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Efficacy and safety of transarterial embolization in patients with intraabdominal hemorrhage: Experience from two centers

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Abstract

Aim: To evaluate the safety, efficacy, and clinical outcomes of transarterial embolization (TAE) in patients with intraabdominal hemorrhage.

Materials and Methods: Eighty-one patients who underwent intraabdominal TAE between January 1, 2020, and March 1, 2023 were evaluated retrospectively. Patients who underwent transarterial chemoembolization (n=15), mass embolization (n=12), and venous embolization (n=4) were excluded. Patient characteristics, hemorrhage etiology, embolized arteries, embolizing agents used, clinical and technical success, and rebleeding and in-hospital mortality rates were recorded.

Results: A total of 50 patients (37 males, 74%) were included in the study. The mean age of patients was 53.4±21.1 years. The most common pathology causing hemorrhage was upper gastrointestinal bleeding due to peptic ulcers (n=21, 42%), followed by tumors (n=8, 16%), iatrogenic causes (n=8, 16%), and trauma (n=6, 12%). The most commonly used embolizing agents were isolated coil (n=26, 52%) and a combination of coil and polyvinyl alcohol (n=12, 24%). The rate of technical success was 98% (n=49/50), and catheterization could not be performed in only one of the patients due to advanced vasospasm in the first procedure. After the first angiography, rebleeding occurred in 8% (n=4) cases, of which three were due to peptic ulcers and one was related to gastric cancer. One of these patients died in hospital, while the remaining three were discharged. The rate of in-hospital mortality was 16% (n=8) in all patients, and the clinical success rate was 84% (n=42).

Conclusion: TAE provides high rates of immediate and complete hemostasis with low complication rates. It is an effective method, especially for solid organ injuries and in the management of bleeding complications after surgery or intervention.

Introduction

Acute abdominal hemorrhage can be life-threatening, and therefore it should be promptly and effectively treated. Abdominal hemorrhage may have intraperitoneal or extraperitoneal (in the abdominal wall or retroperitoneum) localization and primary or secondary (post-traumatic) causes. The causes of intraperitoneal hemorrhage include trauma, spontaneous bleeding, complications of anticoagulant therapy, infection, malignancies, and surgical complications [1,2]. Most cases of intraperitoneal hemorrhage are associated with traumatic solid organ injuries. In the presence of blunt trauma, the most frequently affected organs are the spleen and liver [2]. Extraperitoneal hemorrhage may occur in the abdominal wall or in the retroperitoneum. Retro-peritoneal hemorrhage develops after trauma, ruptured abdominal aortic aneurysms, pancreatitis, malignancies, or as a complication of anticoagulant drugs or endovascular procedures (e.g., complications of femoral artery puncture). Abdominal wall and muscle hematomas can similarly be a complication of anticoagulants or trauma but may also occur after severe coughing [2]. Conservative medical methods, vasopressin infusion, endoscopic hemostasis, transcatheter embolization, and surgery can be used in the treatment of intraabdominal hemorrhage [3]. Endoscopic methods are the first choice for the diagnosis and treatment of gastrointestinal system (GIS) hemorrhage, with transarterial embolization (TAE) being an alternative treatment method in cases where endoscopy fails or cannot be performed [3, 4].

The use of TAE has become more widespread as a result of advances in catheter technology, the development of new agents for embolization, and the increase in the number of

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interventional radiologists (IRs) with appropriate skills [5]. Because of these, some authors suggest that endovascular therapy and radiological imaging are now preferred over open surgery for the treatment of abdominal hemorrhage due to their lower complication, morbidity, and mortality rates [6,7]. However, studies on the use of TAE in abdominal hemorrhage are limited and generally in the form of case reports [1,8,9]. The purpose of this study was to evaluate the efficacy, safety, and clinical outcomes of TAE performed in our clinic for the treatment of intraabdominal hemorrhage.

