

Endovascular embolization in the management of traumatic and postoperative abdominopelvic bleeding: a single-center experience

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Background/aim: Endovascular embolization is widely used instead of surgery in the treatment of traumatic and postoperative abdominopelvic bleeding. The objective of this study is to evaluate the efficiency of computed tomography in the determination of active bleeding and the efficiency of endovascular embolization in traumatic and postoperative abdominopelvic bleeding.

Materials and methods: Thirty-one patients admitted to our hospital with traumatic and postoperative abdominopelvic bleeding between January 2006 and September 2012 and treated with endovascular embolization were retrospectively enrolled in the study. In 15 hemodynamically stable patients, abdominal computed tomography was performed to detect the presence and/or localization of the hemorrhage. All 31 patients underwent digital subtraction angiography (DSA) and endovascular embolization.

Results: Active hemorrhage was detected in all patients evaluated by computed tomography. Thirty-two embolization procedures were performed in 31 patients. Embolization was successful in all procedures. Two patients needed retreatment because of recurrent bleeding. One patient died 2 days after embolization as a result of concomitant multiorgan injury.

Conclusion: Computed tomography is able to detect active bleeding, allowing it to take the place of diagnostic DSA. If careful patient selection is carried out, endovascular embolization may be the final treatment, despite high-grade visceral organ injury.

Key words: Active hemorrhage, trauma, endovascular treatment, computed tomography, digital subtraction angiography

1. Introduction

Trauma is the most common reason for death among the young population. Uncontrolled bleeding is a major factor in early mortality after trauma and is responsible for 30%–40% of trauma-related deaths (1). In cases of postoperative bleeding, surgery may be difficult and life-threatening, especially in hemodynamically unstable patients (2). Endovascular techniques are widely used in the treatment of trauma patients to stop active bleeding of visceral organ injuries and pelvic fractures (3,4). Endovascular embolization is the intentional and controlled occlusion of a vessel. It represents a rapid method that is less harmful to the tissues than operative surgery, allowing the control of bleeding with a minimally invasive technique. Digital subtraction angiography (DSA) localizes bleeding and enables embolization within the same procedure.

Timely manipulation of active bleeding is an important issue in the management of traumatic and postoperative bleeding. The improved technology in multidetector

computed tomography (MDCT) enables the rapid evaluation of active hemorrhage. Early determination of an active hemorrhage site allows faster treatment planning and endovascular embolization if necessary (5).

The aim of this study is to evaluate the efficiency of endovascular embolization in patients with traumatic and postoperative abdominopelvic hemorrhage.

2. Materials and methods

This study was carried out during routine procedures at our hospital with the approval of the institutional review board. All patients provided written informed consent for MDCT and endovascular embolization procedures, which were performed within the medical standard of care for diagnosis and treatment of active abdominopelvic hemorrhage under suitable conditions.

Between January 2006 and September 2012, patients who were admitted to the Department of Radiology with traumatic or postoperative abdominopelvic hemorrhage

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and underwent endovascular embolization were included in the study. The patients were presented to our clinic for evaluation of vascular injury and probable endovascular treatment. A total of 31 patients were included in this study. Demographic data for the patients are shown in Table 1.

Fifteen patients who were hemodynamically stable underwent abdominal MDCT examination for determination of the existence and localization of active bleeding. All these patients were examined using MDCT (Somatom Sensation 16, Siemens Medical Systems, Erlangen, Germany). Examinations were performed according to the bleeding protocol, in which 3-mm axial sections were evaluated in four phases: one before intravenous contrast administration and three after intravenous contrast administration in the arterial (25 s), venous (75 s), and late venous (150 s) phases. These images were evaluated at a workstation in the axial plane and three-dimensional (3D) multiplanar reformatted images were used as needed. All patients with active bleeding underwent DSA and endovascular embolization.

Patients with high clinical suspicion with a decrease in hemoglobin levels and ultrasonography findings suggesting active hemorrhage, including the presence of massive abdominal free fluid, underwent direct diagnostic DSA and endovascular embolization in the same procedure.

For DSA and endovascular embolization procedures, a monoplane was used until 2009 (Advantex, GE Medical Systems, Milwaukee, WI, USA), whereas a biplane with 3D reconstruction was used after 2009 (Neurostar, Siemens Medical Solutions, Erlangen, Germany).

