Iatrogenic abdominal bleeding: radiologic features and clinical significance

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Learning objectives

Make a revision of important causes of iatrogenic abdominal bleeding

Set the diagnostic and therapeutic algorithm to identify the exact source of bleeding and to treat it efficiently from a radiological approach

Recognise the possible bleeding points after: surgery, peritoneal drainage, nephrostomy, gastrostomy, liver biopsy, ERCP and pacemaker implantation

Discuss pitfalls in image interpretation that may hinder accurate diagnosis of a bleeding as cone beam artifacts
Background

Iatrogenic abdominal bleeding is a critical condition increasingly seen due to the rise of interventional and surgical procedures and frequently requires prompt intervention, with significant morbidity and mortality.

Acute abdominal bleeding remains a diagnostic and therapeutic challenge that may threaten a patient’s life depending on the severity and duration of the event.

Rapid identification of the source and cause of bleeding is the primary objective in the evaluation of the hemorrhage to guide proper treatment. This usually requires a multidisciplinary approach.

Numerous studies have shown the potential role of multidetector computed tomography in the identification of active bleeding or acutely hemorrhagic lesions.

Factors influencing the ability to visualize active bleeding at computed tomography (CT) are multiple and include the nature of the bleeding lesion (bleeding rate, intermittence), patient factors (hemodynamics status, body mass index), the CT angiography (CTA) technique (rate of injection, concentration of iodine in contrast material, number of phases, type of scanner, postprocessing), and the experience of the radiologist.

Vascular injuries that may be seen on pelvic CTA include active arterial hemorrhage, pseudoaneurysm, arteriovenous fistula, dissection, occlusion, and venous injury. The most common injury and significant source of morbidity and mortality is active arterial extravasation. On a portal venous phase image, an arterial hemorrhage should have a higher attenuation than from a venous source, but significant overlap makes this distinction difficult. Contrast extravasation seen on a portal venous phase image is defined as an arterial hemorrhage if it is present on the earlier, arterial phase image. An arterial source of hemorrhage often dictates further intervention, usually in the form of embolization if the hemorrhage is ongoing. The larger the hemorrhage, the greater the likelihood an intervention required.

Contrast extravasation seen on a portal venous phase image but not on the earlier arterial phase image is more likely venous in nature. Venous hemorrhage can often be managed successfully with medical stabilization without the need for coil embolization or surgical intervention.

The addition of imaging phases to the CT angiography study may provide more information but also increases the total radiation dose. However, in some cases in which the bleeding point is not found in the arterial or in the portal phase, a delayed phase may
help. Indeed, the major accumulation of contrast material in a slowly bleeding jet with the pass of some minutes may diagnose or confirm a doubtful bleeding point.

The preliminary unenhanced scan minimizes misinterpretations of hyperattenuating material that can mimic contrast medium extravasation and can be a cause of false positive results, such as retained contrast material in diverticula, medications, surgical material, hemostatic clips, or calcifications. Another false positive result may occur due to cone beam artifacts. Indeed, hyperdensities may be observed at the interface between normal bowel content fluid and air simulating an acute gastrointestinal bleeding.

On delayed phases, foci of extravasated blood are typically larger, and the relative hyperattenuation persists throughout the various phases of image acquisition, differentiating from a pseudoaneurysm that would be identical in size and shape and the attenuation would be similar to the aorta in all phases, washing out on later phases of image acquisition. The differentiation has important therapeutic implications. Active bleeding requires urgent endovascular or surgical management whereas pseudoaneurysms or arteriovenous fistulas may be treated in a semiurgent manner.
Imaging findings OR Procedure details

**CT Angiographic technique**

No oral contrast material must be administrated. Fluid, as water is recommended if the patient condition allows it, to distend the small bowel loops.

All CT examination were performed with a 64-detector CT scanner (Somatom Sensation; Somatom Definition; Siemens, Forchheim, Germany). A triphasic CT examination was applied to all patients, from the hepatic dome to the inferior pubic ramus. The tube voltage was set at 120 KVp and an automatic program (CARE dose) assigned the mAs to minimize the radiation dose. Slice thickness of 1mm, reconstruction interval of 0.7 mm, and 5 mm were used. A preliminary unenhanced CT scan was routinely obtained by using a low-dose radiation technique, searching for any pre-existing intraluminal hyperattenuating material. 125-150 ml of intravenous contrast material (iohexol, Omnipeaque 300; GE Healthcare, Madrid, Spain) was administrated with a power injector at a rate of 4 mL/sec), followed by a 50-ml saline chaser, through an antecubital vein. The arterial phase was obtained by using automated bolus triggering (bolus tracking) setting the treshold at 150 HU. The portal venous phase was obtained 70 seconds after beginning of contrast material injection.

