

Covered stent placement in interventional radiology: a single-center experience

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Received: 21.05.2026

Accepted: 27.06.2026

Published: 29.06.2026

Cite this article: Durmaz H. Covered stent placement in interventional radiology: a single-center experience. *J Radiol Med.* 2026;3(2):42-46. doi:10.51271/JRM-0048

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ABSTRACT

Aims: This study aimed to retrospectively evaluate the technical and clinical outcomes of covered stent applications in interventional radiology practice.

Methods: Seventeen patients (10 male, 7 female; mean age: 54.1±16.9 years) who underwent covered stent placement for pseudoaneurysm (PA) and/or arteriovenous fistula (AVF) between January 2018 and December 2024 were retrospectively analyzed. Patients were categorized into two groups according to the underlying etiology: Group 1 (post-hepatopancreatobiliary [HPB] surgery, n=7) and group 2 (post-trauma and iatrogenic injury, n=10). Technical success, clinical success, complication rate, and 30-day mortality were assessed.

Results: Technical and clinical success rates were 100% in all patients. The mean procedural time was 36.6±11.1 minutes. One patient (5.9%) developed a major complication (sepsis). The 30-day mortality rate was 5.9% (1/17); this patient had undergone HPB surgery. A statistically significant difference was found between the groups regarding age (p=0.044), while hemoglobin levels did not differ significantly (p=0.968).

Conclusion: Covered stent placement is a safe and effective method with high technical and clinical success rates for the treatment of both visceral and peripheral PAs and AVFs. Interventional radiology may be considered a first-line treatment option in appropriately selected patients.

Keywords: Covered stent, pseudoaneurysm, arteriovenous fistula, interventional radiology, endovascular treatment

INTRODUCTION

Pseudoaneurysms (PAs) and arteriovenous fistulas (AVFs) are among the vascular complications frequently encountered in interventional radiology practice. These lesions may arise following surgical interventions, iatrogenic vascular injuries, and penetrating trauma. Minimally invasive endovascular treatment modalities are increasingly preferred in patients with high surgical mortality and morbidity risk.^{1,2}

PAs developing after hepatopancreatobiliary (HPB) surgery are well-known vascular complications, particularly associated with pancreaticoduodenectomy and distal pancreatectomy. The coexistence of pancreatic fistula, abscess, and recurrent hemorrhage complicates management in these cases.^{3,4} Peripheral PAs most commonly develop following cardiac and peripheral angiography procedures, hemodialysis catheter placement, or penetrating trauma.^{5,6}

Covered stents (stent grafts) are endovascular implants that exclude PA or AVF flow while preserving the parent vessel lumen. They are manufactured in two main types: balloon-expandable (BE) and self-expandable (SE), coated with polytetrafluoroethylene (PTFE) or Dacron over a nitinol or cobalt-chromium scaffold.^{7,8} Technical success rates of 80-100% have been reported for covered stent use in visceral artery PAs.^{9,10} High success and low complication rates have also been achieved in the treatment of peripheral arterial PAs and AVFs.^{11,12}

This study aimed to retrospectively evaluate patients who underwent covered stent placement for PA and AVF of various etiologies at our center. Primary endpoints were technical success, clinical success, and complication rates.



METHODS

Ethics

This study was conducted with the approval of the Clinical Researches Ethics Committee of the Dışkapı Yıldırım Beyazıt Training and Research Hospital, University of Health Sciences (Date: 29.04.2019, Decision No: 62/27). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Patient Selection

This study was conducted as a single-center, retrospective cohort study. A total of 17 consecutive adult patients who underwent coated stent implantation for PA and/or AVF between January 2018 and December 2024 were included in the study. Informed consent was obtained from all patients.

