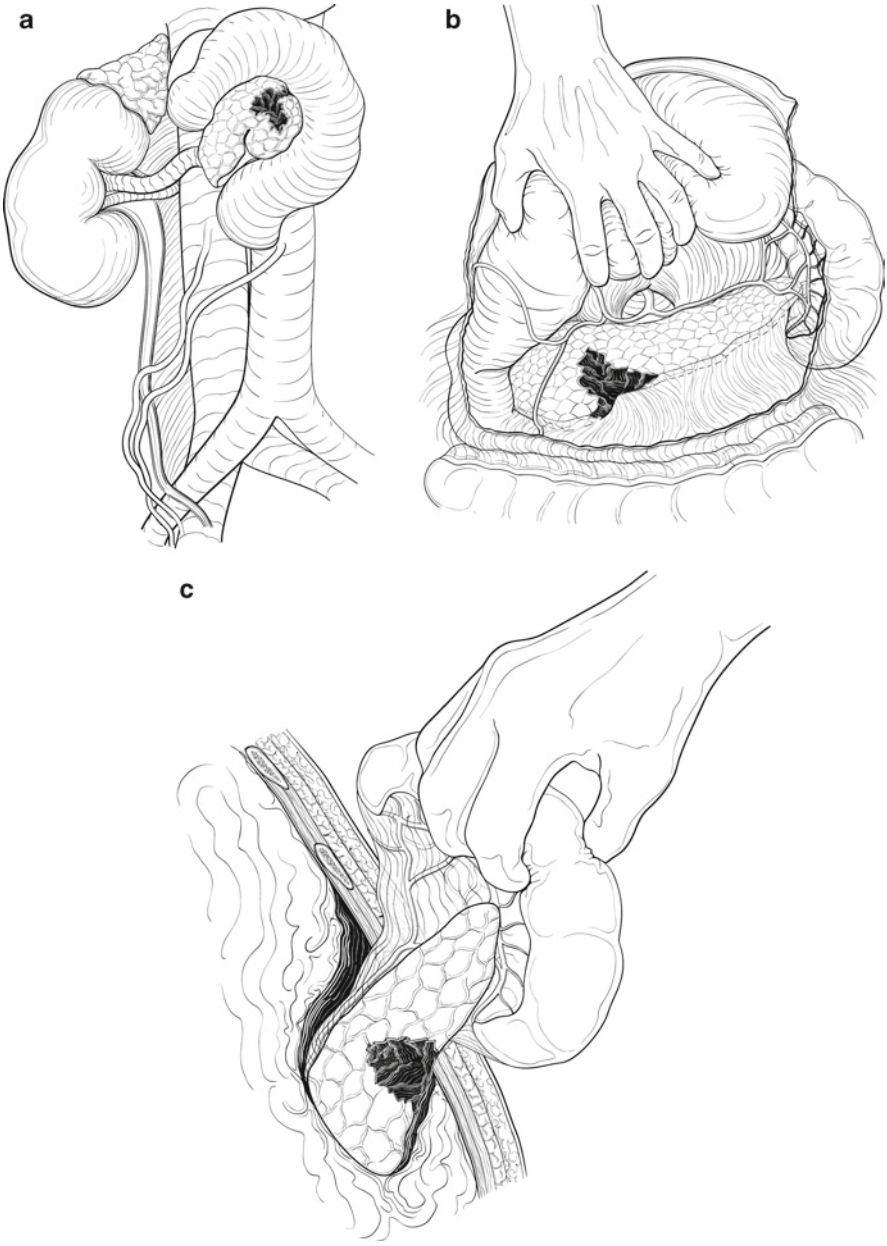

Fig. 9.2 Surgical exposure of the pancreas and duodenum. (**a**) Exposure of the head of the pancreas and duodenum is obtained via a generous Kocher maneuver. (**b**) Exposure of the body and tail of the pancreas by entry into the lesser sac. (**c**) Complete exposure of the tail of the pancreas requires lateral to medial splenic mobilization

The Body and Tail of the Pancreas

When we talk about the body and tail of the pancreas, we are referring to the pancreas to the left of the portal vein. Injuries to this portion of the pancreas can consist of a simple contusion, deep lacerations, or complete division or disruption of the pancreas. The primary concern is injury to the pancreatic duct and the possibility of a pancreatic fistula. The management of a contusion to the pancreatic body consists of drainage with a closed suction drain. If there is a deep laceration or complete disruption of the pancreatic body or tail, then a distal pancreatectomy and splenectomy should be completed. There is no place for a spleen-sparing distal pancreatectomy in combat trauma surgery. This is a technically challenging and time consuming operation in an elective setting and is not appropriate in combat trauma. A distal pancreatectomy and splenectomy is safe, quick and definitive. A closed suction drain should be left in place after any pancreatic resection.

