Application of Cutting Balloon Angioplasty for Undilatable Venous Stenoses Causing Dialysis Access Dysfunction

Jiann-Jong Wang, Wen-Pin Huang, Wei-Hsian Yin, Mason-Shing Young and Jeng Wei

Adequate vascular access is a fundamental requirement to keep alive patients on regular hemodialysis. Unfortunately, one of the major problems encountered in long-term hemodialysis is vascular access stenosis, leading to poor dialysis and ultimately resulting in thrombosis. Percutaneous transluminal angioplasty (PTA) for failing vascular access significantly prolongs the life of access. However, two major problems have not been solved in conventional high pressure balloon angioplasty. One is a strong tendency of reobstruction within a short time; the other problem is balloon-resistant stenosis, which represents the major cause of technical failure and inevitably requires surgical intervention. Development of new device is necessary to overcome such problems. From April to July 2005, we identified 5 cases with severe undilatable lesions, accounting for about 3% of our treatment patients. Four of them were treated by cutting balloon with excellent angiographic results without complication or difficulty, successfully salvaging the dialysis access. Cutting balloon angioplasty should be an essential adjunct treatment modality for those patients with undilatable lesions.

Key Words: Hemodialysis fistula stenosis • Cutting balloon

BACKGROUND AND INTRODUCTION

Adequate vascular access is a fundamental requirement for keeping alive patients on regular hemodialysis. Unfortunately, one of the major problems encountered in long-term hemodialysis is vascular access stenosis, that may diminish flow in the conduit, leading to poor dialysis, and ultimately result in thrombosis. Combining detection and prophylactic percutaneous balloon angioplasty for failing access has significantly prolonged the life of access, and is endorsed by the Dialysis Outcomes Quality Initiative. Compared to arteries, veins have a higher frequency of lesions that are resistant to balloon dilatation, and high-pressure balloon is frequently required to overcome this problem. However, some lesions are too rigid to be fully dilated in spite of high pressure balloon dilatation, subsequently a significant barotrauma or stenotic failing access remains, and intervention is inevitably ensued. Development of new device is required for those undilatable lesions. From April to July 2005, we encountered four cases with venous stenosis which could not be dilated at high pressure but were successfully salvaged by the use of cutting balloon angioplasty.

CASE REPORTS

Case 1

A 54-year-old female presented with a malfunctioning polytetrafluoroethylene forearm loop graft fistula. The patient had undergone previous surgical thrombectomy for acute thrombosis. Hemodynamic monitoring showed persistent high venous pressure during hemo-
dialysis. Fine needle angiography showed high grade stenoses at the distal portion of the draining vein (Figure 1A). After antegrade entry into the shunt vein, a 0.035-in hydrophilic guide wire and an 8 × 40 mm diameter high pressure balloon (Blue Max, Boston Scientific, Natick, MA USA) were passed to and inflated at the stenotic sites. Despite prolonged dilatation with maximal pressures more than 20 atm, the stenosis did not open, showing a constant waist of the inflated balloon (Figure 1B). Then the 0.035-in guidewire was exchanged for a 0.018-in guidewire, and an 8 × 10 mm diameter peripheral cutting balloon catheter (peripheral cutting balloon™, Boston Scientific, Natick, MA USA) was inserted through a 7-F introducer sheath into the stenotic segment. Under fluoroscopy, the cutting balloon was slowly inflated with a pressure gauge (1 atm per 3-5 sec) up to 6 to 8 atm, two or three times for 30 to 60 seconds (Figure 1C) each time. The lesion was easily dilated and the balloon indentation completely disappeared. (Figure 1D) The patient has since undergone uncomplicated hemodialysis.

Case 2

A 66-year-old female presented to our cardiovascular center with high venous pressure of her upper arm brachio-basilic arteriovenous fistula during hemodialysis. Initial fine needle angiogram demonstrated a typical outflow stenosis in the basilic vein. Despite using high pressure dilatation of at least 20 atm with an 8 × 40 mm Blue Max peripheral balloon (Boston Scientific, Natick, MA USA), a band-like waist was persistently seen in the inflated balloon. Although multiple balloon inflations of 30 seconds duration and 20 atm pressure were performed, a constant balloon waist still remained, and the lesion was really undilatatable. The balloon was exchanged for a 7 × 10 mm cutting balloon (peripheral cutting balloon™, Boston Scientific, Natick, MA USA), the balloon was inflated slowly, no faster than 2 seconds per atmosphere, allowing safe deployment of the atherotomes which are initially recessed between the folds of the balloon. Deflation was also carried out slowly to allow refolding the balloon and proper return of the atherotomes to their recessed position. This rigid, undilatable lesion was surprisingly dilated without any resistance, and the balloon was very easily expanded in full size with low pressure, 6 atm. Post-dilatation angiogram showed an excellent angiographic result.

![Figure 1](image_url)

**Figure 1.** Undilatable venous stenosis. The stenosis in the left basilica vein (arrow, A), could not be dilated with a 8 mm × 4 cm high pressure balloon taken to more than 20 atm, showing a constant balloon indentation (arrow, B). A cutting balloon is able to dilate completely with 4 to 6 atm pressure (C). An excellent angiographic result was achieved (D).
Case 3
A 64-year-old female presented with insufficient arterial flow for hemodialysis. A high grade venous stenosis at the proximal portion of the cephalic vein was identified by fine needle angiography, near the atriovenous anastomosis of the Brescia-Cimino forearm fistula. Percutaneous transluminal angioplasty (PTA) was attempted with a 6 × 40 mm high pressure balloon (Blue Max, Boston Scientific, Natick, MA USA), the lesion was dilated (to between 20 and 25 atm) 3 times for 30-60 seconds’ duration each time, but a focal balloon indentation had no any change, suggesting a very hard and rigid lesion. Successful dilatation was easily achieved by a 6 × 10 mm peripheral cutting balloon without dissection or extravasation. This Brescia-Cimino forearm fistula has now been functioning well for up to 6 months’ follow-up.