Materials and Methods

Patient population

Eighty-one patients who underwent intraabdominal TAE at the interventional radiology unit of Harran University Faculty of Medicine and Mehmet Akif Inan Training and Research Hospital between January 1, 2020, and March 1, 2023, were evaluated retrospectively. After excluding patients who underwent transarterial chemoembolization (n = 15), mass embolization (n = 12), and venous embolization (n = 4), 50 patients with acute intrabdominal hemorrhage who underwent TAE were included in the sample. Figure 1 shows the flow chart of the inclusion and exclusion criteria. Local ethics committee approval was obtained for the study (Harran University Clinical Research Ethics Committee, date: April 10, 2023, number: HRU/23.06.03).

Patient data and definitions

Patient characteristics, laboratory results, pathologies causing hemorrhage, rebleeding, clinical outcomes, technical/clinical success and mortality rates were obtained from the medical records of the patients. Technical success was defined as the disappearance of contrast agent extravasation immediately after embolization, cessation of flow to the vessel or branches feeding the bleeding focus, and loss of pseudoaneurysm filling causing bleeding according to angiographic findings. Spontaneous cessation of bleeding as a result of arterial spasm during catheter advancement or failure to selectively catheterize and embolize the bleeding vessel was defined as a technical failure. Clinical success was defined as the improvement of the signs and symptoms of bleeding, including hemoglobin and blood pressure levels, within a 30-day period following the TAE procedure. Clinical failure was defined as persistent or recurrent active bleeding that occurred within 30 days following the procedure, requiring surgical intervention and/or resulting in mortality [10-13]. All patients underwent computed tomography angiography (CTA) before angiography to determine the arterial anatomy and bleeding focus.

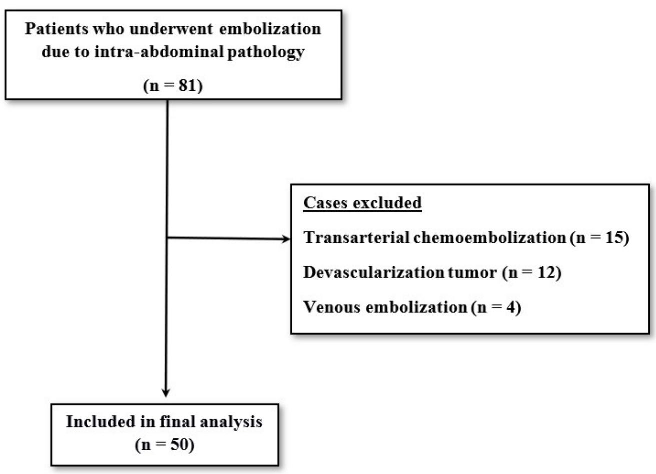

Figure 1. Flow chart diagram of the study design.

Interventional procedure

All angiographies were performed by two IRs with five and six years of experience in endovascular procedures in the interventional radiology unit. Before TAE, all patients signed an informed consent form that included the risks and possible complications of the procedure. The procedure was started by disinfecting the right femoral region and covering it with a surgical towel. Under local anesthesia, the femoral artery was accessed with an 18-gauge needle under ultrasound guidance. A 5-French (Fr) vascular sheath was placed over a 0.035-inch guidewire using the Seldinger technique. Depending on the bleeding site identified on the CTA images, the celiac trunk, superior mesenteric artery, inferior mesenteric artery, renal artery, iliac artery, and its branches were selectively catheterized using 5-Fr angiography catheters. Diagnostic angiography was performed to confirm bleeding, localize its source (active contrast extravasation, contrast blushing, or tumor bleeding), or detect a pseudoaneurysm. Then, the target artery was superselectively catheterized using a microcatheter (1.7–2.1 Fr Echelon, Medtronic, USA; 2-2.7 Fr Progreat®, Terumo, Tokyo, Japan). An appropriate embolic agent for the patient and administered through the microcatheter by GR. Agents used for embolization were polyvinyl alcohol (PVA) particles (ContourTM; Boston Scientific), platinum coils. The sizes of the PVA particles used were 355—500, 500—710, and 710—1000 microns. In addition, a mixture of lipiodol and glue was used as a liquid embolizing agent (N-butyl 2-cyanoacrylate (NBCA) glue [Glubran®, GEM, Viareggio, Italy]). Finally, post-embolization angiography was performed to confirm the technical success of the procedure and to re-evaluate the presence of other possible hemorrhages.