The technical aspects of a distal pancreatectomy are very straightforward (Fig. 9.3). The pancreas should be approached by dividing the gastrocolic ligament and elevating the stomach to expose the anterior surface of the pancreas. A hematoma of the body and/or tail of the pancreas should be opened to evaluate

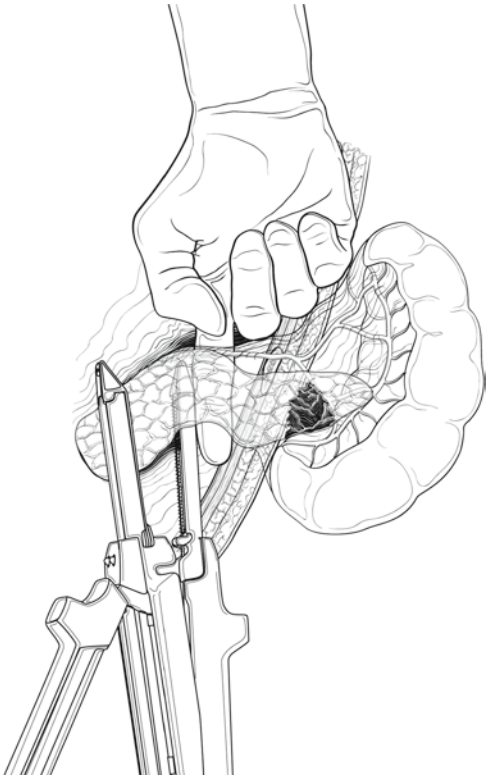

Fig. 9.3 Technique for a stapled distal pancreatectomy. Use a finger or blunt instrument to encircle the pancreas and guide a linear stapler through the retropancreatic tunnel

the anterior surface of the pancreas directly. The spleen and tail of the pancreas can be swiftly brought to the midline by placing the hand behind the spleen and pulling the spleen and pancreatic tail up as one unit, sliding the fingers in the retroperitoneal space behind the pancreas. Once the spleen is elevated, the short gastric vessels between the spleen and stomach can be divided quickly with clamps and the retroperitoneal surface packed with sponges. An important anatomic consideration is that the superior and inferior borders of the pancreas to the left of the middle colic vein are a "free zone", with no significant vessels in the area other than the splenic artery which should easily be mobilized with the body of the pancreas. With the body and tail of the pancreas now mobilized, the short gastric vessels divided, and the retroperitoneal attachments along the superior and inferior edge of the pancreas divided by electrocautery, the pancreas can now be divided with a linear stapler. I will typically use a medium staple load (linear stapler with a blue load) and divide the splenic vein and artery along with the pancreas with one staple load. I will then over-sew the artery and vein as well as the pancreatic duct if there is bleeding or if I can visualize the structures along the staple line. If the splenic artery is obvious coursing along the superior edge of the pancreas it can be divided individually; however, excessive time should not be wasted in looking for it. A technical point that should be mentioned is that a stapler occasionally will fracture the pancreatic body and you will be looking at raw edge of pancreas in some instances. This should not raise undue concern or action beyond over-sewing the duct if it can be visualized and placing a drain along the edge of the pancreas. Any retroperitoneal bleeding should be minor and easily controlled. If a topical sealant such as fibrin glue is available it can be applied over the cut edge of the pancreas and may assist in hemostasis or sealing parenchymal leaks.

This is a good place to talk about pancreatic fistulas because a pancreatic fistula is certainly possible in the procedure I just described. The important point here is that a pancreatic fistula is not life-threatening and the large majority can be treated non-operatively with full recovery. To take an excessive amount of time in a pancreatic procedure trying to avoid a pancreatic fistula will potentially cost a patient's life. Adequate drainage is all that you need to achieve in the early management of a pancreatic leak. If you are in damage control mode and plan to return within 24 h, then you do not have to place a drain – just pack and do your temporary abdominal closure. Always leave a closed suction drain prior to performing your definitive fascial closure or final exploration of the abdomen.