All patients were sedated during the procedures, which included cardiac and respiratory monitoring. The procedure consisted of navigating a 4-F to 5-F introducer sheath through the femoral artery. A 0.889-mm hydrophilic guide wire was then used, and a catheter suitable for the localization and structure of the target vessel was inserted. Angiograms were obtained to determine the existence and localization of bleeding. Selective catheterization of actively bleeding vessels was carried out. If possible, 2.6-F to 3-F microcatheters (Rapid Transid, Excel SL-10, Rebar 14-18, Renegade, Prograde) were used for superselective catheterization. Various embolizing agents, including

NBCA (Histoacryl; B. Braun Medical Ltd., Melsungen, Germany) with iodized oil (Lipiodol, Laboratoire Guerbet, Roissy, France), polyvinyl alcohol (PVA) particles, coils, and autologous blood clots, were used for embolization according to the flow characteristics and localization of active bleeding. If the organ fed by the target vessel had well-developed collaterals and permanent embolization was necessary, coils were used. PVA particles were used for the permanent occlusion of small-sized vessels. Moreover, due to low viscosity and rapid, stable embolization properties, cyanoacrylate was used when stable small-vessel embolization was needed. When temporary embolization was required, as in the case of major pelvic vascular injury, autologous blood clotting was used. Hemostasis was achieved by compression of the puncture site of the femoral artery following embolization.

In the evaluation of the MDCT and DSA images, shapeless extravasation of contrast media was accepted as active extravasation, a saccular protrusion of the contrast media from the related vessel as a pseudoaneurysm, and direct communication between the artery and vein as an arteriovenous fistula.

Angiograms were used immediately after the procedure to evaluate the efficiency of embolization. If these angiograms showed no active bleeding, this was defined as early technical success. The patients were invited back 1 month after the process, when a clinical examination was performed and hemoglobin levels were determined. Absence of any clinical findings and normal levels of hemoglobin were considered adequate for the acceptance of cessation of the bleeding. Imaging techniques were not performed. If recurrent hemorrhage was not seen at the 1-month follow-up, this was defined as late technical success.

3. Results

Thirty-one patients underwent 32 embolization sessions. The etiology of bleeding was surgery in 16 patients and trauma in 15 patients. Detailed etiologies of bleeding are shown in Table 2.

Fifteen patients were evaluated by CT. Of these patients, active extravasation was detected in nine, pseudoaneurysm in three, arteriovenous fistula (AVF) in one, and both active extravasation and pseudoaneurysm

Table 1. Demographic data of the patients.

	Number of patients	%	Age distribution, years	Median age, years
Total	31	100	4–74	47.6
Female	6	19.3	22–57	47.8
Male	25	80.7	4–74	47.6

Table 2. Etiologies of abdominopelvic bleeding.

Etiology of bleeding	Number of patients	%
Vehicle accident	11	35.48
Gunshot wound	1	3.23
Stabbing injury	3	9.68
Percutaneous nephrolithotomy	13	41.94
Stomach surgery	1	3.23
Cholecystectomy	1	3.23
Trauma surgery	1	3.23

in two. These patients underwent DSA and endovascular embolization. In all patients examined by MDCT (15 patients), MDCT and DSA findings were relevant, both of which showed active hemorrhage. MDCT examinations showed that one patient with bleeding from the left hepatic artery, caused by a stabbing injury, had Grade 3 hepatic injury; one patient with bleeding from the splenic artery showed Grade 3 splenic injury; two patients with bleeding from the renal artery had Grade 2 renal injury; and one patient with bleeding from the renal artery had Grade 3 renal injury, according to the American Association for the Surgery of Trauma injury scoring scale.

Sixteen patients with highly suspect clinical or ultrasonography findings strongly suggesting intraabdominal hemorrhage underwent DSA directly, and endovascular embolization was performed in the same session. DSA showed active extravasation in 14 patients (Figure 1), pseudoaneurysm in 11, AVF in 3 (Figure 2), active extravasation and pseudoaneurysm in 1 (Figure 3), and active extravasation, pseudoaneurysm, and AVF in 2 patients. The embolizing agents used in the embolization procedures are given in Table 3.