Imaging and Procedural Protocol

All patients were evaluated with computed tomography angiography (CTA) prior to the procedure. PA dimensions, parent artery origin, presence of fistulous tract, and additional complications (abscess, pancreatic fistula) were recorded. Procedures were performed under digital subtraction angiography (DSA) guidance. Appropriately sized covered stents (stent diameter 1-2 mm larger than the parent artery) were selected based on the location and diameter of the parent artery. BE covered stents were preferred for visceral arteries (hepatic artery, superior mesenteric artery) requiring high radial force, while SE covered stents were used in peripheral and tortuous vessels requiring flexibility. BE covered stents used in visceral artery cases included the iCover (iVascular, Barcelona, Spain) device. SE covered stents used in peripheral cases included the Viabahn (W.L. Gore & Associates, Flagstaff, AZ, USA) device. All patients received intraoperative systemic heparinization (70 IU/kg). Post-procedurally, dual antiplatelet therapy (aspirin 100 mg/day+clopidogrel 75 mg/day) was prescribed for a minimum of one month, followed by aspirin monotherapy indefinitely, per institutional protocol.

Definitions of Technical and Clinical Success

Technical success was defined as complete exclusion of the PA/AVF with preservation of main vessel flow on completion angiography. Clinical success was defined as cessation of active hemorrhage confirmed on completion angiography, hemodynamic stabilization within 24 hours post-procedure, absence of reintervention or surgical rescue during the index hospitalization, and no recurrent bleeding episode during the available follow-up period. Major complication was classified as any event requiring sepsis management, organ failure support, or additional surgical/endovascular reintervention.

Statistical Analysis

The data were performed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean±standard deviation (SD), and categorical variables as counts and percentages. Independent samples t-test was used to compare continuous variables between two groups. A p-value <0.05 was considered statistically significant.

RESULTS

Patient Characteristics

Seventeen patients were included: 10 male (58.8%) and 7 female (41.2%), with a mean age of 54.1±16.9 years (range: 27-82 years). Patients were categorized into two groups according to the underlying etiology: Group 1 consisted of 7 PA/AVF cases following HPB surgery (subtotal gastrectomy n=1, HPB surgery n=6). Group 2 comprised 10 cases following trauma (stab wound, gunshot injury) or iatrogenic intervention (angiography puncture, dialysis catheter placement).

The mean pre-procedure hemoglobin level was 8.14±1.45 g/dl (range: 5.3-11.2 g/dl); all patients were anemic. The mean time from symptom onset to procedure was 15.9±16.6 days (median: 9.0 days, range: 2-60 days). The mean PA size was 10.8±13.0 mm (median: 7.0 mm, range: 2.5-55 mm). A statistically significant difference was found between the groups for age (group 1: 63.7±11.7 vs. group 2: 47.3±17.1 years; p=0.044) and time from symptom onset to procedure (27.7±17.4 vs. 7.7±7.0 days; p=0.005), the latter reflecting the more complex preoperative course in HPB surgery patients often complicated by concurrent pancreatic fistula or abscess. No statistically significant difference was observed regarding PA size (17.3±17.0 vs. 6.4±2.4 mm; p=0.061), procedure duration (32.4±13.4 vs. 39.7±9.2 min; p=0.201), or hemoglobin levels (8.16±1.12 vs. 8.13±1.70 g/dl; p=0.968). Comparative demographic data are presented in **Table 1**.

Table 1. Comparative demographic and procedural characteristics by group

Variable	Group 1: hepatobiliary (n=7)	Group 2: trauma/iatrogenic (n=10)	p-value
Age, mean±SD (years)	63.7±11.7	47.3±17.1	0.044
Sex (M/F)	5M/2F	5M/5F	-
Pre-procedure Hgb (g/dl)	8.16±1.12	8.13±1.70	0.968
Time from symptom to procedure (days)	27.7±17.4	7.7±7.0	0.005
PA size (mm)	17.3±17.0	6.4±2.4	0.061
Procedure duration (min)	32.4±13.4	39.7±9.2	0.201
Technical success	100%	100%	-
Clinical success	100%	100%	-
30-day mortality	1 (14.3%)	-	-

SD: Standard deviation, M/F: Male/female, Hgb: Hemoglobin, PA: Pseudoaneurysm, Min: Minute

