



Rupture, Breakdown, and Pulmonary Artery Embolism of a Balloon Catheter Tip during Percutaneous Transluminal Angioplasty of Arteriovenous Fistula

Young Min Han¹, Kun Yung Kim¹, Byeoung Hoon Chung², Hee Chul Yu², Kyung Hwa Kim³, and Hong Pil Hwang²

Departments of ¹Radiology, ²Surgery, and ³Thoracic and Cardiovascular Surgery, Research Institute for Clinical Medicine, Biomedical Research Institute, Chonbuk National University Hospital, Chonbuk National University Medical School, Jeonju, Korea

Percutaneous transluminal angioplasty is a well-known treatment for arteriovenous fistula stenosis. Balloon rupture during endovascular procedures is a rare but possible complication. The bursting balloon itself does not cause a serious problem, but it can occasionally cause entrapment, especially in case of breakdown of the balloon catheter tip. Here, we present four cases of balloon rupture during angioplasty in the hemodialysis circuit. In three cases, the ruptured balloon catheter was removed by cutdown of access conduit, while in one case, tip of ruptured balloon catheter was migrated into the pulmonary artery and was removed surgically. The operator must attempt to reduce the risk of balloon rupture by gradually expanding the balloons under bursting pressure. If the balloon bursts, it should not be removed excessively and attempt should be made to remove it using endovascular techniques. Surgical removal is considered after careful evaluation of the condition of the balloon and vessel.

Key Words: Angioplasty, Breakdown, Arteriovenous fistula

Received July 18, 2019

Revised October 13, 2019

Accepted October 15, 2019

Corresponding author: Hong Pil Hwang
Department of Surgery, Research Institute of Clinical Medicine, Biomedical Research Institute, Chonbuk National University Hospital, Chonbuk National University Medical School, 20 Geonji-ro, Deokjin-gu, Jeonju 54907, Korea
Tel: 82-63-250-1570
Fax: 82-63-271-6197
E-mail: h2p@jbnu.ac.kr
<https://orcid.org/0000-0003-3489-7883>

Copyright © 2019, The Korean Society for Vascular Surgery

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Vasc Specialist Int 2019;35(4):245-250 • <https://doi.org/10.5758/vsi.2019.35.4.245>

INTRODUCTION

Percutaneous transluminal angioplasty (PTA) is usually used in the treatment of arteriovenous fistula (AVF) stenosis [1-7]. Several studies revealed that intractable intimal stenosis failed to be resolved by conventional balloon angioplasty and accounted for 16.2% of patients with AVF dysfunction [2]. Sometimes, the balloon catheter ruptures, with an incidence rate of 3.6% to 10% of all balloon angioplasty cases [8]. Most cases of balloon rupture do not cause complications. However, retrieval is difficult from the introducer sheath with size discrepancy in some cases [3,4,8]. Occasionally, it is possible that the embolized balloon fragments enter the flow in any vessel, and immediate and careful retrieval is required, but the most effective method

of retrieval has not been established [8]. We describe four cases of balloon rupture during angioplasty in the hemodialysis circuit, in which three ruptured balloons were removed by cutdown of access conduit. However, in another case, the catheter was separated from the balloon, which became an embolic material and migrated into the pulmonary artery and was removed surgically from the pulmonary artery. This study aimed to present various cases of balloon rupture and consider the safe removal of ruptured balloons in unexpected situations. This study was approved by the Institutional Review Board of Chonbuk National University Hospital (2019-08041).