Early technical success was identified when angiograms did not show active bleeding following embolization. All procedures achieved 100% early technical success. No complications were noted during or after the procedures. On follow-up, one patient who had embolization for renal artery bleeding after percutaneous nephrolithotomy (PNL) had recurrent bleeding 3 days after endovascular embolization; consequently, embolization was performed a second time. Another patient, bleeding from the renal artery because of PNL, had recurrent bleeding and underwent surgery. One trauma patient died from an accompanying multiorgan injury 2 days after embolization (3.2% mortality rate). Other patients showed no recurrent bleeding on follow-up (93.3% late technical success).

4. Discussion

Physical examination is not often sufficient for evaluating trauma patients. Diagnostic imaging is an accepted standard and a necessity in cases of multiple trauma. Ultrasonography is used as a first-step diagnostic tool. However, if the patient is hemodynamically stable, solid organ injury should be confirmed with CT (6). It may also be useful in selected hemodynamically unstable patients (7).

With recent innovations in CT technology, active bleeding is easier to detect. Short acquisition time, multidetector technology, and contrast agent pumps are helpful (8). Active contrast extravasation and localization can be determined with contrast-enhanced CT (9). If active extravasation can be diagnosed by CT, catheter angiography may only be needed for therapeutic purposes. Arterial extravasation is surrounded with low attenuation clots and its density is close to that of adjacent major arteries. Active extravasation is observed as 85–350 Hounsfield units (HU) on CT, whereas clotted blood is between 40 and 70 HU (10). Detecting arterial embolization on CT enables timely endovascular embolization, whereas defining the localization of bleeding provides selective practice on DSA. Previous studies have reported that contrast-enhanced CT has 66%–90% sensitivity, 85%–95% specificity, and 87%–98% accuracy in detecting active bleeding (11). An in vitro study showed that 16-detector MDCT is comparable with DSA in detecting active bleeding (12). In the present study, active bleeding was shown on MDCT for all patients evaluated (15 patients), and active bleeding was confirmed with DSA. Cases with active bleeding were detected by CT examination, but that could not be shown on DSA performed immediately thereafter, as reported previously (13,14). In the present study, there were no cases of active bleeding detected by MDCT that could not be demonstrated by DSA.

Contrast extravasation is the classic angiographic finding of active bleeding. Extravasation shows the