The radiologist interpreted the images at a PACS or independent workstation with interactive postprocessing capabilities, taking into account the axial data sets (5 mm) and the generated two-dimensional (sagittal and coronal) reformations and three-dimensional (volume rendered and maximum intensity projection) that are most useful for illustrating abnormalities and to guide therapy performed by interventional radiologists or vascular surgeons. The radiologist looked for the presence and location of active extravasation of contrast-enhanced blood, characterized as an hyperatenuation point visible in the arterial and/or portal venous phase but not seen on the unenhanced scan.

Evidence of active extravasation indicating ongoing hemorrhage was seen on CT angiograms in 14 patients. Of the 14 patients who were found to have active bleeding at CT angiography, 12 patients were transferred directly to the angiography suite for possible embolization and 2 patients were immediately taken to the operating room.

Conventional angiography confirmed the presence and location of the bleeding suggested at CT angiography in all of the cases referred for embolization.

In 1 patient, CT angiography demonstrated intraluminal hyperattenuating material, indicating recent bleeding, without active extravasation.

**Iatrogenic abdominal bleeding**
Radiologic percutaneous gastrostomy has become an accepted method of enteral access for patients requiring long-term nutritional support for a variety of conditions. While the safety of this procedure is well documented, major (hemorrhage, peritonitis, tube migration, aspiration and sepsis) and minor complications associated with gastrostomy do occur in a percentage under 6% and 8% respectively. Nevertheless, radiologically guided placement of gastrostomy and gastrojejunostomy tubes has lower morbidity and fewer major complications compared with surgical and endoscopic methods.

With radiological control, the stomach is inflated though a nasogastric tube. Ths site for gastrostomy tube placement is chosen and the stomach is puncture percutaneously. The tract between the skin and the stomach is dilated and the gastrostomy tube is introduced.

Gastrointestinal complications such as hemorrhage and perforation following percutaneous gastrostomy occur in under 2% of cases. Tansarterial embolotherapy may be useful for controlling massive hemorrhage.

Other potential complications-laceration of the liver, pancreas or spleen, and gastroenteric fistula-are very rare.

Involving the tube maintenance, several problems may be observed as accidental dislodgement, leakage from the insertion site, tube obstruction, migration, breakage and kink.

Specific to the left side approach in superior abdominal or inferior thoracic interventional procedur, a sometimes ignored but important cause for bleeding is the injury to the superior epigastric artery.

Superior epigastric artery is an important collateral that communicates the thoracic aorta to the abdominal aorta. It arises from the internal thoracic artery (referred to as the internal mammary artery in the accompanying diagram). It anastomoses with the inferior epigastric artery at the umbilicus and supplies the anterior part of the abdominal wall and some of the diafragm.
Along its course, (approximately 4 cm from the midline at the level of the xiphoid and about 5 cm from the midline between the xiphoid and the umbilicus) it is accompanied by a similarly named vein, the superior epigastric vein.

**Bleeding secondary to nephrostomy** [Fig. 8 on page 16](#) [Fig. 9 on page 17](#)

Familiarity with renal anatomy is necessary for selection of a safe route through the kidney for percutaneous nephrostomy. The renal artery divides into mayor ventral and dorsal branches, which creates a zone of relative avascularity between the divisions (the Brödel bloodless line of incision), that is the optimal region to be traversed to minimize the bleeding complications related to the percutaneous nephrostomy.

A lower pole posterior calix accessed via a subcostal approach is usually the puncture site selection for simple urinary drainage.

*Complications of percutaneous renal entry*

Minor complications that do not require specific therapy may be seen in 15-25% of patients who undergo a nephrostomy procedure. Indeed, transient hematuria occurs in virtually every patient. Transfusion or intervention by severe bleeding is needed in 1-3% of patients. At the time of nephrostomy an important bleeding may be controlled by tamponade of the track with a nephrostomy catheter or with a balloon dilatation catheter. An angiography may be needed in cases of worsening of the bleeding to depict renal arteriovenous fistula, pseudoaneurysms, or vessel laceration. Most of these vascular injuries can be treated by means of angiographic embolization.

Puncture of adjacent organs (as a retrorenal colon) may also occur, as well as hydrothorax and pneumothorax when a supracostal entry is used.