The ambiguous areas for injuries to the body and tail of the pancreas are those with a superficial laceration to the pancreas in which pancreatic duct involvement is unclear. My bias in these situations is as follows. If the spleen needs to be removed due to splenic injury or the vessels of the pancreas are involved, then I will generally remove the involved portion of the pancreatic tail. If none of these factors are present, and you have a very superficial laceration or contusion of the pancreas then I will typically leave a drain and move on. The preceding guidelines apply to both the stable and the unstable trauma patient, as a distal pancreatectomy and splenectomy is usually a rapid procedure with quick hemostasis.

Injury to the Head of the Pancreas

Injuries to the head of the pancreas typically involve contusions or deep lacerations, and may be associated with a duodenal injury. The most important point to establish up front is that if you don't remove the head of the pancreas as a frequent part of your elective practice, your patient will not survive the procedure in a trauma. Given this fact, the management of most pancreatic head injuries is really quite simple: stop any hemorrhage, lay drains, and get out. The majority of bleeding from the head of the pancreas can be controlled a simple suture ligation with little concern of ligating the superior mesenteric artery due to its deep posterior position. A portion of the portal vein may potentially be ligated, and this is okay if it is necessary to stop the bleeding. The only way to access the retro-pancreatic portal vein is by dividing the pancreas overlying the portal vein. From here bleeding can be controlled with vascular control of the splenic vein, superior mesenteric vein, and the portal vein at the region of the portal triad as well as multiple small branches running directly into the head of the pancreas. Given the extensive dissection required for direct access and the typical amount of bleeding associated with portal vein injury, suture ligation through the substance of the pancreas is likely the only lifesaving maneuver. I do not recommend performing a Kocher maneuver to mobilize the head of the pancreas for a contusion involving the head of the pancreas with no evidence of an expanding hematoma. However, for ongoing bleeding from the head of the pancreas, a Kocher maneuver will allow for anterior and posterior compression of the head of the pancreas for temporary hemostasis. Once bleeding is adequately controlled, closed suction drains should be placed and the operation terminated. In general, I do not recommend an attempt at bowel anastomosis to the pancreas during an initial trauma operation. This typically requires a more extensive dissection of the pancreas with division of the intestine and results in a higher fistula rate and a more difficult follow-on operation. Simply laying drains around the pancreas will handle the large majority of injuries and allow for a subsequent thorough evaluation of the pancreatic anatomy when the patient is stable and when the needed surgical expertise is available.

The Pancreatic Duct

Much of the civilian literature describes various techniques and algorithms based on trying to assess the status of the pancreatic duct. Complex procedures such as intraoperative ERCP or intraoperative direct pancreatography have been described to ascertain whether the main duct is involved in the injury. You will rarely have the ability, or the need, to do this in combat trauma. The majority of injuries can be assessed by visual inspection to determine if it is likely or unlikely that the duct is involved. It is usually obvious that destructive type injuries have involved the pancreatic duct, and that minor contusions or lacerations don't involve the duct. Either way, you should be widely draining the area and can manage the now-controlled

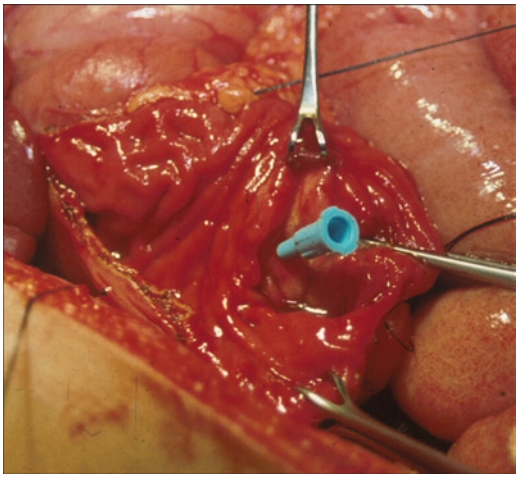

Fig. 9.4 Cannulation of the ampulla of Vater to perform intraoperative ductography. Note that this should usually only be done if the status of the duct is truly in question and there is already a duodenal injury present

pancreatic fistula at a subsequent laparotomy or non-operatively. If an assessment of the duct is absolutely critical, then I would recommend against trying to open the duodenum and cannulate the pancreatic duct, unless the duodenum is already traumatically opened (Fig. 9.4). You can access the gallbladder or the common bile duct with a butterfly needle or angiocatheter and inject contrast material and/or methylene blue dye. Allow several minutes for distribution of the contrast and observe for blue staining of the tissues or fluoroscopic evidence of contrast extravasation.