CASE

1) Case 1

A 51-year-old man with systemic lupus erythematosus, hypertension, and stroke had left upper arm arteriovenous graft (AVG) dysfunction. The left upper arm AVG was placed 2 years ago in the brachial artery and axillary vein using a 6-mm polytetrafluoroethylene (PTFE) graft. He underwent balloon angioplasty of the left AVG four times during 2 years. We inserted a 6-Fr sheath into the right femoral vein and confirmed severe stenosis of venous anastomotic site and central vein through conventional venography. A 7 mm×15 cm balloon catheter (EverCross, EV3; Medtronic, Minneapolis, MN, USA) was used in PTA. While expanding the balloon to burst pressure (12 mm Hg) for 3 minutes in the tight stenotic venous anastomotic site, the balloon ruptured. Although we attempted to remove the ruptured balloon through the femoral sheath, the tip of the balloon catheter was jammed and fell apart via the right femoral approach site. The migrated tip was stuck at the left upper interlobar pulmonary artery (Fig. 1A, B). Initially, we removed the remaining balloon catheter by cutdown of the femoral vein. Subsequently, we selected the left main pulmonary artery using bent-tip angiocatheters (such as Omniflush, Headhunter, and Newton types) with guidewire passage and attempted to recapture the ruptured balloon catheter tip using a gooseneck snare. Despite several trials, the balloon tip was buried deeper into the left main pulmonary artery. We decided to remove the balloon tip from the pulmonary artery by open thoracotomy because the patient had complained of mild dyspnea and anxiety. Lateral thoracotomy was performed by the thoracic surgeon to remove the embolized balloon tip (Fig. 1C, D). He was discharged

without other complications after 7 days. A new AVG was inserted in the right arm after 2 months.

2) Case 2

An 83-year-old man with diabetes mellitus and hypertension was admitted for dialysis circuit dysfunction. The left upper arm AVF was created 5 years ago in the brachial artery and transposed basilic vein. He had a history of myocardial infarction with triple-vessel disease, colorectal cancer, and multiple PTAs on the left AVF. We inserted a 6-Fr sheath into the femoral vein to access the conduit because one puncture allows the performance of PTA on both the artery and vein from the juxta-anastomotic site to the central vein. Conventional venography revealed multiple severe stenoses from juxta-anastomotic site to the central vein. A 5 mm×8 cm balloon catheter (EverCross, EV3) was used in PTA at the juxta-anastomotic site, 6 mm×8 cm balloon catheter at the transposed basilic vein, and 9 mm×8 cm balloon catheter at the central vein. Applying burst pressure (12 mm Hg) in severe stenotic lesion of the basilic vein for 3 minutes, the 6 mm×8 cm balloon catheter ruptured (Fig. 2A, B). Despite continued attempts, the ruptured balloon was not removed using a femoral sheath but clumped and jammed to the sheath. We performed cutdown of the right femoral vein and removed the lump together with the sheath and rupture balloon (Fig. 2C). The patient was discharged after 2 days without other complications. A new AVG was inserted in the right arm after 1 month.

3) Case 3

An 89-year-old woman with hypertension had left AVG dysfunction with thrombotic occlusion. The left upper arm

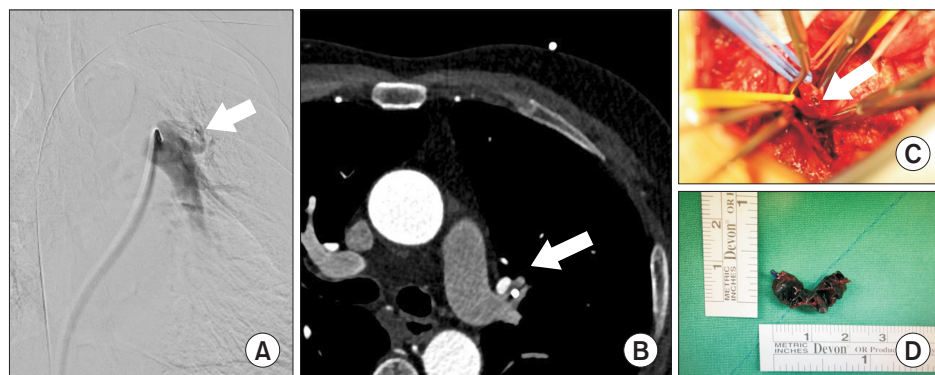


Fig. 1. A 51-year-old man underwent with angioplasty of arteriovenous fistula. (A) The tip of the ruptured balloon catheter was located in the left upper pulmonary artery in venography. (B) Chest computed tomography showed migrated ruptured balloon catheter tip in the left upper pulmonary artery. (C) Open thoracotomy showed ruptured balloon catheter. (D) The removed ruptured balloon catheter looked like ripe peppers (white arrow, ruptured balloon tip).