Major complications are reported to occur in 5-7% of percutaneous nephrostomy procedures and minor complications occur in 15-28%. Complications include infection, colon perforation, hemorrhage, and urinoma. Complications related to the catheter include dislodgment and obstruction. With use cross-sectional imagen guidance (CT or US) virtually no major complications have been reported, and minor complications have been reported to occur in 2% of patients.

**Colon perforación**

Because the normal relationship of the kidneys to adjacent visceral organs varies, occasional puncture of these organs during percutaneous nephrostomy is possible. The colon can lie in the path of a percutaneous nephrostomy tract that originates near...
the posterior axillary line. This far posterolateral position of the colon appears more commonly in patients with little retroperitoneal fat. Occasionally, the colon can even lie in a retroperitoneal position. Perforation of the colon is virtually eliminated when the procedure is performed using US or CT guidance for access needle placement.

**Bleeding secondary to liver biopsy Fig. 10 on page 18**

Percutaneous biopsy using CT or US guidance is an important diagnostic technique in organs and soft tissue to depict the presence of malignancy or intrinsic parenchyma disease, specially at liver and kidney levels.

The optimal sites for the puncture and needle path is selected by US or CT avoiding large interposed blood vessels.

After proper placement or the needle the biopsy is obtained with the patient in suspended respiration. For biopsies of focal hepatic lesions, healthy liver in traversed before the lesion to avoid possible peritoneal tumor spillage or tumoral bleeding.

The risk of bleeding after percutaneous biopsy has been extensively reported in the literature. In a revision by Atwell TD et all, the bleeding risk after liver biopsy was 0,5%. Severe bleeding is the most feared complication, with literature indicating the incidence to be less than 1%. Bleeding may occur in patients with or without an underlying coagulopathy.

Early detection of postbiopsy bleeding, is important for proper management to prevent a catastrophic result. In general, the detection of postbiopsy bleeding has been made on the basis of suggestive clinical symptoms and signs such as shock or hypotension and a drop in serum hemoglobin concentration. In general CT is better than US to depict a profuse parenchymal bleeding, a peritoneal bleeding and the bleeding point.

Specific to the left side approach in liver biopsy, a sometimes ignored but important cause for bleeding is the injury to the superior epigastric artery.

Active extravasation from the hepatic artery or branches is a potentially life-threatening injury when associated with hemodynamic inestability. When present, this finding is a strong predictor of failure of nonsurgical treatment.

**Bleeding secondary to paracentesis Fig. 11 on page 19 Fig. 12 on page 20 Fig. 13 on page 21**
Percutaneous drainage of fluid collections can usually be safely achieved using CT or US guidance. Drainage procedures are performed either for definitive treatment or as a temporizing procedure until surgery can be safely performed. Bleeding diathesis is a relative contraindication, and abnormal bleeding parameters should be corrected before the procedure. Lack of a safe route for puncture precludes drainage.

In the abdominal cavity, it is important to find an access route into the fluid collection that avoids puncturing the surrounding bowel. When a fluid collection is loculated, multiple drainage catheters may have to be placed.

In the pelvis, a variety of approaches (transrectal or transvaginal) may be used. In all cases, one must avoid the bowel, bladder, and seminal vesicles in men and the uterus and ovaries in women. If using a transgluteal approach, the sciatic nerve, sacral plexus, and gluteal vessels must be avoided. Fig. 11 on page 19  Fig. 12 on page 20

In the abdomen, one must have in mind the anatomical course of the epigastric artery while performing interventional procedures as intraperitoneal fluid drainage. In fact, bleeding from perforationg branches of the superior and inferior epigastric artery is a common cause for rectus sheat hematomas.

The deep inferior epigastric artery has many variable anatomic features, including its location, its branching pattern, and the number of perforating vessels that it supplies.

The deep inferior epigastric artery arises medially from the distal external iliac artery and courses superiorly, entering the rectus sheath just below the arcuate line.

The artery then passes between the posterior layer of the rectus sheath and the rectus muscle. Fig. 13 on page 21

**Bleeding secondary to biliary drainage** Fig. 14 on page 14 Fig. 15 on page 15

Drainage can be successfully established in 70 to 97% of patients.

However, the transhepatic biliary decompression is an invasive procedure and a variety of procedure-related complications have been reported. Major complications occur in about 4% of procedures. Some methods of reducing the frequency of hemorrhagic complications are the normalization of coagulations factors before the procedure; the use of a fine-needle coaxial technique; a peripheral-duct puncture, and a careful positioning of side holes to avoid communication with an intrahepatic vessel.

