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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Efficacy and safety of transcatheter arterial embolization for active arterial esophageal bleeding: a single-center experience

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PURPOSE
The study aimed to evaluate the safety and clinical efficacy of transcatheter arterial embolization (TAE) for the treatment of arterial esophageal bleeding.

METHODS
Nine patients (8 male, 1 female; mean age, 62.3±7.5 years) who underwent TAE for arterial esophageal bleeding between January 2004 and January 2020 were included. Preceding endoscopic treatment was unsuccessful in five patients and was not attempted in four patients due to the non-cooperation of the patients in endoscopic treatment. The etiologies of bleeding were esophageal cancer (n=4), Mallory-Weiss syndrome (n=3), erosive esophagitis (n=1), and esophageal ulcer (n=1). Technical and clinical success, recurrent bleeding, procedure-related complications, and clinical outcomes were retrospectively reviewed.

RESULTS
The angiographic findings for bleeding were contrast media extravasation (n=8) or tumor staining without a definite bleeding focus (n=1). The bleeding focus at the distal esophagus (n=8) was the left gastric artery, whereas that at the middle esophagus (n=1) was the right bronchial artery. Technical success was achieved in all patients. The embolic agents were n-butyl cyanoacrylate (NBCA, n=5), gelatin sponge particles (n=2), microcoils (n=1), and NBCA with gelatin sponge particles (n=1). Clinical success was achieved in 77.8% of cases (7/9); two patients with recurrent bleeding one day after the first TAE showed culprit arteries different from the bleeding foci at the first TAE. One patient who underwent embolization of both the left and short gastric arteries died of gastric infract/perforation one month after TAE.

CONCLUSION
TAE can be an alternative to the treatment of arterial esophageal bleeding. TAE can be attempted in the treatment of recurrent bleeding, but there is a risk of ischemia/infarct in the gastrointestinal tract involved.

Acute arterial esophageal bleeding is a major cause of morbidity and mortality (1, 2). Peptic ulcer disease, Mallory-Weiss syndrome, esophagitis, and malignancy are the most common etiologies.

Upper gastrointestinal (GI) endoscopy is the gold standard for the diagnosis and treatment of upper GI bleeding (1, 3). However, as technology advances, transcatheter arterial embolization (TAE) with gelatin sponge particles, coils, and liquid embolic materials is increasingly used as an alternative to surgery to treat GI bleeding which is refractory to endoscopic management (4–7).

TAE was first reported in 1972 as an alternative to the surgical management of GI bleeding in case of endoscopic treatment failure (8). Since then, there have been constant innovations in the embolic agents used in endovascular therapy for GI bleeding. The purpose of this study was to evaluate the safety and clinical efficacy of TAE for the treatment of arterial esophageal bleeding.

Methods

Study design and patient population

This retrospective study was approved by the hospital institutional review board (No. S2020-1045-0001), and written informed consent was waived due to its retrospective nature. Nine

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consecutive patients (8 males, 1 female; mean age, 62.3±7.5 years) who underwent TAE for the treatment of arterial esophageal bleeding between January 2004 and January 2020 were included in this study. All patients presented with massive bleeding and required blood transfusion of at least 4 units of packed red blood cells every 24 h due to hemodynamic instability (hypotension with systolic pressure less than 90 mm Hg despite the use of vasopressor).

CT scans were performed for bleeding focus localization in patients whose vital sign was stable but endoscopy was not possible or bleeding persisted after endoscopy.

Preceding endoscopic treatment was unsuccessful in five patients, and no attempt was made in four patients because they were unable to cooperate in endoscopic treatment. None of the patients responded to conservative medical therapy. The etiologies of bleeding were esophageal cancer (n=4), Mallory-Weiss syndrome (n=3), erosive esophagitis (n=1), and esophageal ulcer (n=1). The site of bleeding was identified by endoscopic examination in five patients and pre-embolization arteriography in all patients. Technical and clinical success, recurrent bleeding, procedure-related complications, and clinical outcomes were retrospectively reviewed.