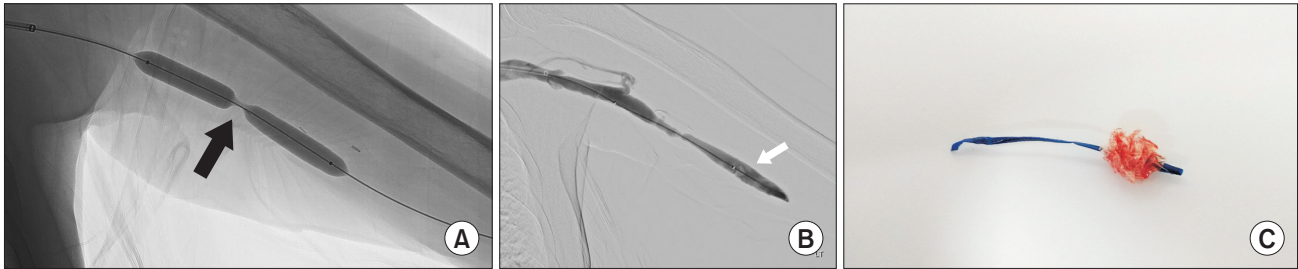


Fig. 2. An 83-year-old man underwent angioplasty of arteriovenous fistula stenosis. (A) Percutaneous transluminal angioplasty using a 6 mm×8 cm balloon catheter was performed for transposed basilic vein stenosis. (B) The flap condensed after the first removal attempt. (C) The removed ruptured balloon catheter looked like a rose on a condensed balloon tip (black arrow, waist of the balloon in the stenotic basilic vein; white arrow, ruptured balloon tip).

AVG was placed 4 years ago in the brachial artery and axillary vein using a 6-mm PTFE graft. He had a history of cervical and breast cancer and PTA of the left AVF. We performed cutdown of the midportion of the AVG conduit and thrombectomy using 5.5-Fr catheter (Fogarty clot management catheter; Edwards Lifesciences, Tokyo, Japan). After thrombectomy, a 7-Fr introducer sheath was inserted, and PTA was performed using a 7 mm×15 cm balloon catheter (Mustang; Boston Scientific, Marlborough, MA, USA). The balloon catheter ruptured at the burst pressure of 20 mm Hg in the severe stenotic lesion of the juxtavenous anastomotic site (Fig. 3). We completely removed the ruptured balloon without complications through the thrombectomy incision.

4) Case 4

A 46-year-old woman with diabetes mellitus and hypertension had dialysis conduit dysfunction. The left upper arm AVF was created 8 years ago in the brachial artery and cephalic vein in another hospital. Ultrasonography revealed severe stenosis of the cephalic arch with normal dilation of the left upper arm dialysis conduit. We inserted a 6-Fr sheath into the midportion of the upper arm cephalic vein. Venography revealed severe stenosis of the cephalic arch. After guidewire passage through the stenotic lesion, PTA was performed using 6 mm×8 cm and 10 mm×10 cm balloon catheters (Fortrex; Plymouth, MN, USA). Before applying burst pressure (20 mm Hg), the balloon catheter ruptured with partial vein tearing. We performed 2-cm venotomy of the puncture site and immediately removed the ruptured balloon catheter (Fig. 4A). Subsequently, 8-mm balloon tamponade in the cephalic arch was performed for 10 minutes. After confirming hemostasis of the cephalic arch with venography, we closed the venotomy site (Fig. 4B). The patient was admitted for 7 days because of left chest wall swelling and mild hematoma.