Technical Characteristics

Regarding the distribution of parent arteries, visceral arteries included the hepatic artery (n=4, 23.5%) and superior mesenteric artery (n=3, 17.6%) (**Figure 1**). Peripheral arteries included the femoral arteries (right/left SFA n=3, right/left DFA n=2), brachial artery (n=1), axillary artery (n=1), vertebral artery (n=1), radial arteries (n=2), and right carotid artery (n=1) (**Figure 2**). The femoral approach was the most commonly used access site (76.5%, 13/17). Left brachial access was preferred in two patients (11.8%) in whom the lesion anatomy made femoral approach unsuitable.

Regarding stent type, 10 patients (58.8%) received a BE covered stent, and 7 patients (41.2%) received a SE covered

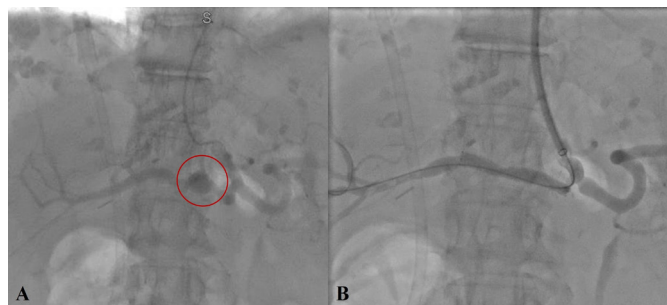


Figure 1. An 82-year-old female patient with pseudoaneurysm (PA) of the common hepatic artery following hepatobiliary surgery

(A) Digital subtraction angiography (DSA) image demonstrating the PA arising from the common hepatic artery. (B) Post-procedure DSA confirms complete exclusion of the PA following covered stent placement, with preserved patency of the hepatic artery



Figure 2. A 48-year-old female patient with right vertebral artery injury sustained during temporary cervical catheter insertion

(A, B) Digital subtraction angiography (DSA) images demonstrating a pseudoaneurysm (PA) at the origin of the right vertebral artery. (C) Fluoroscopic image showing covered stent placement at the lesion site. (D) Post-procedure DSA confirms complete patency of the right vertebral artery with full exclusion of pathological filling

stent. BE covered stents were exclusively used in visceral arteries, while SE covered stents were selected at peripheral locations requiring flexibility and conformability (**Figure 3**). Regarding diagnostic catheters used: Vertebral (n=6), Cobra 2 (n=5), SIM 1 (n=4), SIM 2 (n=2).

Technical Success, Clinical Success, Complications, and Mortality

Technical and clinical success were achieved in all patients (100%). The mean procedure time was 36.6 ± 11.1 minutes (group 1: 32.4 ± 13.4 min; group 2: 39.7 ± 9.2 min). One patient (5.9%) developed post-procedure sepsis as a major complication; this was a 63-year-old female patient with SMA PA and pancreatic fistula in whom technical success was achieved, but the underlying infectious process persisted and progressed to sepsis. The overall 30-day mortality rate was 5.9% (1/17). The deceased patient was a 60-year-old male HPB surgery patient with a triad of SMA PA, pancreatic fistula, and abscess; despite technical success, he died due to infectious complications and multi-organ failure. Individual patient data are summarized in **Table 2**.

