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Outcomes of Percutaneous Transluminal Angioplasty for Central Vein Stenosis in Hemodialysis: A Literature Review

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Abstract

Percutaneous transluminal angioplasty (PTA) is the mainstay treatment for central vein stenosis. However, the recurrent rate of the stenotic lesion after PTA remains high. Thus, we ran a review found on some databases. Out of thirteen articles, five articles were eligible and reviewed. Drug-coated balloon angioplasty, plain old balloon angioplasty, percutaneous transluminal angioplasty, and stenting angioplasty were discussed regarding the outcomes with a focus on interest to prevent the stenosis.

Key words: Percutaneous transluminal angioplasty, central vein stenosis, restenosis

Introduction

Central vein stenosis (CVS) is a narrowed blood vessel due to central venous catheter usage in hemodialysis patients with end-stage renal disease (ESRD).¹ ESRD prevalence in Indonesia is 20,000 cases per year based on 2012 data.² Some studies showed that CVS incidence is 19% in patients with central venous catheters and up to 50% prevalence.³⁻⁶ The actual prevalence and incidence were hard to find because of the challenging diagnosis as the patients usually remain asymptomatic. In dr. Cipto Mangunkusumo hospital, 38 cases of CVS were identified and managed with a technical success rate reaching 85.3% from 2013 to 2016.⁷

Percutaneous transluminal angioplasty (PTA) is the mainstay treatment for CVS. Over the years, many findings suggest that PTA provides efficacy in managing CVS. However, the recurrent rate of the stenotic lesion after PTA remains high. Various studies addressed histological changes and elastic recoil changes, purposed to identify the underlying etiology. An intravascular stent developed as a measure to prevent recurrent stenosis after PTA. A review addressed to find what is unknown regarding the outcomes of this PTA procedure.^{3,4,5,8}

Central vein stenosis and its management

CVS might develop asymptotically despite leading to long-term complications such as inadequate hemodialysis delivery due to recirculation, impaired maturation of arteriovenous fistula, long-term patency decrease, and superior vena cava syndrome.¹ A condition referred to the most frequent complication of catheter placement in the central vein. Risk factors for CVS development include the location, the material, the interval between the placement and the onset of symptoms, stenosis location, and long catheter placement (more than six weeks duration).^{3,4,7} In symptomatic cases, the diagnosis may be instituted clinically. The arm is swelling as to the chief complaint, along with collateral blood vessels finding. In asymptomatic cases, the diagnosis is

instituted by venography. Venography is superior to Doppler ultrasound and remains a gold standard in evaluating venous abnormality.⁹

There are modalities in CVS treatment, either it's endovascular intervention, open surgery, medication, and palliative treatment. The treatments consist of access abandonment, thrombolysis therapy, angioplasty, and bypass operation. Access abandonment is done by ligation of venous access that results in immediate symptoms free. The anatomical pathology is not corrected with this method, and there might be a problem with venous access placement in the future. Thrombolysis is referred to as a treatment for total vein obstruction due to acute thrombosis. The treatment usually proceeds with angioplasty. Angioplasty may be carried out with or without a stent.^{10,11} The angioplasty remains as the treatment of choice by The Kidney Disease

Outcomes Quality Initiative (K/DOQI) Guideline 20.¹² The angioplasty is used for diagnostic purposes and therapy per se by injecting contrast and expanding the intravenous balloon. Percutaneous angioplasty showed a high success rate of 70-90%. Bypass procedure is not recommended since the method followed by high postoperative mortality and morbidity.⁹ We ran a review enrolling studies found in literature search from databases (Cochrane, SCOPUS, PubMed, and EBSCO) in accordance with PRISMA protocol. Out of 13 relevant articles, five articles were eligible.