**Immediate complications** (5-10% of patients) include pericatheter bile leak (less than 16%); septic shock with hypotension (3 to 5%); pancreatitis (0-4%); pneumothorax, hemothorax, biliothorax (less than 1%), contrast reaction (less than 2%) and hemorrhage/
hemobilia: (2 to 13.8%). This can sometimes be self-limited when the bleeding is the result of a venous injury. Arterial injury often causes persistent hemobilia, which must be aggressively treated with embolotherapy.

*Delayed complications* include cholangitis (14-25%); catheter dislodgment (less than 18%); peritonitis (1-3%); hypersecretion of bile (0-5%); biliopleural fistula (2.5%); skin infection (common); intrahepatic or perihepatic abscess (rare); metastatic seeding of the serosa or tract with cholangiocarcinoma and pancreatic carcinoma.

**Bleeding secondary to cholangiopancreatography** Fig. 16 on page 29 Fig. 17 on page 30 Fig. 18 on page 31

Endoscopic retrograde cholangiopancreatography (ERCP) is an invasive procedure performed to diagnose and treat biliary and pancreatic disease. The technique is operator dependent being the complications rates lower with increased experience of the endoscopist. The complications can be secondary to biliary and pancreatic manipulation or related to endoscopy, as pancreatitis, cholangitis, duodenal perforation, bleeding and stent migration.

**Duodenal hemorrhage**

Hemorrhage from ERCP usually occurs with sphincterectomy (prevalence 2.5-5%). Significant hemorrhage is defined as clinical evidence with melena or hematemesis with an associated decrease in hemoglobin concentration that needs embolization, surgery or repeat endoscopy and epinephrine injection.

**Bleeding secondary to endoscopy** Fig. 19 on page 35 Fig. 20 on page 36 Fig. 21 on page 37

The celiac trunk is the common output from the abdominal aorta of three arteries: the left gastric artery, the splenic artery and the common hepatic artery. The common hepatic artery extends to the liver by partially irrigating the stomach, duodenum and pancreas. This artery gives rise to the gastroduodenal artery and proper hepatic artery. The arterial supply of the papilla derives from branches of the gastroduodenal artery.

The presence of aberrant vessels and/or the anatomic alteration resulting from hypertension (as aneurismatic dilatations), or other entities as mediolysis or vasculitis that course with vascular alterations with a direct trauma with the endoscope might explain the injury of the gastroduodenal artery in this patient.
Depending on the anatomical location of the abdominal surgery, big attention must be paid to the course of the vessels in this determinate territory.

The CT angiography helps identify patients with active bleeding and accurately determine the site of the bleeding. This information is helpful for directing therapy and, when necessary, for selecting the most appropriate hemostatic intervention: endoscopic, angiographic, or surgical. Precise anatomic localization of the bleeding point allows a targeted endovascular embolization, with a reduction in the number of angiographic series and a resulting saving in time, radiation dose, and the load of contrast material administered. A completely negative CT angiogram decreases the likelihood of subsequent angiographic identification of bleeding and might warrant a more conservative treatment.

Active extravasation from the hepatic artery or branches is a potentially life-threatening injury when associated with hemodynamic instability.

The one absolute indication for surgical treatment in renal injury is life-threatening arterial bleeding whereas other injuries may be managed nonemergently or conservatively.

An arterial source of hemorrhage from a branch of the superior mesenteric artery often dictates further intervention, usually in the form of angiography with embolization if the hemorrhage is ongoing. The larger the hemorrhage, the greater the likelihood an intervention required.