Statistical analysis

All analyses were performed with SPSS software v. 22.0 (IBM SPSS Statistics version 22.0. Armonk, NY: IBM Corp.). The data were divided into two groups as a continuous variable and categorical. Continuous variables were given as mean ± standard deviation and categorical variables as frequency and percentage.

Results

Fifty patients, 37 (74%) male and 13 (26%) female, were included in this study. The mean age of the patients was 53.4 ± 21.1 (min-max: 12-92) years. The most common pathology causing bleeding was upper GIS bleeding due to peptic ulcers (n = 21, 42%), followed by tumors (n = 8, 16%), iatrogenic causes (n = 8, 16%), and trauma (n=6,

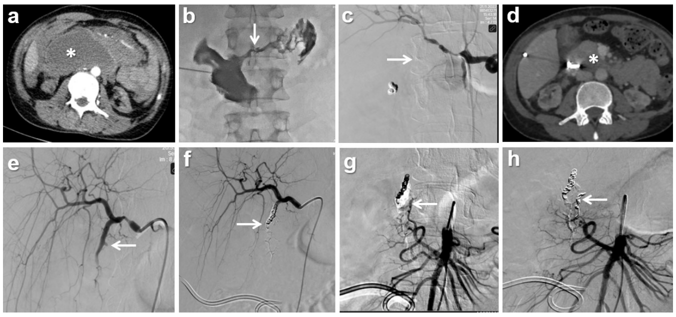

Figure 2. Digital subtraction angiography (DSA), fluoroscopy, and computed tomography (CT) images of a 25-year-old female patient with chronic renal failure and massive upper GIS bleeding. Axial CT image (a) shows a periduodenal hematoma (asterix), fluoroscopy image (b) shows a perforated peptic ulcer (arrow), DSA image (c) shows that the gastroduodenal artery (GDA) is not filled due to vasospasm (arrow), and CT image (d) shows that the hematoma healed after percutaneous drainage and embolization. The images of the second DSA procedure (e and f) demonstrate the pseudoaneurysm (arrow) originating from the GDA and embolization with coil + glue. Images (g) and (h) show the coil embolization of the inferior pancreaticoduodenal artery originating from the superior mesenteric artery.

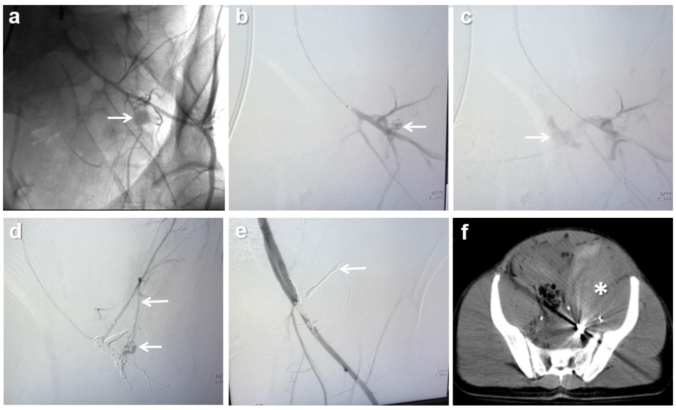

Figure 3. Digital subtraction angiography (DSA) and computed tomography (CT) images of a hemodynamically unstable 18-year-old male patient with a pelvic fracture and massive abdominal bleeding due to a fall from a height. Diagnostic DSA images (a, b, and c) show active extravasation (arrows) in arteries originating from the posterior sector of the left internal iliac artery. After coil transarterial embolization, DSA image (d) shows retrograde filling from a different artery (arrows) and superselective complete embolization (e). Pelvic CT image (f) shows a massive hematoma (asterisk).