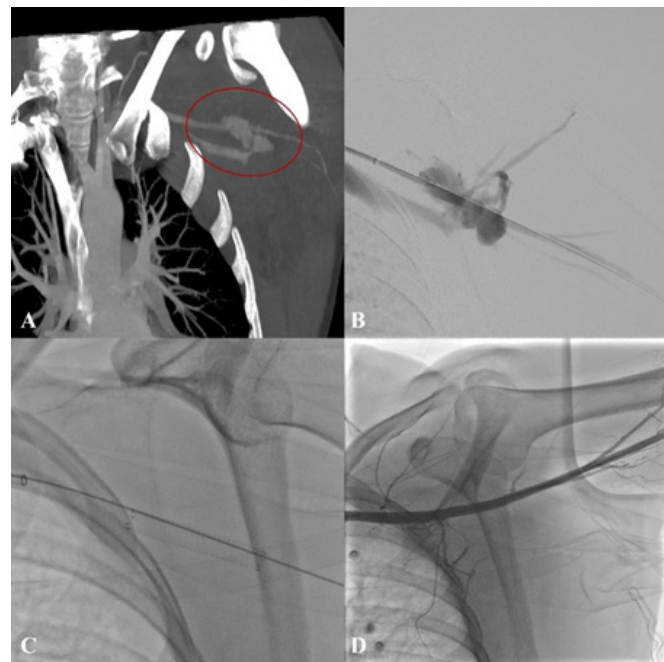


Figure 3. A 27-year-old male patient with stab wound injury

(A) Volume rendering computed tomography angiography (CTA) image demonstrates pseudoaneurysm (PA) and arteriovenous fistula (AVF) arising from the left axillary artery (red circle). (B) Digital subtraction angiography (DSA) image confirming the PA and AVF prior to intervention. (C) Fluoroscopic image demonstrating self expandable covered stent delivery across the lesion. (D) Post-procedure Digital subtraction angiography (DSA) confirms complete exclusion of the PA and AVF with full patency of the axillary artery and its distal branches

DISCUSSION

In this study, a 100% technical and clinical success rate was achieved in the endovascular treatment of PAs and AVFs using covered stents across both visceral and peripheral anatomical distributions. This high success rate is consistent with previous reports and suggests the feasibility of covered stent use across different anatomical locations.

The treatment of visceral PA/AVFs developing after HPB surgery is technically challenging due to coexisting complications such as pancreatic fistula, abscess, or hemobilia. Pedersoli et al.³ reported an 82.8% technical success rate with stent graft placement for hepatic artery PAs following pancreaticoduodenectomy. In our HPB group, technical success was 100%; however, the higher 30-day mortality (14.3%) in this group reflects the complexity of the underlying disease and multi-organ involvement. The death in the SMA PA case, despite technical success, was related to uncontrolled retroperitoneal infection. This finding has been similarly reported by Venturini et al.¹⁴ in their visceral aneurysm stent graft series.

The majority of peripheral PAs and AVFs are of iatrogenic origin. Cardiac and peripheral angiography procedures currently constitute the most common cause of iatrogenic PAs; large sheath size, anticoagulation, and inadequate compression are among the risk factors.^{5,6} Thalhammer et al.⁵ reported technical success in 26/29 cases (89.7%) in their series evaluating covered stent use for femoral PA and AVF treatment. Similar success rates were achieved in the iatrogenic group of the present study, with 100% technical success across the entire series.

In a series evaluating PAs of the superior mesenteric artery, immediate technical success was achieved in all 6 patients,

Table 2. Individual patient clinical and procedural data

No	Etiology	Age	Sex	Parent artery	PA (mm)	Stent type	Time (min)	Complication	Mortality
1	Subtotal gastrectomy	64	M	HA (extrahepatic)	6	Balloon-expandable	55	-	-
2	HPB surgery	64	M	HA (extrahepatic)	30	Balloon-expandable	22	-	-
3	HPB surgery	60	M	SMA	55	Balloon-expandable	34	-	Yes
4	HPB surgery	43	M	HA (extrahepatic)	4	Balloon-expandable	36	-	-
5	HPB surgery	82	F	HA (extrahepatic)	13	Balloon-expandable	15	-	-
6	HPB surgery	63	F	SMA	7	Balloon-expandable	40	Major (Sepsis)	-
7	HPB surgery	70	M	SMA	6	Balloon-expandable	25	-	-
8	Stab wound	27	M	Left axillary artery	5	Self-expandable	30	-	-
9	Dialysis catheter	48	F	Right vertebral artery	4	Balloon-expandable	36	-	-
10	Angiography	72	F	Right SFA	8	Self-expandable	42	-	-
11	Angiography	58	F	Right DFA	7	Balloon-expandable	28	-	-
12	Coronary angiography	32	M	Left radial artery	3.5	Self-expandable	40	-	-
13	Angiography	47	M	Left brachial artery	7	Self-expandable	35	-	-
14	Dialysis catheter	64	F	Right carotid artery	5	Self-expandable	48	-	-
15	Angiography	66	F	Right SFA	10	Self-expandable	34	-	-
16	Stab wound	29	M	Right radial artery	2.5	Self-expandable	47	-	-
17	Gunshot wound	30	M	Right DFA	10	Balloon-expandable	56	-	-