Contrast extravasation seen on a portal venous phase image but not on the earlier arterial phase image is more likely venous in nature. Venous hemorrhage can often be managed successfully with stabilization without the need for coil embolization or surgical intervention. Differentiating and characterizing the type and localization of vascular injury rapidly and accurately is essential in these postsurgical severely injured patients.
Fig. 5: 42-year-old woman with a congenital heart disease type Ebstein anomaly, is admitted to our hospital for replacement of an epicardic peacemaker generator. Ten hours after the procedure the patient complained of severe abdominal pain and an important decreased in her hematocrit level (two points from the pre procedure level). A CTA of the abdomen is performed. An unenhanced phase (A, B) revealed a metallic artifact from the peacemaker and a big abdominal wall hematoma. The arterial, portal and delayed phases (C, D, E, F, G, H) revealed an active leak inside the hematoma that confirmed the presence of an active arterial hemorrhage from the superior epigastric artery. An arteriography was performed, confirmed a section os a muscular branche of the superior epigastric artery. An embolization with microcoils was carried out to embolize the proximal and the distal segments (I, J, K)
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Fig. 14: A 58-year-old woman with advanced pancreatic carcinoma, severe jaundice with dilated intrahepatic ducts secondary to intrapancreatic ductal obstruction underwent a biliary drainage through a right approach (Fig. A). Forty-eight hours later, the patient experimented acute abdominal pain and hypotension ans a CT angiography was performed. The CT showed anterior and right hematoma (Fig B) with hyperdense foci representing active extravasation (Fig C, D). Interventional angiography following CT confirmed active bleeding from a right hepatic branch (Fig E,F). Control angiogram after embolization showed complete cessation of bleeding (Fig G, H)
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Fig. 8: A 71-year-old man with history of chronic renal failure and kidney transplantation two years before is admitted for deteriorating renal function. A percutaneous nephrostomy is placed for severe hydronephrosis in right iliac fossa. Three hours later, the patient is reported to the emergency room complaining of abdominal pain and with a decreased hematocrit level. A CTA demonstrates high-attenuation free intraperitoneal fluid (hemoperitoneum) in the unenhanced image (Fig. A). The arterial phase (Fig. B, C) depicts a focal area of high attenuation within an ileal loop in the right iliac fossa. The portal (Fig. D, E) and the delayed phases (Fig. F) show a growth in the active arterial extravasation with a bigger mesenteric bleeding depicting the ileal artery as bleeding source. Convencional angiogram (Fig. G) confirms an area of extravasation that arises from vasa recta from an ileal artery. Completion arteriogram (Fig. H) obtained following coil embolization of the ileal branch demonstrates no evidence of residual bleeding.

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Fig. 9: A 71-year-old man with history of chronic renal failure and kidney transplantation two years before is admitted for deteriorating renal function. A percutaneous nephrostomy is placed for severe hydronephrosis in right iliac fossa. Three hours later, the patient is reported to the emergency room complaining of abdominal pain and with a decreased hematocrit level. A CTA demonstrates high-attenuation free intraperitoneal fluid (hemoperitoneum) in the unenhanced image (Fig. A). The arterial phase (Fig. B, C) depicts a focal area of high attenuation within an ileal loop in the right iliac fossa. The portal (Fig. D, E) and the delayed phases (Fig. F) show a growth in the active arterial extravasation with a bigger mesenteric bleeding depicting the ileal artery as bleeding source. Convencional angiogram (Fig. G) confirms an area of extravasation that arises from vasa recta from an ileal artery. Completion arteriogram (Fig. H) obtained following coil embolization of the ileal branch demostrates no evidence of residual bleeding.

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Fig. 10: A 54-year-old man with a history of hepatitis C virus infection and alcohol abuse was referred for a liver biopsy. An hour after, the patient noted to be anxious, complaining of diffuse abdominal pain. The hematocrit level decreased abruptly from prebiopsy levels. A subsequent CT scan revealed a large intrabdominal hematoma in the unenhanced phase (Fig A) and arterial and portal phases depicted a branch of the hepatic artery to be the bleeding source (Figures B,C). Coil embolization stopped the bleeding.

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**Fig. 11:** A 44-year-old-woman with history of colon carcinoma surgically treated and hepatic metastases is admitted with abdominal distention. US (Fig A) demonstrated the presence of "ascites" and a drainage was recommended. After the procedure, the patient suffered from abdominal pain and hypotension. A CT angiography was carried out and a pelvic complex collection with high-attenuation areas near the drainage catheter was seen (Fig. B). Contrast-enhanced CT image (Fig. C, D) show active bleeding, and angiography (Fig. E, F) confirmed the bleeding to originate from a branch of the left ovarian artery, which could be completely stopped by coil embolization. The "ascites" corresponded to a malignant ovarian lesion.

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Fig. 12: A 44-year-old-woman with history of colon carcinoma surgically treated and hepatic metastases is admitted with abdominal distention. US (Fig A) demonstrated the presence of "ascites" and a drainage was recommended. After the procedure, the patient suffered from abdominal pain and hypotension. A CT angiography was carried out and a pelvic complex collection with high-attenuation areas near the drainage catheter was seen (Fig. B). Contrast-enhanced CT image (Fig. C, D) show active bleeding, and angiography (Fig. E, F) confirmed the bleeding to originate from a branch of the left ovarian artery, which could be completely stopped by coil embolization. The "ascites" corresponded to a malignant ovarian lesion.