Duodenal Injuries

Duodenal injuries can range from simple lacerations to complex injuries with involvement of the duodenum, pancreas and common bile duct (Fig. 9.5). Complete evaluation of duodenal injuries should include a Kocher maneuver to fully examine the posterior wall of the duodenum (Fig. 9.6). No matter what the stability of the patient is, you should try to achieve at least temporary closure of the duodenal injury. If the patient is unstable, then just whipstitch it closed and figure out a definitive repair at a second-look operation. For definitive repair, you must assess the injury and decide if you can do a simple repair or a more complex procedure will be required. Your goal is an adequate closure that preserves the luminal area (at least 50%), protects the surrounding structures, and allows adequate drainage. Either way, assume your repair will leak and *always* leave a closed suction drain (or two) in the area.

Simple lacerations of the duodenum can be closed primarily in one or two layers after debriding the wound edges (Fig. 9.7). I prefer a single layer closure with interrupted silk suture, typically in a longitudinal fashion. Small lacerations can be closed

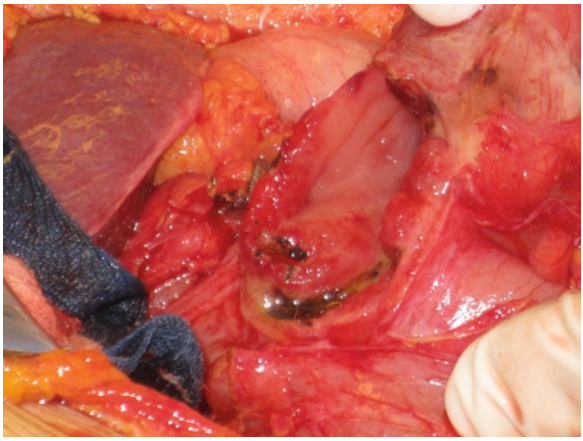

Fig. 9.5 Large laceration (>50% circumference) to the second portion of the duodenum

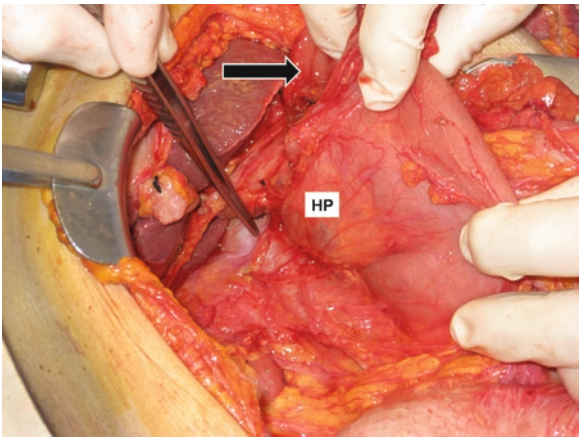

Fig. 9.6 Injury shown in Fig. 9.5 (*black arrow*) after mobilization of the duodenum and head of pancreas (HP) via a Kocher maneuver. Forceps are pointing to the inferior vena cava

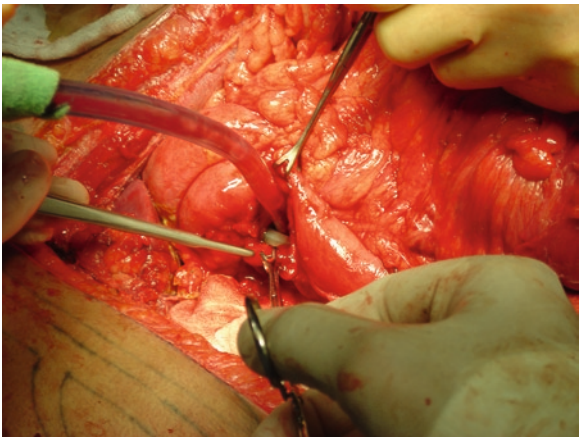

Fig. 9.7 Simple laceration of the duodenum ready for suture repair. Note that nasogastric tube has been advanced through the area of planned repair for postoperative decompression

transversely but care should be taken at the "dog ears" of the closure to ensure no leak and to ensure no undue tension on the closure due to the relatively fixed nature of the duodenum. Do not apply the typical strictureplasty technique of "longitudinal incision and close transversely" on the c-loop of the duodenum – it will create an obstructing fold. It is mandatory to identify the Sphincter of Oddi and avoid injury to this structure during closure. Drains should be placed after any closure of the duodenum, pancreas, or biliary tree.