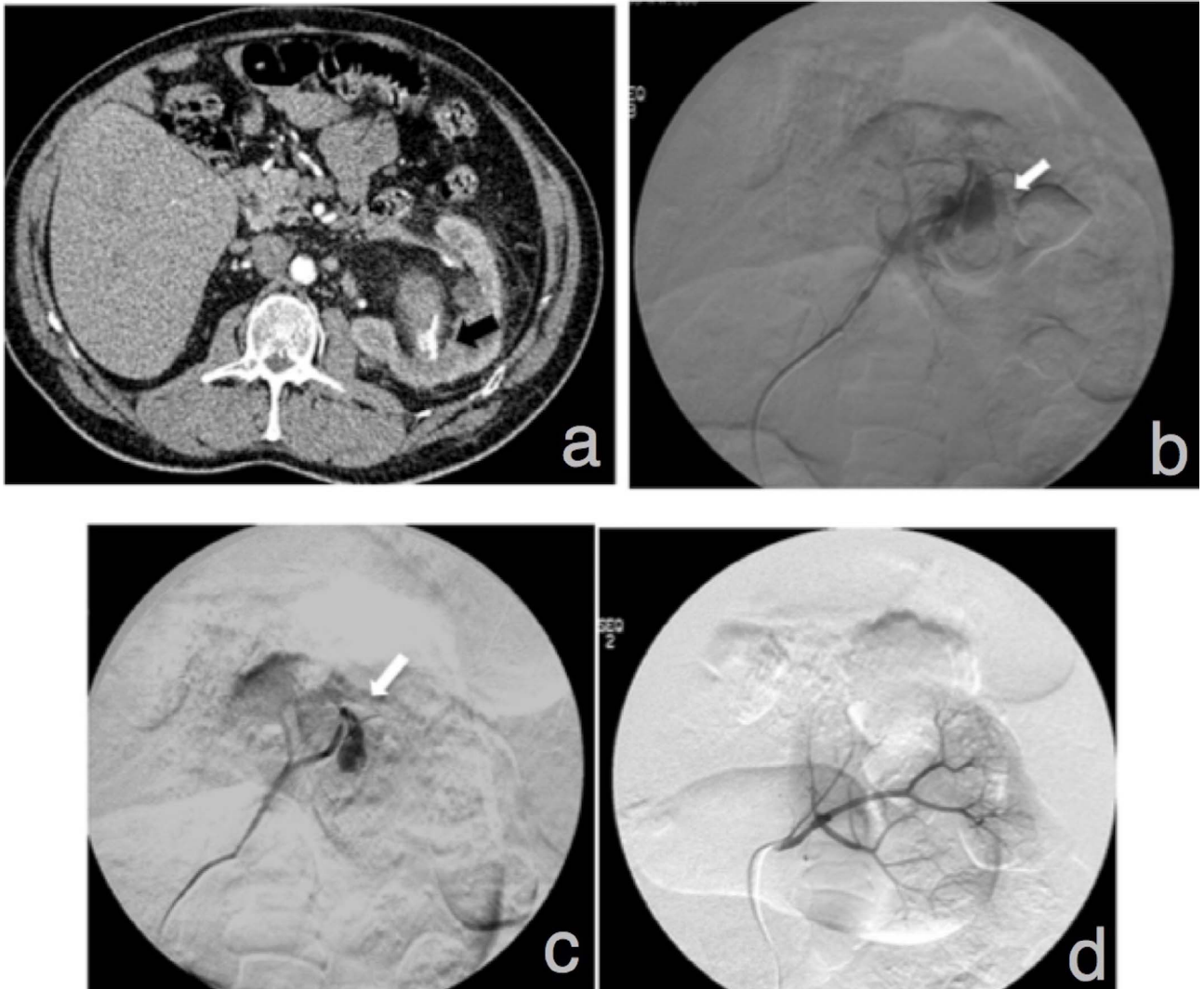


Figure 1. 61-year-old male patient with hematuria after percutaneous nephrolithotomy: a) CT showed hyperdense focus with active extravasation (black arrow) in left kidney; b, c) on DSA, active extravasation (white arrows) was detected; d) NBCA-Lipiodol was used to embolize the bleeding vessel. Postembolization angiograms showed no extravasation. The patient underwent surgery because of rebleeding 3 days after embolization.

rupture of a vessel so that it is shapeless, whereas the other finding of active bleeding, pseudoaneurysm, is a saccular protrusion isodense to the adjacent vessel (15).

In previous studies, the bleeding rate detectable by percutaneous visceral angiography was reported to be 0.5 mL/min in dogs (16). Nuclear medicine studies can detect rates of bleeding as low as 0.1 mL/min (17). The detectable bleeding rate by helical CT was reported as 0.35 mL/min in an *in vitro* study carried out by Roy-Choudhury et al. (18). More recently, with improvements in technology, MDCT is preferred over diagnostic DSA in the detection of abdominopelvic bleeding.

Arterial embolization is a more efficient and reliable method in intra- and retroperitoneal bleeding control,

especially in patients with high anesthetic and surgical risk. In addition, compared to surgical ligation, the catheter can be more distally located in endovascular embolization, which enables more selective embolization. Hemodynamically unstable trauma patients may also be candidates for endovascular embolization as a treatment modality (19).

Success rates of up to 100% for endovascular embolization in traumatic and postoperative bleeding from hepatic vasculature have been reported in previous studies. Monnin et al. (20) additionally reported successful endovascular embolization in hemodynamically unstable patients. In the present study, a patient with Grade 3 hepatic injury and active extravasation from the left