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**Fig. 13:** A 70-year-old man with a history of heart insufficiency and chronic hepatopathy with portal hypertension is admitted by disnea and gained weight. A therapeutic paracentesis is indicated to relieve the patient of the respiratory compromise and the abdominal pain. After the procedure, the patient experimented an acute drop of haemoglobin and haematocrit and directly underwent CT examination. The unenhanced CT image (Fig. A) shows high-attenuation ascitis with a focus of active extravasation seen on arterial and portal phases (Fig. B,C). At angiography (Fig. D), the bleeding vessel was found to be a muscular branch from the left inferior epigastric artery. Subsequent embolization with microcoils was successful.

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Fig. 2: 57-year-old man with a history of advanced esophageal carcinoma treated with chemotherapy. To provide enteral nutrition a percutaneous gastrostomy was successfully performed under fluoroscopy guidance. A month later, the patient suffered from abdominal pain and fever. A CT was performed without finding the pain cause due to the presence of oral contrast. Retrospectively a metallic element was found in the cecum (Figures A, B). Two days later, the patient continued with abdominal pain, hypotension, and blood with feces. An CT angiography was performed. The metallic element was located in the descending colon (Figures C, D). Dilatated intestinal loops were seen and an active bleeding point in the terminal ileum (Figures E, F, G, H, I, J). The angiography revealed a bleeding point from an ileal branch from the ileo-colic artery that was selectively embolized (Figures K, L, M, N). The metallic elements seen on the first CT in the cecum and two days before found in the descendent colon corresponded to broken parts of the gastrostomy tube, that migrated through the intestinal lumen, eroding the wall.

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Fig. 3: 57-year-old man with a history of advanced esophageal carcinoma treated with chemotherapy. To provide enteral nutrition a percutaneous gastrostomy was successfully performed under fluoroscopy guidance. A month later, the patient suffered from abdominal pain and fever. A CT was performed without finding the pain cause due to the presence of oral contrast. Retrospectively a metallic element was found in the cecum (Figures A, B). Two days later, the patient continued with abdominal pain, hypotension, and blood with feces. An CT angiography was performed. The metallic element was located in the descending colon (Figures C, D). Dilated intestinal loops were seen and an active bleeding point in the terminal ileum (Figures E, F, G, H, I, J). The angiography revealed a bleeding point from an ileal branch from the ileo-colic artery that was selectively embolized (Figures K, L, M, N). The metallic elements seen on the first CT in the cecum and two days before found in the descending colon corresponded to broken parts of the gastrostomy tube, that migrated through the intestinal lumen, eroding the wall.

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**Fig. 4:** 57-year-old man with a history of advanced esophageal carcinoma treated with chemotherapy. To provide enteral nutrition a percutaneous gastrostomy was successfully performed under fluoroscopy guidance. A month later, the patient suffered from abdominal pain and fever. A CT was performed without finding the pain cause due to the presence of oral contrast. Retrospectively a metallic element was found in the cecum (Figures A, B). Two days later, the patient continued with abdominal pain, hypotension, and blood with feces. An CT angiography was performed. The metallic element was located in the descending colon (Figures C, D). Dilatated intestinal loops were seen and an active bleeding point in the terminal ileum (Figures E, F, G, H, I, J). The angiography revealed a bleeding point from an ileal branch from the ileo-colic artery that was selectively embolized (Figures K, L, M, N). The metallic elements seen on the first CT in the cecum and two days before found in the descendent colon corresponded to broken parts of the gastrostomy tube, that migrated through the intestinal lumen, eroding the wall.

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**Fig. 22:** A 74-year-old woman with a history of cecum carcinoma was referred for surgical treatment (laparoscopic right hemicolectomy). Twelve hours after, the patient suffered from sudden hypotension and a CT angiography was carried out. The CT scan revealed a large intrabdominal hematoma in the unenhanced phase (Fig A). Axial arterial (Fig B) and portal phase (Fig C) and coronal delayed phase (Fig D) show highly attenuating extravasated contrast material in the surgical bed in the right lower quadrant. The patient underwent surgical treatment which confirmed the presence of a large vascular lesion.

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Fig. 23: A 68-year-old man with a history of perforated gastric ulcer treated with gastrectomy (Bilroth II) was admitted due to massive hematemesis. A CT angiography showed in the unenhanced phase a intragastric hematoma (Fig A). Axial and coronal arterial (Fig B, D) and portal phase (Fig C) showed several active bleeding points near the surgical suture, in the gastric lumen. The angiography (Fig. E, F) confirmed the bleeding to originate from a branch of the left gastric artery and from the gastroduodenal artery, which could be completely stopped by coil embolization.