For more extensive injuries to the duodenum with loss of a portion of the duodenal wall or requiring a complex closure of the duodenal wall, duodenal diversion is recommended. The duodenal wall which cannot be closed primarily can be addressed in two ways. A large Malecot tube can be placed in the duodenum, secured with a purse string silk suture and brought out through the abdominal wall for a controlled fistula. Note that this will often leak somewhat around the Malecot, so you still should leave closed suction drains in the area. This is the fastest and simplest option for a damage control scenario. If you have a little more time then several options are available. One often described technique is to bring a loop of jejunum up to the duodenal defect, and perform a "serosal patch" by suturing the margins of the defect to the serosal surface of the jejunal loop. I would not recommend this technique due to the high failure and leak rate. A better choice is to bring that loop of jejunum up to the defect and do a formal side to side anastomosis between the duodenum and the jejunum. This allows for much better drainage and less chance of luminal obstruction than the serosal patch option.

Following any complex or high risk type of duodenal repair you should consider whether or not to add a pyloric exclusion procedure. The theory is that you will protect your repair and decrease the chance and severity of leaks by excluding it from gastric acid and secretions. Remember that this can be done at a second-look operation and does not have to be done immediately with the duodenal repair. There is no good data that pyloric exclusion reduces complications, and it definitely adds time and complexity to your operation. I use a "gestalt" approach to exclusion – if I feel relatively confident about my repair then I don't do it. If I have concerns, had to do a very complex repair, or have a concomitant pancreatic injury then I will perform pyloric exclusion. I recommend exclusion of the duodenum with a transverse non-cutting staple line (TA-60 blue load) across the proximal duodenum and completion of a Roux-en-Y gastrojejunostomy. Another excellent option is to make a longitudinal gastrotomy adjacent to the pylorus, evert the pylorus into the gastrotomy and sew it closed (prolene or PDS suture), and then use the gastrotomy as the site of your gastrojejunal anastomosis (Fig. 9.8). I would also recommend a feeding jejunostomy for nutritional support in these patients at the time of definitive closure. For large non-expanding hematomas overlying the head of the pancreas, I recommend placement of drains overlying the pancreas and adjacent to the duodenal sweep, with gastrostomy and jejunostomy placement. No attempt should be made to unroof this injury if there is no evidence of ongoing bleeding. If there is a strong concern for an associated duodenal injury under the hematoma, then you can perform intraoperative upper endoscopy with the duodenum submerged in saline to evaluate for any leak.