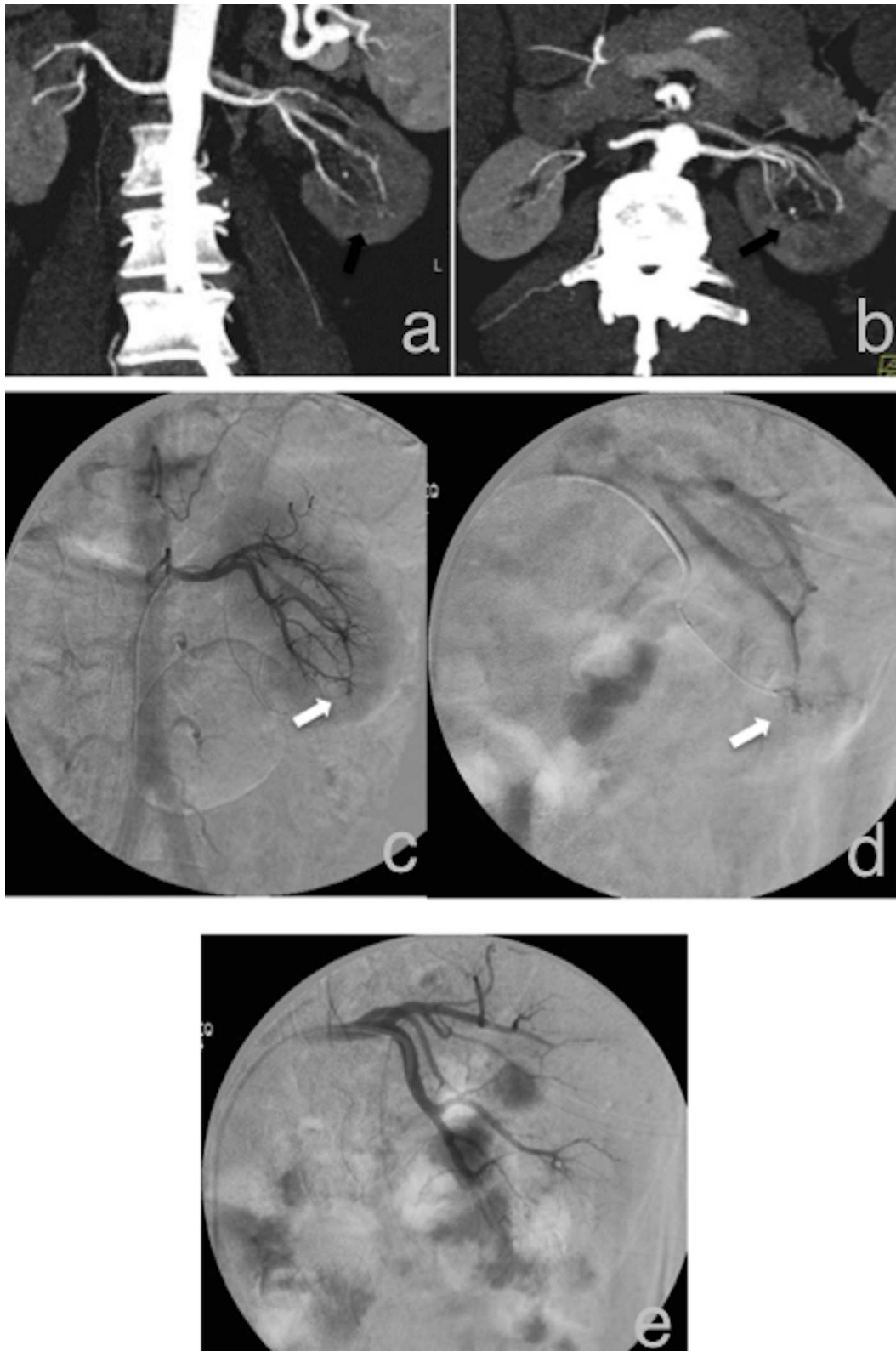


Figure 2. a, b) CT showed left renal arteriovenous fistula (black arrows) in a 43-year-old male after percutaneous nephrolithotomy; c, d) DSA showed AVF (white arrows), and AVF was closed with NBCA-Lipiodol mixture; e) angiograms showed no pathologic picture immediately after embolization.