Angiography and TAE technique

A 5 F introducer sheath (Terumo Interventional Systems) was inserted through the common femoral artery under local anesthesia. For distal esophageal bleeding, arteriography of the left gastric artery, splenic artery, short gastric artery, left hepatic artery, and inferior phrenic artery was performed. For middle esophageal bleeding, arteriography of the bronchial artery and intercostal artery was performed. Aortography was performed when the arteriograms did not show any bleeding focus. The bleeding focus was then selected using a 1.7–2.0 F microcatheter (Progreat; Terumo Interventional Systems) and 0.016-inch microwire (Asahi Meister; Asahi Intecc). The signs of active bleeding on angiography included contrast media extravasation, pseudoaneurysms, and abrupt arterial cutoff.

Different embolic agents were used, and their selection was based on the preference of the operator. N-butyl cyanoacrylate (NBCA) (Histoacryl; B. Braun), vascular microcoils (Cock Medical), and small gelatin sponge particles (Gelfoam; Pharmacia & Upjohn) cut with scissors were used. NBCA was mixed with ethiodized oil (Lipiodol; Andre Guerbet) at a ratio of 1:3. The microcatheter was flushed with 5% dextrose solution to prevent the premature polymerization of the mixture within the microcatheter prior to embolization.

Statistical analysis

Technical success was defined as successful embolization with the superselection of the bleeding vessel without evidence of active bleeding on angiography after embolization. Clinical success was defined as cessation of signs or symptoms of esophageal bleeding, and no requirement for additional procedures (e.g., surgery, endoscopy, or TAE) within two weeks after the TAE procedure. Patients were identified as having coagulopathy if they met one of the following criteria: Prothrombin time-international normalized ratio (PT-INR) of >1.5 or thrombocytopenia with a platelet count of <50 000/μL (9).

Procedure-related complications were defined according to the clinical practice guidelines of the Society of Interventional Radiology. Major complications were defined as those necessitating further treatment or prolonged hospitalization, and minor complications were defined as those that resolved spontaneously (10).

Wilcoxon signed test was used to compare hemoglobin levels before and after TAE. The statistical analysis was performed with SPSS Statistics Version 23 (IBM Corp.). A p value < 0.05 was considered statistically significant.

Main points

- Interventional radiologists should be familiar with arterial anatomy of the esophagus for a complete investigation of a bleeding focus, enabling high technical and clinical success.
- The clinical success rate of embolization for arterial esophageal bleeding was 77.8%, so the embolization can be an alternative in the treatment of arterial esophageal bleeding.
- Embolization can be attempted in the treatment of recurrent bleeding, but there is a risk of ischemia/infarct in the gastrointestinal tract involved.

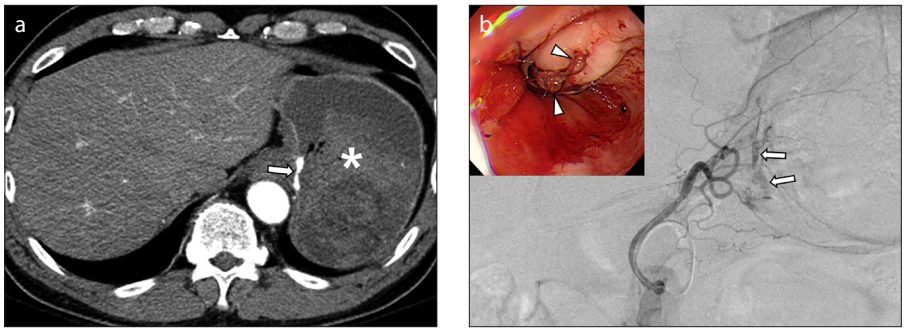

Figure 1. a, b. A 59-year-old male (No. 9) diagnosed with Mallory-Weiss syndrome presented with hematemesis. Enhanced axial CT scan **(a)** shows active bleeding *(arrow)* at the distal esophagus with a large amount of hematoma *(asterisk)* in the stomach. Left gastric arteriogram **(b)** shows active contrast extravasation *(arrows)*. Embolization with n-butyl cyanoacrylate (NBCA) was performed (not shown). A linear array of mucosal breaks with superficial clots *(arrowheads)* at the distal esophagus were noted on the endoscopic image 8 h after embolization (inset).