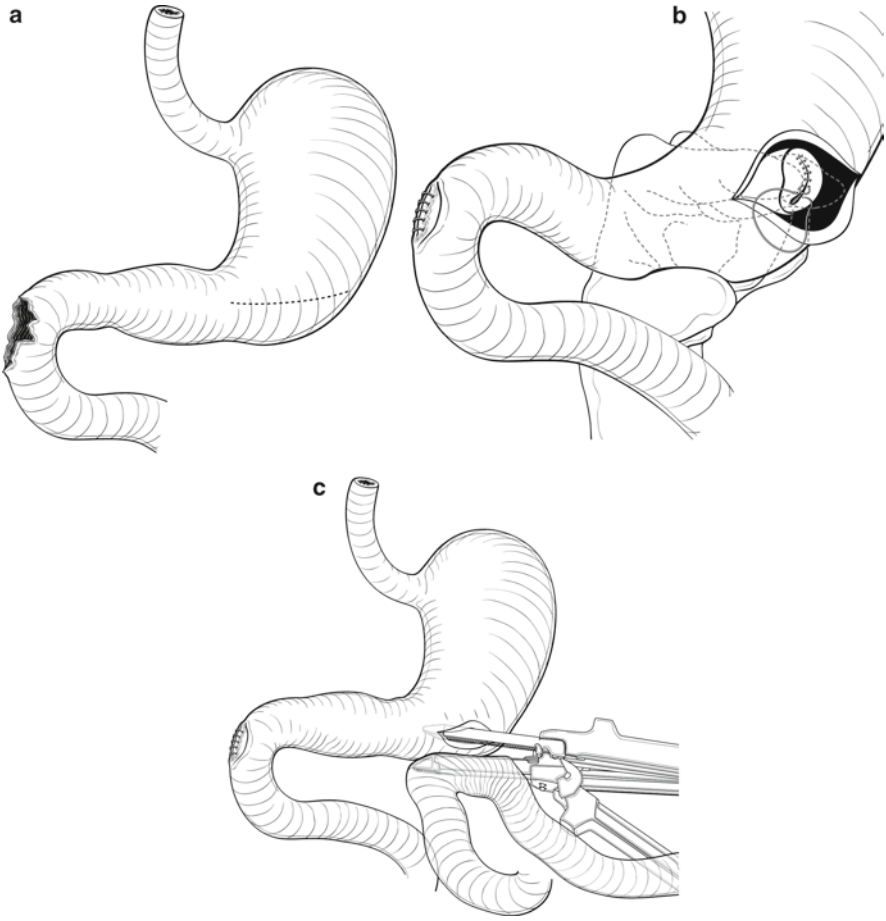

Fig. 9.8 Technique for sutured pyloric exclusion. (**a**) Incision on antrum. (**b**) Pylorus is everted and sutured closed (**c**) Gastrojejunostomy using the initial incision, duodenal injury closed

One final unique injury pattern you may encounter in combat trauma is that of multiple small fragment wounds to the duodenum. This can result in multiple injuries of various sizes, from an obvious laceration to a subtle pin-hole defect. Full mobilization of the duodenum should be performed and air or methylene blue instillation is useful for identifying occult perforations. A particularly difficult injury to identify and manage is a perforation of the mesenteric/pancreatic wall of the duodenum. You cannot mobilize the pancreatic head away from the inner duodenal wall to adequately expose and repair these injuries. If you suspect or identify one of these injuries, then an excellent option is to open the duodenum by performing a longitudinal duodenotomy along the anti-mesenteric border, and

inspect the inside surface for injury. Always locate the major ampulla before suturing things closed if you are in the second/third portion. You can easily repair these defects with full-thickness interrupted sutures from the inside, and then close the duodenotomy with running or interrupted silk suture.

The Trauma Whipple

A full description of the technical aspects of a pancreaticoduodenectomy for trauma is beyond the scope of this chapter, and should not be a consideration for 99% of these injuries in the acute setting. You may rarely encounter an injury that is best managed with this approach. These would include major devascularization of the second/third portions of the duodenum, destructive injury of the pancreatic head with or without duodenal injury, or injuries to the pancreas/duodenum/common bile duct that are not amenable to simpler reconstruction. Even if you identify such an injury pattern, your best option is to control bleeding and any spillage, leave adequate drainage, and disturb the anatomy as little as possible. Bring the patient back to the ICU for resuscitation and stabilization, discuss the case with your colleagues and gather your most experienced people. If the determination is that a major resection and reconstruction is the best option, then you can now proceed in a more elective setting with a stable patient (Fig. 9.9). Remember that you will not have all of the modern adjuncts immediately available for postoperative problems, such as percutaneous drainage or ERCP and stenting. If the patient is going to be evacuated to a higher level of care, then consider leaving the abdomen open for a re-exploration and evaluation at the next facility. Ensure adequate drains are placed at all anastomoses and that a secure route for nutrition is obtained, usually with a feeding jejunostomy.

In conclusion, these injuries are among the most stressful and challenging that you will encounter in a combat or disaster situation. Stick to the basic principles outlined

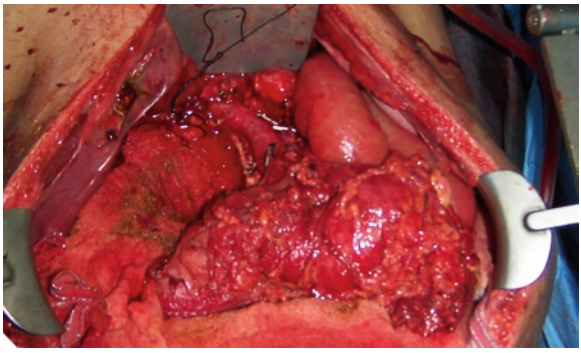

Fig. 9.9 Introperative photo of resected head of pancreas and duodenum immediately prior to reconstruction at a Combat Support Hospital. The patient underwent initial damage control surgery with no attempt at resection, and subsequently underwent a delayed Whipple procedure (48 h later) which allowed interim stabilization and operative preparations

here and *always* seek out experienced help if it is available. Wide drainage is the primary initial treatment modality for most injuries of the pancreas. Simple injuries of the duodenum can be repaired primarily but more extensive injuries may require diversion of gastric contents and options for enteral feeding. Complex repairs of the pancreas and duodenum should not be undertaken in the acute trauma setting. And remember to eat when you can, sleep when you can, and don't mess *too much* with the pancreas and duodenum.