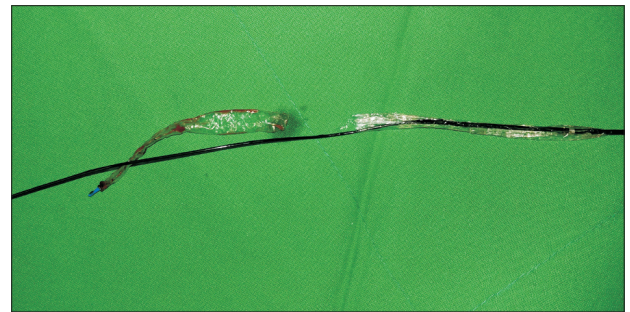


Fig. 3. An 89-year-old woman underwent angioplasty for stenosis of arteriovenous graft. Removal of the ruptured balloon catheter was performed with open venotomy.

DISCUSSION

Angioplasty is currently the general procedure for treatment of immature and dysfunctional AVF or AVG [1]. There are three approaches of access for angioplasty of AVG and AVF: femoral vein, direct dialysis conduit, and jugular vein. In case 1 and 2, we used the femoral vein to access the dialysis conduit because one puncture allows the performance of PTA on both the artery and vein from the juxta-anastomotic site to the central vein without dialysis conduit access. The advantages of the transfemoral approach are as follows [6]: 1) Through a single access, multiple lesions along the dialysis circuit can be treated. 2) Since crossing sheaths are not within the outflow vein, the thrombus tends to be much easier to clear. 3) Operators' hands are never within the fluoroscopic field. 4) Potential complications, such as direct puncture site hematoma secondary to access into a high-flow system and failure of purse-string stitches, are also prevented. However, this approach cannot be used for all AVFs or AVGs because the retrograde approach may be difficult due to the valve and anatomical variations along with angulation. Therefore, it can be selectively applied to appropriate lesions or additionally used when direct

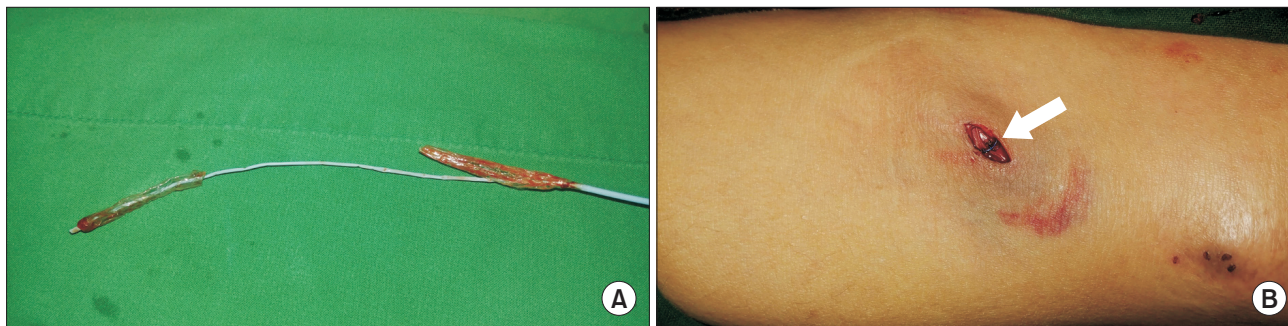


Fig. 4. A 46-year-old woman underwent angioplasty for stenosis of arteriovenous fistula. Removal of ruptured balloon catheter (A) was performed with open venotomy (B) (white arrow, venotomy site).

access is difficult in approximating central vein stenosis.

Various balloon catheters, such as cutting, high-pressure, drug-coated, and high-technology balloon catheters, have been developed because of the lesion's high resistance to conventional balloon dilation [2]. However, these different types of balloon catheters always present a risk of rupture depending on the condition of the balloon or severity of the target vessels, which can cause serious sequelae. There are several studies on the mechanism of balloon rupture. Some studies reported that balloon catheters were able to withstand pressures that exceeded the rated burst pressure [8,9]. However, a recent study revealed that rupture can occur within the recommended burst pressure [3]. Because the prediction of balloon rupture is extremely difficult, operators should try to reduce the risk of balloon rupture by gradually expanding the balloons or passing an angiography catheter through the narrow segment for dilation (Dotter method) [8].