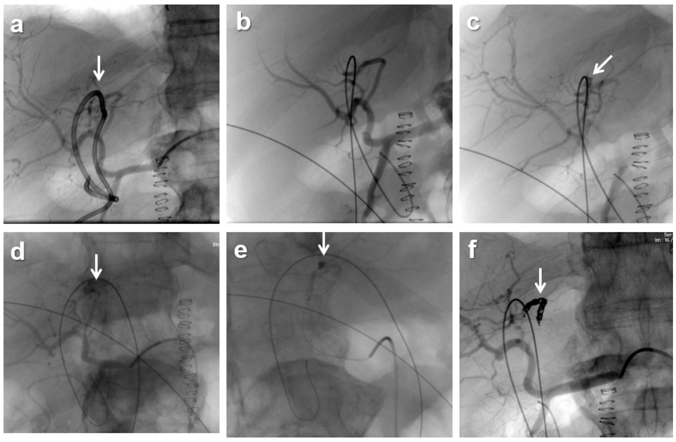

Figure 4. DSA images of a 71-year-old male patient with a hepatic artery pseudoaneurysm after percutaneous biliary drainage. No vascular pathology is observed in the DSA images taken before the catheter was removed. DSA images taken after catheter removal (b, c, d, and e) show pseudoaneurysmatic filling from the left hepatic artery (arrows). DSA image (f) shows a selective pseudoaneurysm and arterial embolization (arrow).

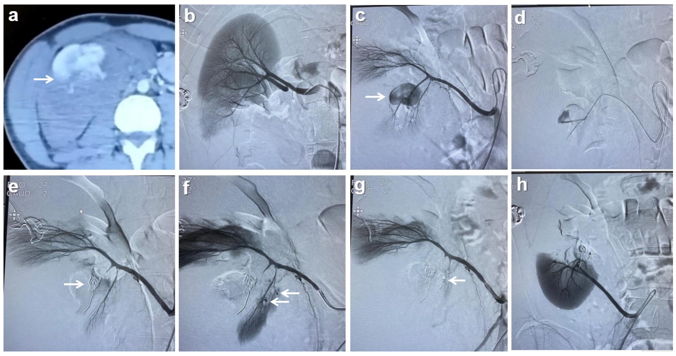

Figure 5. CT and DSA images of a 19-year-old male patient with a solitary kidney laceration due to horse kick injuries. Axial abdominal CT image (a) shows the laceration of the right kidney and a perirenal hematoma (arrow). DSA image (b) shows the renal artery feeding the upper and middle zones; (c) shows the pseudoaneurysm filling from the accessory renal artery feeding the middle zone (arrow); (d) shows selective catheterization; (e, f, and g) show coil embolization of pseudoaneurysms originating from the middle zone, and (h) shows the accessory renal artery originating from the right common iliac artery and feeding the lower pole.

12%). The mean hemoglobin value of the patients was 8.2 ± 3.3 (min-max: 3.4-15.8) g/dL. In 24 (48%) patients, erythrocyte transfusion was performed due to hypovolemic shock and hemodynamic instability (Table 1).

The most commonly used embolizing agent was a coil (n = 26, 52%), followed by a combination of a coil and PVA (n = 12, 24%). Table 2 shows the embolized arteries according

Table 1. Characteristics and bleeding etiologies of patients with abdominal hemorrhage

Patient characteristics	n (%)
Gender (male), n (%)	37 (74%)
Age, years (mean ± SD)	53.1 ± 22.1
Serum Hb level on the day of bleeding (g/dL)	8.2 ± 3.3 (range: 3.4-12.8)
Blood transfusion 24 hours before angiography, n (%)	24 (48%)
Units of blood transfusion 24 hours before angiography, n (%)	
<4 units	10 (20%)
≥ 4 units	14 (28%)
Comorbidity	
Cardiovascular disease (IHD, HT)	27 (54%)
Malignity	10 (20%)
Metabolic disease (DM and DLP)	28 (56%)
Inflammatory bowel disease	1 (2%)
Chronic liver disease	1 (2%)
Cause of bleeding or accompanying condition	
Peptic ulcer	21 (42%)
Tumor	8 (16%)
Trauma	6 (12%)
Iatrogenic	
Nephrostomy	3 (6%)
Percutaneous biliary drainage	2 (4%)
Surgery	3 (6%)
Splenic artery aneurysm rupture	3 (6%)
Pseudoaneurysm after partial nephrectomy	1 (2%)
Inflammatory colitis	1 (2%)
Renal mass	1 (2%)
Hepatocellular carcinoma rupture	1 (2%)

SD: standard deviation, IHD: ischemic heart disease, HT: hypertension, DM: diabetes mellitus, DLP: dyslipidemia.