PA: Pseudoaneurysm, min: Minute, M: Male, F: Female, HA: Hepatic artery, HPB: Hepatopancreatobiliary, SMA: Superior mesenteric artery, SFA: Superficial femoral artery, DFA: Deep femoral artery

with long-term patency maintained in the majority.¹³ Venturini et al.,⁷ in a comparative study of covered stenting versus coil embolization in 100 patients, reported significantly higher long-term patency rates in the stent graft group. These findings support the preference for covered stents in lesions with wide necks where flow continuity must be maintained.

Stent type selection is a key determinant of effective treatment. BE stents are preferred for short, necked, and visceral artery lesions owing to their high radial force and precise sizing capability. SE stents offer advantages in peripheral and tortuous arteries due to their flexibility and conformability.^{7,15} In our series, this distinction was appropriately applied: BE covered stents were exclusively used in visceral cases, while SE covered stents were predominantly used in peripheral cases.

Regarding procedure time, the mean 36.6 minutes observed in our series is relatively short. The fact that group 1 (32.4 min) had a shorter procedure time than group 2 (39.7 min) may be explained by the tortuosity and small vessel diameter of peripheral arteries complicating navigation. Among the main complications associated with covered stent placement are stent migration, kinking, thrombosis, and disruption of graft integrity.^{8,10} None of these were observed in our series; the only major complication was a sepsis case related to the underlying infectious process.

Limitations

The main limitations of this study include its retrospective design, relatively small sample size, and single-center experience. Due to the small sample size, particularly in the HPB surgery group, the statistical power of between-group comparisons is limited, and the findings should be interpreted accordingly. Larger multicenter prospective studies are needed to confirm these results. The inability

to obtain systematic long-term patency follow-up data limits the interpretation of results. Nevertheless, this series covering heterogeneous anatomical distributions provides an important contribution documenting the broad-spectrum use of covered stents in interventional radiology practice. Long-term stent patency, thrombosis, and reintervention rates are critical outcome measures that could not be fully assessed in this retrospective series due to inconsistent imaging follow-up. Published series report primary patency rates of 70-90% at 12 months for covered stents in visceral and peripheral arteries, with antiplatelet therapy being a key determinant of long-term outcomes. Future prospective studies with standardized follow-up imaging protocols are warranted to define long-term durability in this patient population.

CONCLUSION

Covered stent placement represents a technically feasible and clinically effective endovascular approach for the management of both visceral and peripheral PAs and AVFs, with high procedural success rates demonstrated in this single-center series. However, given the retrospective design, limited sample size, and absence of systematic long-term follow-up, these findings should be interpreted with caution. Prospective multicenter studies with standardized outcome assessment are needed to further define the role of covered stents in this clinical setting.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was conducted with the approval of the Clinical Researches Ethics Committee of the Dışkapı Yıldırım Beyazıt Training and Research Hospital, University of Health Sciences (Date: 29.04.2019, Decision No: 62/27).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained. This retrospective study used pre-existing anonymized patient data. No additional intervention was performed, and there was no direct patient contact. The study was approved by the Ethics Committee, and the requirement for written informed consent was waived by the ethics committee.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The author declare no conflicts of interest related to this study.

Financial Disclosure

The author received no financial support for the conduct or publication of this research.

Author Contributions

The author is solely responsible for the conception, data collection, analysis, and writing of this manuscript.

Acknowledgments

The author would like to thank all clinical staff involved in the care of the patients included in this study.

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