Results

Patient demographics, clinical characteristics, and angiographic data are summarized in the Table. Treatment was determined for all patients through multidisciplinary approach, involving gastroenterologists, surgeons, emergency physicians, and interventional radiologists. The bleeding focus was at the distal esophagus in eight patients and middle esophagus in one patient (Patient No. 2). Coagulopathy with an INR of 1.55 was present in one patient (No. 3) at the time of embolization. Three patients underwent CT scan immediately before the TAE procedure; contrast media extravasation was observed in one patient (No. 9, Fig. 1a), while the remaining two patients (No. 6, 8) had negative findings for bleeding on CT scans.

The angiographic findings for bleeding were contrast media extravasation (n=8) or tumor staining without a definite bleeding focus (n=1). Bleeding foci were successfully excluded on completion angiography in all patients, and the technical success rate was 100%. The embolized arteries were the left gastric artery (n=8, Fig. 1b, Fig. 2b) and right bronchial artery (n=1, Fig. 3) at the initial embolization treatment. The embolic agents used were NBCA (n=5, Fig. 2c), gela-

Table. Patient characteristics and embolization details

No./ Sex/ Age (yrs)	Etiology of bleeding	Esophageal level	Angiographic findings	Bleeding artery	Embolization			Remark	Coagulation profile					
					Embolic agent	Technical success	Clinical success		INR Pre	INR Post	Plt Pre	Plt Post	Hb* Pre	Hb Post
1/F/52	Erosive esophagitis	Distal	Contrast extravasation	LGA	GSP	Yes	Yes		1.08	1.28	359	218	5.9	8.9
2/M/63	Esophageal cancer	Mid	Contrast extravasation	Right bronchial	Coils	Yes	Yes		1.46	1.30	148	102	7.8	10.5
3/M/65	Esophageal ulcer	Distal	Contrast extravasation	LGA	NBCA	Yes	No, 2nd TAE one day after		1.55	1.52	41	50	5.6	6.1
4/M/63	Esophageal cancer	Distal	Contrast extravasation	LGA	NBCA	Yes	Yes	Died of disease progression	1.29	1.24	305	104	6.0	13.4
5/M/56	Esophageal cancer	Distal	Contrast extravasation	LGA	NBCA	Yes	No, 2nd TAE one day after	Gastric infarct/ perforation → death	1.27	1.27	115	170	4.7	10.3
6/M/61	Esophageal cancer	Distal	Tumor staining	LGA	GSP	Yes	Yes	Died of disease progression	10.1	0.97	180	130	10.5	11.1
7M/79	Mallory-Weiss	Distal	Contrast extravasation	LGA	NBCA	Yes	Yes		0.97	0.94	280	195	7.3	12.0
8/M/63	Mallory-Weiss	Distal	Contrast extravasation	LGA	GSP + NBCA	Yes	Yes		1.08	1.13	380	281	6.5	12.3
9/M/59	Mallory-Weiss	Distal	Contrast extravasation	LGA	NBCA	Yes	Yes		0.97	0.97	180	105	13.1	10.6

No., number; INR, international normalized ratio; Plt, platelet count ($\times 10^3/\mu L$); Hb, hemoglobin count (g/dL); F, female; M, male; LGA, left gastric artery: GSP, gelatin sponge particles; NBCA, n-butyl cyanoacrylate; TAE, transcatheter arterial embolization.
* Hb Pre was measured immediately before embolization.

tin sponge particles (n=2), microcoils (n=1, Fig. 3b), and NBCA with gelatin sponge particles (n=1) at the initial embolization attempt.

Clinical success was achieved in seven patients (77.8%, 7/9). However, in two patients (No. 3, 5), there was recurrent bleeding one day after the initial TAE. In these two patients with recurrent bleeding, contrast extravasation or tumor staining was observed on angiography; culprit arteries were different from the bleeding foci at the first TAE. Contrast extravasation was from the left inferior phrenic artery (No. 3), which was embolized with NBCA and gelatin sponge particles; on the other hand, multifocal tumor staining was from the short gastric arteries (No. 5), which were embolized with coils and gelatin sponge particles (Fig. 2e). There was no further bleeding after the second TAE.