Table 2. Bleeding origin and embolizing agents used.

Embolizing agent	n (%)
Coil	26 (52%)
PVA	2 (4%)
Coil + PVA	12 (24%)
Liquid embolizing agent (glue-lipiodol mixture)	4 (8%)
Coil and glue combination	6 (12%)
Embolized artery	
Celiac artery origin	
Isolated GDA	22 (44%)
GDA + pancreaticoduodenal artery	1 (2%)
GDA + left gastric	1 (2%)
GDA + gastroepiploic	1 (2%)
Left gastric	2 (4%)
Left and right gastric arteries	3 (6%)
Splenic artery branches	3 (6%)
Hepatic artery branches	4 (8%)
Renal artery branches	6 (12%)
Iliac artery origin	
Posterior sector branch of internal iliac artery	1 (2%)
Superior and inferior vesical arteries	1 (2%)
Bilateral uterine artery	1 (2%)
Ileocolic artery	2 (4%)
Superior rectal artery	2 (4%)

PVA: polyvinyl alcohol, GDA: gastroduodenal artery.

to the bleeding localization.

The rate of technical success was 98% (n = 49/50) in all patients, and catheterization could not be performed in only one of the patients due to the advanced vasospasm in the first procedure. In this case, the target artery was accessed during the second session, and the procedure was successfully performed. This was a chronic hemodialysis patient who had an ulcer-related perforation in the second part of the duodenum and a retroperitoneal abscess. Due to the high surgical morbidity in this patient, a percutaneous drainage catheter was placed in the periduodenal area. During the second procedure, embolization with a coil and glue was performed on the gastroduodenal artery (GDA) and the inferior pancreatico-duodenal artery originating from the superior mesenteric artery (SMA). No rebleeding occurred in the follow-up of the patient. Abscess and perforation were treated with the conservative method and percutaneous drainage (Figure 2).

Table 3 presents the clinical course of the patients who developed rebleeding. After the first angiography, rebleeding occurred in 8% (n = 4) of the cases, of which three were due to peptic ulcers and one was related to gastric cancer. One of these patients died in the hospital, while the remaining three were discharged. In-hospital mortality occurred in 16% (n = 8) of all patients, and the remaining 84% (n = 42) were discharged.

Table 4 shows the complications that occurred during (n = 5, 10%) and after (n = 4, 8%) the TAE procedure. Glue and PVA were applied to the superior rectal artery of the patient with rectal cancer, and eventually necrosis and ischemic infarction occurred. Another patient developed a splenic artery aneurysm and a focal splenic infarct (15-20% of the total volume) after coil embolization.

Figures 3, 4, and 5 show post-traumatic massive abdominal hemorrhage, hemorrhage due to percutaneous biliary intervention, and hemorrhage and embolization processes due to traumatic renal injury, respectively.

Discussion

Patients presenting with intraabdominal hemorrhage and associated hypovolemic shock still constitute the majority of emergencies. These cases range from GIS bleeding to hemorrhage related to iatrogenic injuries of major intraabdominal organs due to traumatic or interventional procedure/surgery. In recent years, these patients have been treated with endovascular methods that are minimally invasive, life-saving, cost-effective, and eliminate the need for major surgery in most cases [14]. These high success rates are attributed to the increased development of endovascular materials with advancing technology, the growing experience of IRs, and the combined use of embolic agents [15]. The current study demonstrated that intraabdominal hemorrhage due to various causes could be effectively

Table 3. Clinical course of four patients with rebleeding.

Patient number	Age (years) /gender	Etiology	First procedure	Second procedure	Clinical outcome
1	70/M	PUD	Coil embolization of GDA	Glue and coil embolization of inferior pancreaticoduodenal artery	Bleeding stopped and did not recur
2	69/F	PUD	Coil embolization of GDA pseudoaneurysm	Blushing-glue embolization	The patient died three days after the procedure due to sepsis and multiorgan failure
3	60/M	PUD	Administration of PVA into GDA	Coil embolization of GDA	Bleeding stopped and did not recur
4	58/M	Gastric cancer	Left and right gastric PVA embolization	Administration of PVA into GDA and left gastroepiploic artery	Bleeding stopped and did not recur

M: male, F: female, PUD: peptic ulcer disease, PVA: polyvinyl alcohol, GDA: gastroduodenal artery.