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**Fig. 24:** A 68-year-old man with a history of perforated gastric ulcer treated with gastrectomy (Bilroth II) was admitted due to massive hematemesis. A CT angiography showed in the unenhanced phase a intragastric hematoma (Fig A). Axial and coronal arterial (Fig B, D) and portal phase (Fig C) showed several active bleeding points near the surgical suture, in the gastric lumen. The angiography (Fig. E, F) confirmed the bleeding to originate from a branch of the left gastric artery and from the gastroduodenal artery, which could be completely stopped by coil embolization.

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**Fig. 25:** 38-year-old man diagnosed of two renal solid nodules suggestive of malignancy located in the upper and lower poles. Surgical resection of the upper nodule (partial nephrectomy) and radiofrequency ablation of the lower nodule were performed. During the immediate postoperative period in the ICU a significant anemization was detected and an CT angiography was performed. An increase of the density suggestive of bleeding was detected in the surgical site (upper pole right kidney) in the unenhanced phase (Fig. A). Evidence of contrast extravasation in the surgical site was found both in the arterial and the portal phases (Fig. B, C). Thin-thickness reconstructions confirmed the presence of small active bleeding points site (Fig. D). A subcostal right laparotomy was performed confirming the presence of a large amount of clots and an active bleeding point at the end of the suture renal which was sealed. Patient's anemization stopped and he was discharged without sequelae 6 days later.

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Fig. 16: 68-year-old man with a history of a colon adenocarcinoma with multiple liver metastases and an adenopathic conglomerate in the hepatic hilum that caused dilatation of the intra-hepatic and extrahepatic bile ducts with severe hyperbilirubinemia. An ecoendoscopic study confirmed the presence of a tumoral mass that compressed the choledocus and two endoprotesis were place in order to restore the bile flow. 6 hours later the patient started to present blood with feces that continued for two days causing severe anemization. An CT angiography was performed. No significant findings were found in the unenhanced phase (Fig. A). An active bleeding point into the lumen of the digestive tract was detected at the junction of the 2nd and 3rd portion of the duodenum in the arterial, portal and delayed phases (Fig. B, C, D). The angiography confirmed the bleeding point from a branch of the pancreaticoduodenal arcade and selective embolization was performed (Fig. E, F).

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**Fig. 17:** 68-year-old man with a history of a colon adenocarcinoma with multiple liver metastases and an adenopathic conglomerate in the hepatic hilum that caused dilatation of the intra-hepatic and extrahepatic bile ducts with severe hyperbilirubinemia. An ecoendoscopic study confirmed the presence of a tumoral mass that compressed the choledocus and two endoprotesis were place in order to restore the bile flow. 6 hours later the patient started to present blood with feces that continued for two days causing severe anemization. An CT angiography was performed. No significant findings were found in the unenhanced phase (Fig. A). An active bleeding point into the lumen of the digestive tract was detected at the junction of the 2nd and 3rd portion of the duodenum in the arterial, portal and delayed phases (Fig. B, C, D). The angiography confirmed the bleeding point from a branch of the pancreaticoduodenal arcade and selective embolization was performed (Fig. E, F).

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**Fig. 18:** 66-year-old man with a history of symptomatic choledocolithiasis. CPRE was performed with removal of the lithiasis by endoscopic papillotomy. 24 hours later the patient started to refer abdominal pain and mild anemization. An CT angiography was performed. No significant findings were found in the unenhanced phase (Fig. A). Several active bleeding points were detected in the lumen of the duodenum in the arterial and portal phases (Fig. B, C). ICU admission for hemodynamic monitoring and transfusional support was decided. No significant anemization was further detected and patient was discharged 6 days later.

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Fig. 26: 70-year-old man with a history of Crohn’s disease of 20 years of evolution and a significant ileal stenosis. An ileocecal resection with an ileo-colic terminal anastomosis was performed. During the immediate postoperative period in the ICU a significant anemization was detected and an CT angiography was performed. Hematic ascites was found in the proximity of the ileo-colic terminal anastomosis, in right upper quadrant and in the ipsilateral paracolic gutter. An active bleeding point was revealed in the arterial and portal phases next to the surgical anastomosis (Fig. A, B, C). MIP reconstructions were performed to identify the origin of the bleeding point (Fig. D, E, F), which was located in a distal branch of the ileocolic artery. The angiography confirmed the bleeding point from an ileal branch of the ileo-colic artery and selective embolization was performed (Fig. G, H, I).