As a major complication, the aforementioned Patient No. 5 died due to gastric infarct/perforation one month after the second TAE of short gastric arteries (Fig. 2f). He had no relevant surgical history prior to embolization. There were no other major or minor complications.

There was a significant improvement in hemoglobin level after TAE, with an increase in median scores from 6.5 g/dL (range, 4.7–13.1 g/dL) to 10.6 g/dL (range, 8.9–13.4 g/dL) (p = 0.021, Wilcoxon signed rank test); the hemoglobin level was increased in eight patients after TAE, however, in one of them (No. 3), the hemoglobin level was 6.1 g/dL due to severe underlying advanced liver disease despite blood transfusion. In one patient (No. 9), the hemoglobin level decreased after TAE; we assumed that hemoglobin level remained stable during acute hemorrhage due to concomitant loss of red blood cells and plasma and became apparent when blood volume was restored. During the mean follow-up of 11.9±7.5 months, two patients (No. 4, 6) died of disease progression five days and one month after TAE, respectively.

Discussion

The clinical success rate of TAE in the early hemostasis of acute nonvariceal GI bleeding was 52%–90% (4, 11–13). The purpose of TAE is superselective embolization of bleeding arteries to block arterial blood flow while preserving proper collateral blood flow to minimize the risk of intestinal infarction (14). In this study, the clinical success rate of TAE for arterial esophageal bleeding was 77.8%, so TAE could be an alternative in the management of arterial esophageal bleeding.

The arteries that supply the esophagus depend on the esophageal level. Detailed knowledge in the arterial anatomy of the esophagus should be familiar to interventional radiologists for the full evaluation of a bleeding focus. Branches of the left gastric artery or left inferior phrenic artery supply the distal esophagus. In addition, branches from the celiac trunk, splenic artery, short gastric artery, or left hepatic artery can supply the distal esophagus. One or two esophageal arteries originating directly from the aorta and branches of the bronchial arteries supply the middle esophagus. Besides, branches of the right third or fourth intercostal arteries can supply the middle esophagus. Finally, the descending branches of the inferior thyroid artery supply the cervical esophagus. In addition, branches of the subclavian artery, branches of the common carotid artery, thyroid ima artery, or