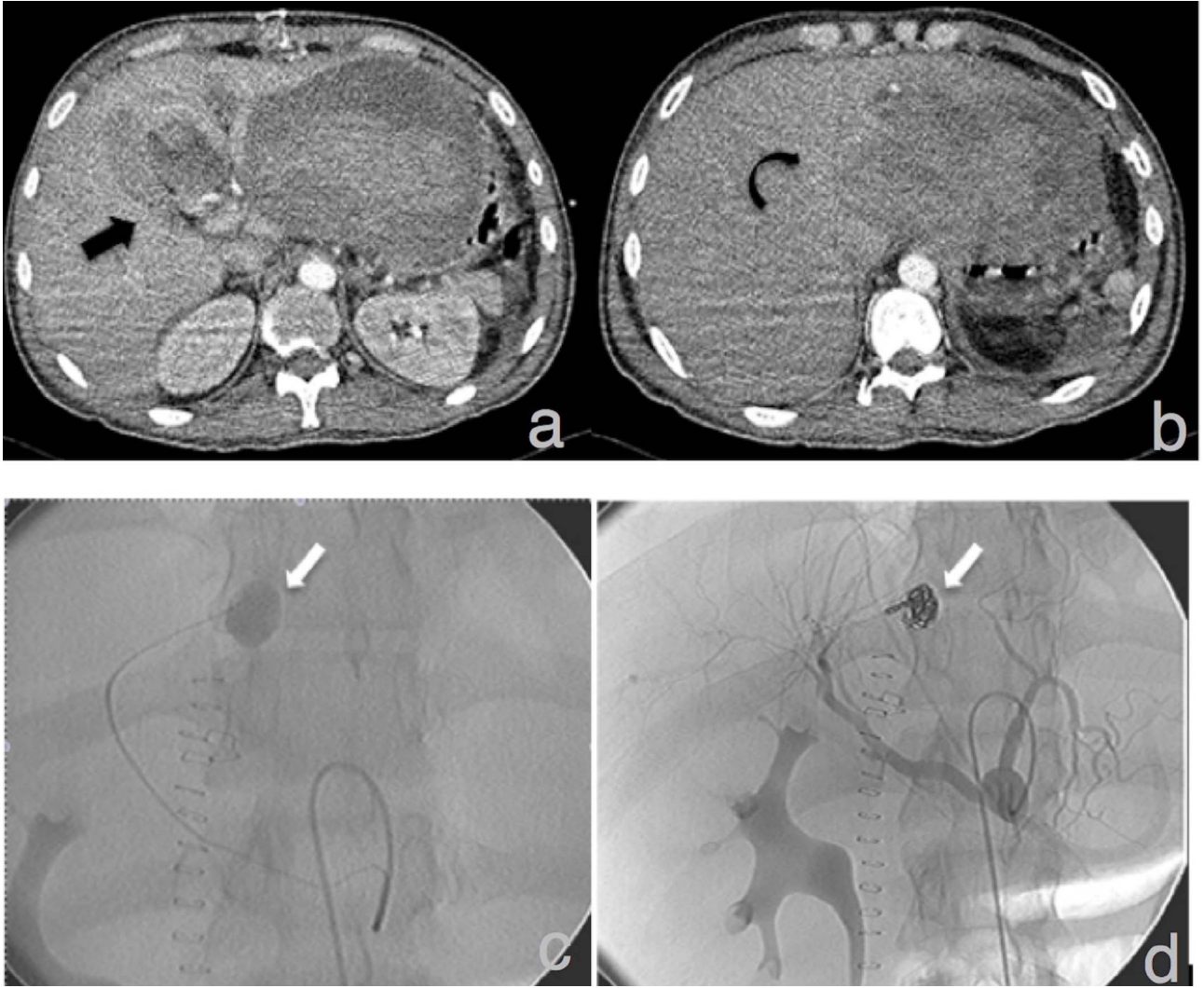


Figure 3. Abdominal CT showed a) hyperdense focus relevant to active extravasation (black arrow) and b) surrounding giant hematoma (curved arrow) due to a stabbing wound in a 33-year-old male; c) DSA showed left hepatic artery distal branch pseudoaneurysm (white arrow); d) coil embolization was performed to stop the hemorrhage.

Table 3. Embolizing agents used in embolization procedures.

Embolizing agent	Number of patients	%
NBCA-Lipiodol	18	58.06
Autologous blood clot	3	9.68
Coil	3	9.68
PVA particles	6	19.35
Coil and NBCA-Lipiodol	1	3.23

NBCA: N-Butyl cyanoacrylate, PVA: polyvinyl alcohol.

hepatic artery, caused by stabbing, was successfully treated with endovascular embolization. Two other patients with postoperative bleeding, one from the right hepatic artery and the other from the gastroduodenal artery, were also treated with endovascular embolization in a single session.