Meta-analysis of Kennedy et al. (2018) regarding drug-coated balloon angioplasty (DCBA) and plain old balloon angioplasty (POBA) enrolled twelve studies on 908 patients. The study concerned about patency outcome after DCBA in the hemodialysis circuit, the patency target lesion in arteriovenous fistula (AVF), arteriovenous graft (AVG), and CVS. DCBA showed better outcomes than POBA with a higher pooled patency percentage for a stenotic lesion with AVF. Pooled patency outcome showed indifferent findings between DCBA and POBA for CVS in hemodialysis patients.¹³

Table 1. Subject Characteristics

Articles	Year	Study Design	Intervention	LoE
Kennedy et al. ¹³	2019	Meta-analysis	Drug-coated balloon angioplasty (DCBA) vs. plain old balloon angioplasty (POBA)	1a
Quartet et al. ¹⁴	2016	Retrospective Cohort	Percutaneous transluminal angioplasty (PTA) vs. bare metal stent vs. stent-graft	2b
Ozer et al. ⁴	2009	Retrospective Cohort	Percutaneous transluminal angioplasty (PTA) vs. percutaneous transluminal stenting (PTS)	2b
Surowiec et al. ¹⁵	2004	Retrospective Cohort	Percutaneous transluminal angioplasty	2b
Bakken et al. ⁵	2007	Retrospective Cohort	Percutaneous transluminal angioplasty (PTA) vs. percutaneous transluminal stenting (PTS)	2b

A study by Quartet et al. focused on percutaneous transluminal angioplasty (PTA) compared with bare-metal stent and stent graft. The outcomes of interest were restenosis occurrence, primary patency rate, and assisted patency rate. Primary patency, restenosis risk, and the need for reintervention were significantly better in stent-graft than bare-metal stent and PTA. A significant difference between each technique was not shown in primary assisted patency.¹⁴ Another retrospective cohort study by Ozyer et al. focused on the outcomes of vein intervention, primary patency, and assisted primary patency duration in PTA and PTS. The primary patency of PTA was significantly better than PTS. Meanwhile, APP was equivalent in both methods. It was found that PTS prolong vein patency that already refractory from PTA.⁴

The study by Surowiec et al. on percutaneous transluminal angioplasty aimed to find the initial technical success rate, primary patency rate, assisted patency rate of PTA. Such a study showed that PTA's initial technical success rate was 89%; primary patency rate in 1, 6, 12, and 24 months consecutively were 85, 55, 43, and 0%; assisted patency rate at the same time point are 80, 80, 80, and 64%, respectively.¹⁵

The study by Bakken et al., who analyze primary patency rate, assisted primary patency, hemodialysis access survival duration in PTA and PTS, found that primary patency rate and APP rate between PTA and PTS were not significantly different. Hemodialysis access survival duration in an ipsilateral vein between PTA and PTS is equivalent.⁵

The outcomes of PTA are classified into two major categories, radiological and clinical outcomes. Radiological outcomes are marked by primary patency and assisted primary patency (APP). Four studies discussed the primary patency rate of PTA procedures.^{5,6,10,11} According to Barret et al., which conducted a study on 125 hemodialysis patients with CVS, PTA had primary patency rates of 90%, 83%, 77%, and 47% at 3,6, 12, and 24 months respectively.⁵

The study of Quaretti et al. showed a similar outcome, and the rest literature revealed the same trend with a lower primary patency rate.¹⁰ The overall primary patency rate ranged between 70-90% in three months after PTA and about 40% in two years.^{5,6,13,14} The other radiological outcome assisted primary patency (APP) rate, showed slightly better rates than the primary patency. Clinical outcomes for PTA showed outstanding performance. PTA was shown to be an effective means of managing signs and symptoms caused by CVS with relatively minor complications. The same study by Quaretti et al. indicates declined venous patency and clinical signs will dissipate between 24–48 hours after PTA.¹⁴

Even though the percutaneous transluminal angiography success rate was excellent, the threat of restenosis was still quite high. All the cohort studies in our review studied the primary patency rate, which was part of the radiological outcome. The average primary patency rate was about 90% in three months after the procedure and about 40% in two years. Primary patency was defined as central vein patency duration before restenosis without other procedures besides initial intervention. Restenosis was highlighted because it would affect hemodialysis treatment by impairing adequate blood flow. Meanwhile, the other radiological outcome, assisted primary patency (APP) rate was slightly higher than the primary patency rate. This finding might be possible because other interventions were performed in APP, which leads to widening lumen diameter resulting higher patency.^{3,4,14,15}