Case 4
Case 4 involved a 72-year-old male. His hemodialysis fistula (Brescia-Cimino forearm fistula) had been created one month before presentation, the arterial inflow for hemodialysis was insufficient. A high grade stenosis (> 90%) at the proximal cephalic vein was identified with fine needle angiography (Figure 2A). Unfortunately the lesion was very hard and could not be dilated, although repeated high pressure (> 16 atm) and prolonged inflations were performed (Wanda, Boston Scientific, Natick, MA USA) (Figure 2B), but a persistent indentation waist of inflated balloon was still demonstrated. Surgical intervention is usually inevitable, but the patient and his family were reluctant to accept surgical treatment. A decision was made to attempt treatment with a 5 × 10 mm cutting balloon (Blue Max, Boston Scientific, Natick, MA USA), the lesion was marvelously dilated with low pressure inflation (3-4 atm), and a satisfactory angiographic result was obtained. (Figure 2C and 2D). After treatment, the patient underwent uncomplicated hemodialysis.

DISCUSSION
Percutaneous transluminal angioplasty (PTA) has

Figure 2. A brachial arteriography showing a high grade stenosis at the proximal cephalic vein of a Brescia-Cimino forearm fistula (arrow, A). The inflated 6 mm × 4 cm balloon maintained a constant tight waist in the stenotic area (arrow, B). The hard lesion was easily dilated with a 5 × 10 mm cutting balloon (C). Post-dilatation angiography shows a well patent draining vein without dissection or extravasation (D).
become the most important treatment modality to maintain venous conduit fistula.4-7 The histological examination of stenotic vein segments reveals marked intimal hyperplasia with a dominance of smooth muscle cell proliferation and accumulation of extracellular matrix.8,9 Therefore venous stenoses are often rigid and frequently found to be highly resistant to balloon dilatation, and high pressure balloons have been recommended to overcome this problem. However two major problems have not been solved in conventional high pressure balloon angioplasty. One is a strong tendency of reobstruction within a short time,10 another problem is balloon-resistant stenosis that represent, the major cause of technical failure.11 Vorwerk et al. first reported cutting balloon angioplasty for resistant dialysis fistula lesion in 1995,12 and subsequent publications supported that cutting balloon was a valuable adjunct to conventional angioplasty.13-14 The cutting balloon catheter consists of a noncompliant balloon with either three or four blades (atherotomes) arranged longitudinally about the balloon. When the balloon is inflated, it unfolds in a manner that exposes the blades to the intima of the vessel, creating controlled intimal disruption, which allows the vessel to be dilated to the desired diameter.12 However, when the cutting balloon was applied as the primary tool to treat the hemodialysis vascular access, the 6-month patency rate was very similar to the results of conventional PTA.15 Therefore the application of cutting balloon may be much more valuable in treating those patients with lesions undilatable by conventional high-pressure balloon. From April to July 2005, we treated 168 consecutive cases of hemodialysis access stenosis and dysfunction, and found 5 cases with severe balloon-resistant lesion (3%). A band-like waist was identified during high pressure balloon dilatation, and following angiography revealed severe residual stenosis. We treated 4 of these patients with cutting balloon and completely dilated the lesion without complication, successfully salvaged and prolonged dialysis access survival. Our experience showed the marvelous effect of cutting balloon for these undilatable rigid lesions; the balloon expanded to their full size easily and quickly. We recommend the cutting balloon could be an important and useful adjunct device for such hard and rigid lesions that cannot be dilated by conventional high-pressure balloon.

REFERENCES

切割氣球應用在傳統氣球無法擴張之洗腎瘻管硬化狹窄病灶上的臨床治療效果

王鑑忠  黃文彬  殷偉賢  楊茂勳  魏崢
台北市  振興醫院  心臟中心

對長期依賴透析治療來維持正常生命的慢性洗腎患者而言，擁有良好順暢的瘻管是最基本的需求，很不幸的，瘻管狹窄阻塞卻是極為常見的問題，造成瘻管功能不良、透析治療效果不全和最終引起血栓致瘻管完全阻塞的情形，經皮氣球擴張術是目前最常使用的治療方法，可有效的延長瘻管的使用壽命，然而傳統氣球擴張術治療，有兩個常見的難題極待克服，一是治療過後近期仍有很高的再狹窄率，二是少數病灶非常硬化，即使使用很高壓力的氣球擴張仍無法撐開狹窄病灶，這些病患往往需要進一步接受外科手術，重建新的瘻管，因此發展新的技術工具刻不容緩。自 2005 年 4 月至 7 日，本院發現有五位這類患者，其中四位進一步接受了切割氣球擴張術治療，結果效果顯著，所有無法用傳統高壓氣球擴張的病灶都輕而易舉的擴張，恢復正常血管管徑，上述經驗顯示切割氣球值得成為洗腎瘻管狹窄治療上不可獲缺的補助工具，針對無法用傳統氣球擴張的病灶，選擇性的使用切割氣球能夠拯救及延長瘻管的壽命。

關鍵詞：洗腎瘻管狹窄，切割氣球。