Table 4. Events and complications that occurred during and after the procedure.

		Complication management
During procedure (n = 5)		
Vasospasm	1	Medical treatment and balloon angioplasty
Allergic reactions	2	Medical treatment
Non-target embolization	1	Removing the coil used for embolization with snare
Cardiac arrest	1	Cardiopulmonary resuscitation
After procedure (n = 4)		
GIS ischemia/necrosis	1	Surgical excision
Focal splenic infarct	1	Medical and symptomatic treatment
Hematoma at the catheter insertion site	2	Hematoma drainage and analgesic therapy
Infection at the catheter insertion site	0	-

GIS: gastrointestinal system.

treated with TAE. Using TAE, we achieved technical success in all but one patient (n = 49/50, 98%) and observed only a few complications that were considered minor according to the Society of Interventional Radiology classification [16]. In our study, mortality occurred in 16% of the patients, and a high clinical success rate of 84% was obtained. Most of our cases consisted of upper GIS bleeding secondary to peptic ulcers and malignancies. TAE is the first-choice method in GIS bleeding that cannot be controlled by endoscopic treatment or is not suitable for this treatment, and it is increasingly used [17]. All advances in medical and endoscopic therapy are not sufficiently effective in treating the aging population with comorbid conditions, who are often co-treated with nonsteroidal anti-inflammatory or anticoagulant drugs. The risk of rebleeding increases when peptic ulcers diagnosed during endoscopic hemostasis are associated with different comorbid conditions and medications that interfere with the coagulation system When rebleeding occurs, several options are recommended, including emergency re-endoscopy, emergency TAE or surgical intervention. Preventive TAE is an additional option to reduce the rate of rebleeding after endoscopic hemostasis intervention [18]. In GIS bleeding, initial bleeding can be controlled in 89-98% of cases with TAE. The clinical success rate of TAE has been reported to vary between studies (52-98%), with most reports showing high success rates reaching 70-80% [19–21]. Many reliable studies support the idea that peptic ulcer disease (PUD) is the most common cause of upper GIS bleeding. Approximately 50% of all acute upper GIS cases are due to PUD [21]. In our study, consistent with the literature, TAE was most commonly applied to upper GIS bleeding secondary to PUD. However, iatrogenic and traumatic causes also constituted an important portion of acute intraabdominal hemorrhages.

Abdominal surgery, biliary and urinary interventions, and trauma occupy an important place in the etiology of abdominal bleeding and can be fatal unless urgent treatment is applied in the clinical setting. Therapeutic strategies for the treatment of postoperative bleeding after abdominal surgery have long been controversial, but given the significant advances in endovascular procedures, many authors have revealed the superior efficacy and safety of TAE compared to reoperation [22]. Our results similarly demonstrated that TAE was an effective and appropriate therapeutic option for managing postoperative bleeding due to surgery and intervention. TAE is effectively used in the treatment of bleeding resulting from liver, spleen, kidney, and pelvic trauma [16,23,24]. Despite recent advances in trauma surgery, pelvic angiography and subsequent embolization are effective, rapid, and safe techniques for patients with arterial bleeding associated with pelvic fractures in both hemodynamically stable and unstable cases. Bleeding is the leading cause of mortality after a severe pelvic fracture, and arterial bleeding causes the most severe bleeding, often resulting in hypotension. Rapid control of bleeding is associated with improved survival [24]. In the presence of penetrating and blunt renal injuries, pseudoaneurysms and arteriovenous fistulas occur in the distal branches of the renal artery, and superselective embolization with microcoils, surgical repair, or stent-grafts are recommended in proximal renal artery injuries [23]. In the current study, TAE was successfully applied to pseudoaneurysms caused by penetrating and blunt trauma, post-surgical/interventional pseudoaneurysms, and post-traumatic extravasations, which eliminated the need for major surgery and produced excellent clinical outcomes.