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**Fig. 27**: 70-year-old man with a history of Crohn's disease of 20 years of evolution and a significant ileal stenosis. An ileocecal resection with an ileo-colic terminal anastomosis was performed. During the immediate postoperative period in the ICU a significant anemization was detected and an CT angiography was performed. Hematic ascites was found in the proximity of the ileo-colic terminal anastomosis, in right upper quadrant and in the ipsilateral paracolic gutter. An active bleeding point was revealed in the arterial and portal phases next to the surgical anastomosis (Fig. A, B, C). MIP reconstructions were performed to identify the origin of the bleeding point (Fig. D, E, F), which was located in a distal branch of the ileocolic artery. The angiography confirmed the bleeding point from an ileal branch of the ileo-colic artery and selective embolization was performed (Fig. G, H, I).

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Fig. 28: 70-year-old man with a history of Crohn’s disease of 20 years of evolution and a significant ileal stenosis. An ileocecal resection with an ileo-colic terminal anastomosis was performed. During the immediate postoperative period in the ICU a significant anemization was detected and an CT angiography was performed. Hematic ascites was found in the proximity of the ileo-colic terminal anastomosis, in right upper quadrant and in the ipsilateral paracolic gutter. An active bleeding point was revealed in the arterial and portal phases next to the surgical anastomosis (Fig. A, B, C). MIP reconstructions were performed to identify the origin of the bleeding point (Fig. D, E, F), which was located in a distal branch of the ileocolic artery. The angiography confirmed the bleeding point from an ileal branch of the ileo-colic artery and selective embolization was performed (Fig. G, H, I).

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Fig. 19: A 87-year-old man with a history of chronic bronchopathy, and arterial hypertension was admitted due to a pneumonic process and a gastric pain. A echoendoscopy was performed and two hours later, a CT is solicited due to increase of the abdominal pain. The CT angiography showed in the unenhanced phase a periduodenal and peripancreatic hematoma (Fig B), secondary to a bleeding point (Fig. C, D) from a small pseudoaneurysm located in the distal posterior part of the gastroduodenal artery (Fig. E, F, G). An angiography demonstrated an aneurysmatic dilatation in the gastroepiploic artery (Fig. H, I) that was embolizated with coils from the mesenteric artery -proximal embolization-, and from gastroduodenal artery -distal embolization- (Fig. J, K).

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Fig. 20: A 87-year-old man with a history of chronic bronchopathy, and arterial hypertension was admitted due to a pneumonic process and a gastric pain. A echoendoscopy was performed and two hours later, a CT is solicited due to increase of the abdominal pain. The CT angiography showed in the unenhanced phase a periduodenal and peripancreatic hematoma (Fig B), secondary to a bleeding point (Fig. C, D) from a small pseudoaneurysm located in the distal posterior part of the gastroduodenal artery (Fig. E, F, G). An angiography demonstrated an aneurysmatic dilatation in the gastroepiploic artery (Fig. H, I) that was embolized with coils from the mesenteric artery -proximal embolization-, and from gastroduodenal artery -distal embolization- (Fig. J, K).

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Fig. 21: A 87-year-old man with a history of chronic bronchopathy, and arterial hipertension was admitted due to a pneumonic process and a gastric pain. A echoendoscopy was performed and two hours later, a CT is solicited due to increase of the abdominal pain. The CT angiography showed in the unenhanced phase a periduodenal and peripancreatic hematoma (Fig B), secondary to a bleeding point (Fig. C, D) from a small pseudoaneurysm located in the distal posterior part of the gastroduodenal artery (Fig. E, F, G). An angiography demonstrated an aneurysmatic dilatation in the gastroepiploic artery (Fig. H, I) that was embolizated with coils from the mesenteric artery -proximal embolization-, and from gastroduodenal artery -distal embolization- (Fig. J, K).

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Conclusion

CT-angiography is a first-line modality for accurate diagnosis of iatrogenic bleeding. It is useful to obviate a negative angiographic examination; discover anatomic variants for posterior angiography; localize the site of bleeding and determine whether surgery or embolization should be indicated, planning the approach to catheter-directed angiography.

Radiologist must be familiar with risks of percutaneous and surgical procedures and with the treatment options that might apply on the way.

The information provided by CT angiography (active bleeding and site of bleeding) is helpful for directing therapy and, when necessary, for selecting the most appropriate hemostatic intervention: endoscopic, angiographic, or surgical. Precise anatomic localization of the bleeding point allows a targeted endovascular embolization, with a reduction in the number of angiographic series as a resulting saving in time, radiation dose, and the load of contrast material administered. A completely negative CT angiogram decreases the likelihood of subsequent angiographic identification of bleeding and might warrant a more conservative treatment.
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