The ruptured balloon can cause target vessel injury or entrapment depending on the pattern of breakdown. The balloon is designed to rupture in a longitudinal orientation [8]. However, in balloons with circumferential tears and in cases of complete detachment of balloons from the shaft, withdrawal is difficult, and there is a risk of balloon fragment dissemination and embolization [10]. Entrapment of devices occurs most often in tortuous, angulated, or calcified lesions with sharp edges [4]. Some factors leading to entrapment have been reported, such as the lack of backup support of guiding catheters, use of relatively weaker wire, incomplete predilation, and stiffer or longer stents [4,5,11]. Moreover, using larger balloons initially to reduce cost is better than gradually enlarging the balloons, as that increases the risk of balloon rupture [8].

The theory of balloon jamming process reveals that the ruptured balloon catheter will be jammed into the introducer sheath (Fig. 5). Normally, the balloon catheter is placed at the stenotic lesion of the AVF or AVG through a

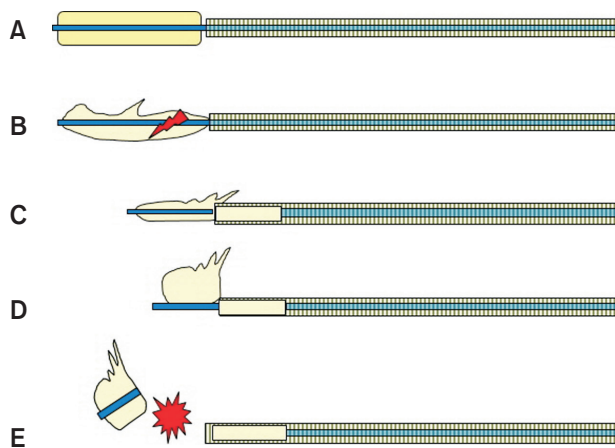


Fig. 5. Balloon catheter jamming process. (A) Normally, the balloon catheter is placed at the stenotic lesion of the arteriovenous fistula through a guidewire. (B) The ruptured balloon forms into the flaps of the membrane. (C) The protruded flap is jammed into the orifice of the sheath. (D) Retraction of the catheter leads to condensation. (E) The tip of the balloon catheter falls apart.

guidewire. When the balloon is inflated to nominal or burst pressure and ruptures, it forms into the flaps of membrane. The protruded flap is jammed into the orifice of the sheath during the removal process, and retraction of the catheter leads to condensation. Eventually, the tip of the balloon catheter falls apart. Since these can seriously affect the safety of patients, excessive attempts to remove it after rupture should be avoided. If the balloon is not removed through the sheath, the safest method is to cutdown the access vessel and remove the ruptured balloon rather than forcing to remove it.

Several studies reported on the methods of retrieval of rupture balloon. Murata et al. [8] suggested the endovascular retrieval method using additional distal access and gooseneck snare in circumferential tearing and divided it into two parts, such as that in case 1. The “pull-through

technique” is used to extract the balloon fragment, and the cobra-head catheter is used as a “pusher” to push the umbrella-like fragment away from the sheath. Using this technique, it is possible to retrieve all residual fragments of the balloon and continue to perform PTA. Chang et al. [4] presented another method using a deeply engaged guiding catheter to the distal vessel including the ruptured balloon in the coronary intervention. However, with this method, the patient may be at risk for dissection of, or even perforation of, the proximal vessels. With deep intubation, large arteries with minimal tortuosity of the proximal part are crucial, and the patient must be carefully evaluated. Most endovascular approaches need a bidirectional through-and-through technique (by additional femoral or jugular vein access) to push into a large sheath using several curved catheters, rather than pull on excessively separated areas [4,8]. Sometimes, surgical removal is required because attempts of removal using the endovascular technique adversely affect patient safety and result in vessel injury [3,4,8,9]. In case 1, the attempt to remove the ruptured balloon tip cause it to be buried deeper into the left main pulmonary artery, requiring the patient to undergo open thoracotomy. Given many factors, the following methods are recommended: If the patient’s condition permits, endovascular retrieval should be attempted. However, if the patient’s condition is unstable and vascular access is difficult, a fast surgical approach is required.