Various embolic agents, such as gelatin sponges, metallic coils, PVA, glue-lipiodol mixtures, vascular plugs, and autologous blood clots, can be used in the TAE procedure, depending on the operator's experience [11,15,21]. In the current study, the most frequently used embolizing agent was a coil, followed by a combination of a coil and PVA. During the procedure, care was taken to place the coil as close to the bleeding artery as possible, and PVA was utilized to embolize collaterals with potential for rebleeding. Although there are a few researchers who have applied coil therapy alone in the embolization of the GDA and pancreaticoduodenal arteries, it is generally recommended to use gelatin sponge or PVA together to successfully achieve hemostasis at the distal levels. Although the gelatin sponge used for this purpose is inexpensive and easily accessible, the rate of rebleeding is higher than observed in the use of non-resorbable PVA due to its resorbable feature. Studies have shown that due to their low success rates (62%), the use of gelatin sponges alone should be avoided considering long-term hemostasis [21]. Investigating upper GIS bleeding, Aina et al. [25] and Loffroy et al. [26] reported a relationship between the use of a coil alone and the incidence of rebleeding, especially in patients with coagulopathies, and emphasized the undeniable advantages of using a combination of PVA and gelatin sponge. In our study, an isolated coil or glue-lipiodol mixture was applied to pseudoaneurysms and extravasation secondary to trauma or iatrogenic causes other than GIS bleeding, and none of these patients developed rebleeding.

Inguinal hematomas (3 to 17%) and contrast-related nephropathy and allergic reactions (0.04% to 12.7%) may occur with the same frequency as with other endovascular procedures. Arterial embolization in the upper gastrointestinal tract above the ligament of Treitz is generally considered very safe due to the rich collateral supply to the stomach and duodenum. However, the risk of significant ischemia after embolization has been shown to be increased in patients who have had previous surgery in the same area or in those using liquid agents (e.g.N-butyl 2-cyanoacrylate (NBCA) glue) [27]. Post-embolization ischemia usually presents as duodenal stenosis in the chronic phase, although cases have been reported in the acute phase. Lang [28] reported duodenal stenosis in seven of 28 patients 8 months to 7 years after embolization of terminal vessels, mostly when tissue adhesive was used. Accidental embolization of the common hepatic artery can cause a wide range of symptoms, from transient increases in liver enzymes to life-threatening liver failure (the latter being more common). The cause of liver failure is related to the formation of cirrhosis and the resulting deterioration of portal vein circulation. Accidental coil insertion into the main branches of the celiac trunk has been reported (up to 3.3%), often due to technical difficulty or coil migration [19]. However, given the rich collateral circulation, coils in the left gastric or splenic artery rarely cause organ-threatening ischemia [19]. In our current study, focal spleen ischemia, which resolved with medical treatment after splenic artery aneurysm coil embolization, was not life-threatening in the patient. In addition, in the patient with non-target embolization, the migrating coils were removed with snare and the complication was managed. In addition, ischemia and necrosis developed in a patient with lower GI bleeding who underwent embolization with a liquid embolizing agent. Therefore, surgical resection was performed.

This study had certain limitations. First, the nature of the study was retrospective, and the sample size was relatively small. The retrospective design limited the data to those recorded in the patients' medical records. Therefore, it is possible that some minor complications were not evaluated and/or recorded. Second, the sample was heterogeneous, with the patients having different etiologies for bleeding. However, this study is valuable in terms of showing that the use of TAE was effective in the treatment of abdominal hemorrhage.

Conclusion

TAE can be used as a fast, safe, and effective method in the management of patients with intraabdominal hemorrhage. It is an effective method, especially for solid organ injuries and the management of bleeding complications after surgery or intervention. TAE helps avoid major surgery and organ loss (such as nephrectomy) in trauma cases and provides sufficient time for patients with unstable hemodynamics who will require surgery.

Ethical approval

Ethical approval was obtained from Harran University Clinical Research Ethics Committee (date: April 10, 2023, number: HRU/23.06.03).

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