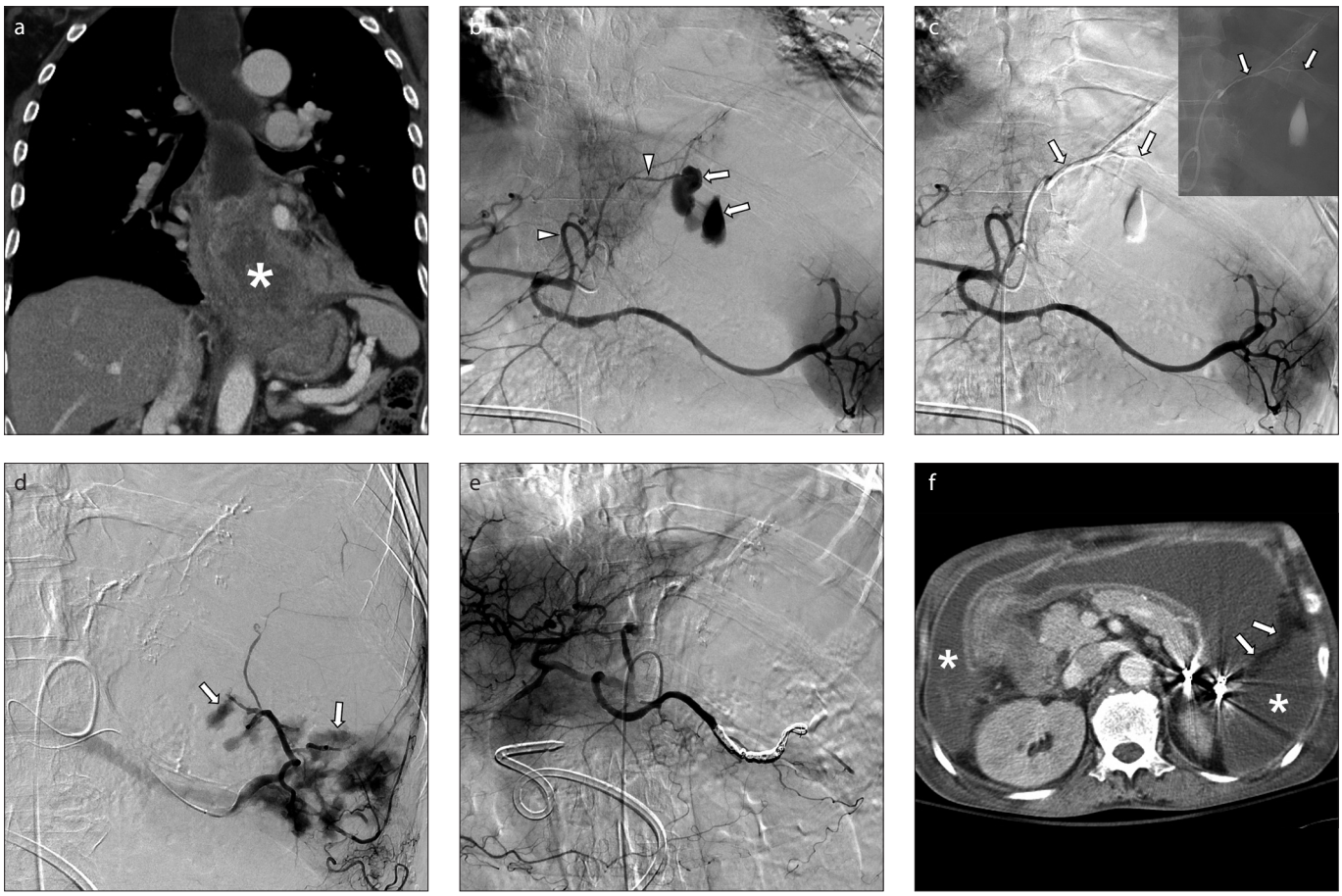

Figure 2. a–f. A 56-year-old male (No. 5) diagnosed with esophageal cancer presented with hematemesis. Coronal contrast-enhanced CT scan **(a)** obtained 13 days before shows a huge distal esophageal mass *(asterisk)* extending to the stomach. Left gastric arteriogram **(b)** shows active contrast extravasation *(arrows)* from the left gastric artery *(arrowheads)*. Left gastric arteriogram **(c)** after embolization with NBCA *(arrows)* shows the disappearance of the bleeding focus. The dense opacification of the bleeder with NBCA was noted (*arrows,* inset). Splenic arteriogram **(d)** one day later for recurrent bleeding shows multifocal tumor staining *(arrows)* from the short gastric arteries. Splenic arteriogram **(e)** after embolization using coils and gelatin sponge particles shows no remaining tumor staining. Follow-up CT scan **(f)** at one month shows gastric perforation *(arrows)* and fluid collection *(asterisks)* in the peritoneal cavity.

superior thyroid artery can also supply the cervical esophagus. (7, 15, 16). In this study, the esophageal pathologies like ulcer, gastroesophageal reflux or esophageal tear, was mostly identified in the distal esophagus, indicating that the left gastric artery was the most common embolized artery.

Therefore, a proper standardized angiography protocol for esophageal bleeding should be based on the anatomic understanding of the arterial supply to the esophagus to save time and reduce radiation as well as minimize recurrent bleeding that can be caused by potential collateral channels. Our angiography protocol according to the bleeding esophageal level (cervical, middle and distal esophageal bleeding) is described in the methods section. For cervical esophageal bleeding, subclavian and carotid arteriograms should also be evaluated (7, 16).

Because the esophageal arteries form a collateral capillary network before penetrating the esophageal muscle layer (17), they can result in bleeding from potential collateral channels. In one case report on the arterial embolization for esophageal bleeding with microcoils, two other esophageal branches proximal and distal to the embolized branch were catheterized (17). These potential collateral channels may cause recurrent bleeding as observed in the two patients in this study; thus, it is necessary to scrutinize potential bleeders to prevent this outcome.