Therefore, ruptured balloons do not cause complications in most cases but can lead to entrapment that requires surgical intervention. Most importantly, operators should attempt to reduce the risk of balloon rupture by gradually expanding the balloons under burst pressure or passing an

angiography catheter through the narrow segment for dilation. If the balloon bursts, it should not be removed excessively and attempt should be made to remove it using an endovascular technique. Surgical removal is always considered after careful evaluation of the patency and condition of the balloon and vessel.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ORCID

Young Min Han

<https://orcid.org/0000-0002-3624-6809>

Kun Yung Kim

<https://orcid.org/0000-0002-2018-8130>

Byeoung Hoon Chung

<https://orcid.org/0000-0002-2737-1261>

Hee Chul Yu

<https://orcid.org/0000-0003-2766-1354>

Kyung Hwa Kim

<https://orcid.org/0000-0002-9417-0769>

Hong Pil Hwang

<https://orcid.org/0000-0003-3489-7883>

AUTHOR CONTRIBUTIONS

Concept and design: HPH. Analysis and interpretation: HCY, KHK. Data collection: BHC, KYK. Writing the article: YMH. Critical revision of the article: HPH. Final approval of the article: all authors. Overall responsibility: HPH.

REFERENCES

- 1) Abreo K, Buffington M, Sachdeva B. Angioplasty to promote arteriovenous fistula maturation and maintenance. *J Vasc Access* 2018;19:337-340.
- 2) Sun X, He Y, Ma Y, He H, Zhang L, de Seabra Rodrigues Dias IR, et al. A single-center retrospective analysis of the efficacy of a new balloon catheter in autogenous arteriovenous fistula dysfunction resistant to conventional balloon angioplasty. *Ann Vasc Surg* 2018;48:79-88.
- 3) Salman L, Castro H, Vazquez-Padron RI, Monrroy M, Abdelwahed Y, Rizvi A, et al. Balloon cinch deformity during angioplasty procedures: an indication for impending rupture. *Semin Dial* 2014;27:E21-E23.
- 4) Chang WT, Chen JY, Li YH, Tsai LM, Lee CH. A two-case series of entrapment of a ruptured balloon in the coronary artery: avoidable complications and nonsurgical management. *J Formos Med Assoc* 2015;114:1135-1139.
- 5) Murata N, Takayama T, Hiro T, Hirayama A. Balloon pin-hole rupture during percutaneous coronary intervention for recurrent, calcified in-stent restenosis: a case report. *Catheter Cardiovasc Interv* 2018;91:1287-1290.
- 6) Wang JW, Padia SA, Lee EW, Moriarty JM, McWilliams JP, Kee ST, et al. Transfemoral venous access facilitates upper extremity dialysis interventions: procedural success and clinical outcomes. *Cardiovasc Intervent Radiol* 2019;42:460-465.
- 7) Bountouris I, Kritikou G, Degermetzoglou N, Avgerinos KI. A review of percutaneous transluminal angioplasty in hemodialysis fistula. *Int J Vasc Med*

2018;2018:1420136.

- 8) Murata R, Kamiizumi Y, Haneda T, Ishizuka C, Kashiwakura S, Tsuji T, et al. Retrieval strategy for ruptured balloon with circumferential tear during angioplasty for arteriovenous fistula in hemodialysis patients. *J Vasc Access* 2019. doi: 10.1177/1129729819870634. [Epub ahead of print]
- 9) Vesely TM, Pilgram TK. Angioplasty balloon inflation pressures during treatment of hemodialysis graft-related stenoses. *J Vasc Interv Radiol* 2006;17:623-628.
- 10) Selby JB Jr, Oliva VL, Tegtmeyer CJ. Circumferential rupture of an angioplasty balloon with detachment from the shaft: case report. *Cardiovasc Intervent Radiol* 1992;15:113-116.
- 11) Kubo S, Fuku Y, Shimamoto T, Kuwayama A, Ohya M, Amano H, et al. Vascular injury caused by retrieval of ruptured and detached balloon valvuloplasty catheter during transcatheter aortic valve replacement. *JACC Cardiovasc Interv* 2017;10:1593-1595.