Grade 1 and 2 splenic injuries are mostly managed by observation. Active contrast extravasation on CT, splenic vascular injury, and Grade 3 or 4 injury are indications for DSA and endovascular embolization. In their study, Haan et al. (21) reported 80% success of endovascular embolization for Grade 4 and 5 injuries in 132 patients with splenic injury. Grade of injury, hemodynamic stability of the patient, and amount of hemoperitoneum are several factors affecting the success of nonoperative management. In the present study, Grade 3 splenic injury was successfully treated with endovascular embolization.

Previous studies on the treatment of renal vascular injuries have reported success rates of endovascular embolization of 80%–95% (22). In our study, endovascular embolization was performed in 13 patients with active bleeding due to PNL. One patient had recurrent bleeding that required a second endovascular embolization session. Another patient with recurrent bleeding underwent operative surgery. Except for these two patients, a single session of endovascular embolization was the final treatment for all patients. The overall late technical success calculated was 84.6%. Selective endovascular embolization is an efficient technique for the treatment of renal vascular lesions caused by PNL.

In previous studies (23), endovascular embolization for pelvic arterial hemorrhage was reported to have a 76%–100% success rate, whereas mortality rates were 33%–55% (24). In the present study, a total of 10 patients with pelvic arterial hemorrhage, eight with hemorrhage from trauma, one from stabbing, and one from a gunshot injury were treated with endovascular embolization. Nine of the patients were hemodynamically stable. One (Case 4) was successfully treated despite hemodynamic instability. Bleeding was stopped in all patients. However, the patient exhibiting hemodynamic instability died 2 days after the procedure as a result of multiorgan injury.

Mesenteric hematoma is rare after a blunt injury. In the case of mesenteric artery pseudoaneurysm, the technique of embolization and embolizing agent used becomes important. The sandwich technique is used, which involves coiling or injecting a high concentration of embolizing agent proximal and distal to the rupture. In the present study, a patient with superior mesenteric artery pseudoaneurysm after surgery for multiorgan trauma was successfully treated with endovascular embolization, using an NBCA-Lipiodol mixture.

Hematoma at the puncture site, pseudoaneurysm, arteriovenous fistula, perforation, thrombosis, and unwanted embolization are the most common general

complications of endovascular embolization. Biloma, hepatic necrosis, and peripancreatic abscess are some complications in hepatic arterial embolization. In previous studies, complication rates were reported to be between 5% and 42% (25). Two patients had hepatic arterial embolization in the present study. No complications occurred during follow-up. Dissection of the renal artery, renovascular hypertension, pseudoaneurysm, and arteriovenous fistula are complications of renal arterial embolization. Further renal insufficiency may be a contraindication for contrast agent usage; therefore, surgery is a choice of treatment. Previous studies reported complication rates of renal artery embolization of up to 63.4% (26). Splenic abscess and splenic infarcts can occur in endovascular embolization of the splenic artery. Various studies have reported complication rates between 6% and 53% (27). Gluteal necrosis, groin hematoma, and urogenital dysfunction are complications related to pelvic embolization. In our study, complications related to endovascular embolization were not observed in any of the patients.

The present study has certain limitations. The patients were referred to the department of radiology by other departments; however, several patients who were potential candidates for endovascular embolization may have been directly referred to surgery. In addition, patients with high clinical suspicion of active bleeding underwent DSA directly; thus, we were not able to evaluate all patients with MDCT. Although patients were followed for a month, this period did not include a complete clinical follow-up.

In conclusion, MDCT is able to detect lower rates of active bleeding, taking the place of diagnostic DSA. Thus, DSA may only be used for therapeutic purposes. In the present study, active bleeding was shown by MDCT in all the patients evaluated. Endovascular embolization is an efficient and reliable method in cases of traumatic and postoperative bleeding. From a total of 31 patients, active bleeding was stopped in 29 patients via a single session of endovascular embolization; only two patients needed retreatment. No complications were seen in our study during or after the embolization procedures, supporting the low morbidity rates of endovascular embolization reported in previous studies. Patient selection is an important issue in the treatment of active bleeding in postoperative and traumatic patients. In the past, it was only used in low-grade visceral organ injury; nowadays, patients with high-grade visceral organ injury may also be candidates for endovascular embolization in selected cases. We stopped bleeding in a patient with pelvic arterial injury despite hemodynamic instability. In terms of high-grade injury, three patients, one with Grade 3 hepatic injury, another with Grade 3 splenic injury, and another with Grade 3 renal injuries, were also successfully treated with endovascular embolization.

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