The presence of coagulopathy is known to negatively affect the success rate of TAE in GI bleeding, increasing the odds of clinical failure, ranging from 2.9 to 19.46 (4, 5, 7, 13). Although one patient (No. 3) with coagulopathy in this study could not achieve clinical success despite embolization of the left gastric artery using NBCA at the initial TAE, it is difficult to assume that the cause of clinical failure is coagulopathy because recurrent bleeding was observed in another artery. According to previous studies, the use of NBCA for upper GI bleeding in coagulation patients was reported to be accompanied by high angiographic and clinical success rates (18, 19), as NBCA does not depend on the coagulation process for its effectiveness. In this study, various embolic agents were used depending on coagulopathic status and the location of the bleeding artery, and there was no large difference in effectiveness.

CT scans may be useful for detecting bleeding arteries. Although CT scans were performed in only three patients (33.3%) just prior to TAE, and only one of them had bleeding focus in this study, bleeding esophageal arteries were identified in 80% (4/5) of study patients in one report (20). If the patients are stable, contrast-enhanced CT will be useful in determining the presence of bleeding, and the anatomy and origin of the bleeding esophageal artery.

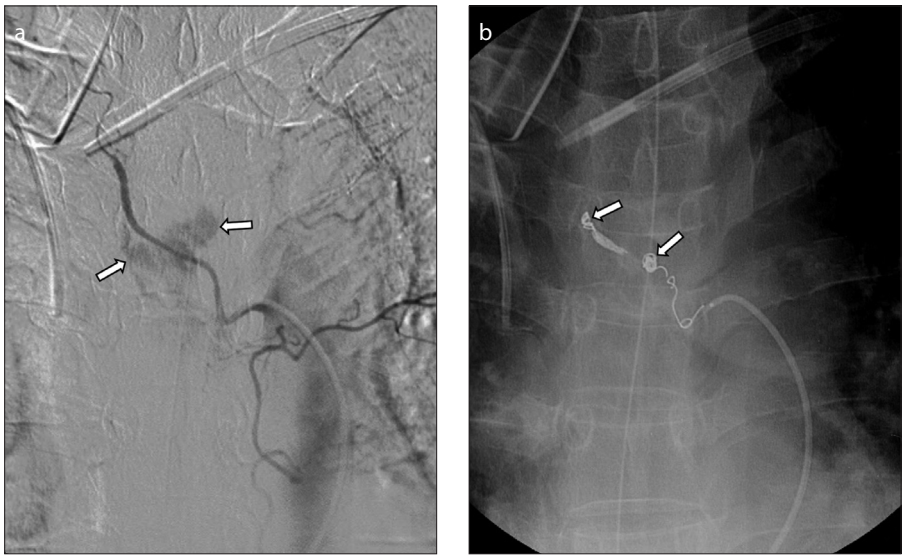

Figure 3. a, b. A 63-year-old male (No. 2) who underwent stent placement for esophageal cancer. Right bronchial arteriogram **(a)** shows active esophageal bleeding *(arrows)* from the right bronchial artery. Radiograph **(b)** shows the microcoils *(arrows)* used for the embolization of the right bronchial artery.

The stomach is supplied with a rich arterial system derived from the celiac trunk. In case of left gastric artery embolization or subtotal gastrectomy, the short gastric artery becomes an important source of perfusion in the stomach. Therefore, the short gastric artery embolization is at high risk for ischemia, as observed in one patient (No. 5), which was complicated by gastric infarct/perforation due to embolization of both the left and short gastric arteries. This risk is higher if the patient underwent prior gastric surgery. Necrosis of the remnant stomach was reported after the main splenic artery embolization in a patient who underwent subtotal gastrectomy (21, 22).

This study has some limitations. First, it was a retrospective study with a small sample size because arterial esophageal bleeding is rare. Second, the observation period after TAE was relatively short. Third, several kinds of embolic agents were used in this study and a comparative study between different embolic agents used in TAE could not be performed.

In conclusion, TAE can be an alternative to the treatment of arterial esophageal bleeding. TAE can be attempted in the treatment of recurrent bleeding, but there is a risk of ischemia/infarct in the GI tract involved.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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