Several factors might take part in restenosis after the endovascular intervention of CVS. Those are physiology and anatomy differences between artery and vein, prolong hemodynamic stress, recurrent vascular leakage, uremia, and endothelial dysfunction.¹⁶ However, the role of each factor in restenosis is still unknown. Further studies should be made to identify significant factors contributing to restenosis and how to interfere with those factors. The patient's age had been known as a non-contributing factor to restenosis after PTA placement in a study conducted by the vascular surgery center in Russia. The subject was assigned into two age groups, <60 years old and >60 years. Between the two groups, it was found that PTA success and primary patency rates were not significantly different.¹⁷

Clinical outcomes for PTA showed excellent performance with minimal complications. There were relatively minor complications following the PTA placement. Ruptured venous membrane, extremities embolism, and post-procedural mortality were not encountered in reviewed publications. Hematoma in venous access site and minimal extravasation was found in one subject and handled by nitinol stent placement.³ Meanwhile, another article reported subcutaneous bleeding in one patient that was managed conservatively.¹⁴ The minimal complications of PTA were adding significant value as the mainstay treatment for CVS. The use of drug-coated balloon angioplasty (DCBA) as an alternative treatment from plain old balloon angioplasty (POBA) improved the primary patency rate of PTA. A meta-analysis study found that DCBA was superior to POBA in treating stenosis with arteriovenous fistula. However, DCBA was substantially indifferent from POBA in regular CVS patients regarding primary patency, complications, and mortality rate.¹³

Another publication identified different parameters to evaluate PTA outcomes. PTA increases blood flow rate up to 111 mL/minute in

vascular access after its placement. In addition, the clinical parameter was also stated. PTA successfully subside clinical sign of CVS that occurs in 96% patients although the symptoms might regain later.¹⁸

Stenting and angioplasty

Percutaneous transluminal stenting (PTS) was an alternative treatment to manage recurrent SCV lesions or stenotic lesions that could not be patented using PTA. Percutaneous transluminal stenting (PTS) consists of various techniques, including bare-stent, graft-stent, and drug-coated stent. In a retrospective cohort study, PTA primary patency and APP have shown better outcomes than PTS.¹⁴ Meanwhile, the contrary result was seen in another retrospective cohort study.⁴ The primary patency and APP were not statistically different between PTS and PTA.

Guideline 20 of K/DOQI recommends PTS placement for elastic lesions recurring within three months.¹² In another publication, stent placement is considered if recurrent stenosis occurs two times within two months after PTA. Other indications include significant vein perforation after PTA include conditions such as recoil of central vein, significant residual stenosis, contralateral circulation with significant gradient pressure, and iatrogenic perforation after angioplasty.⁴

PTS plays no role in prolonging the patency rate. In addition, it will lead to more intervention central vein. The reason was related to impaired vein condition due to former intervention. These findings were not supporting PTS as the primary intervention for de novo CVS. Therefore, PTS was indicated in CVS patients with resistance lesion to PTA treatment or recurrent lesion. Stenting could be used right after PTA placement but would not add up the patency success rate. The major shortcoming of PTS was the overlapping of the stent with the internal jugular vein and the contralateral part of the brachiocephalic vein. This condition would inhibit catheter insertion entry when access failure occurred. Another complication that might arise was intracranial hypertension in intra-stent stenosis that affects the contralateral part of the brachiocephalic or superior cava vein. Wallstent and nitinol-based memotherm stent are the most used stent variant.¹⁹

Summary

PTA is a relatively safe and effective modality for treating CVS with a high success rate, minimal complications, and satisfactory radiology and clinical outcome. The radiological outcomes of primary patency and assisted primary patency was slightly varied but overall showed decent results. However, restenosis might occur 1-2 years after intervention with a high recurrent rate. If a stenotic lesion becomes recurrent, PTS could be performed as an alternative. Several methods have been developed to prevent restenosis. Further study is needed to develop an endovascular technique that will increase the patency success rate and prolong the patency duration in CVS.

Disclosure

Authors declare no conflict of interest

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