Renal Artery Stenting Using CO₂ Gas Angiography in Combination with Iodinated Contrast Angiography

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Abstract

A 76-year-old woman was hospitalized repeatedly due to unexplained heart failure. On admission, she had hypertensive acute heart failure. Her symptoms disappeared promptly after the initial treatment; however, her systolic blood pressure remained at over 160 mmHg despite her taking three antihypertensive drugs. Closer examination revealed hemodynamically significant right renal artery stenosis and a lack of left kidney function. We performed percutaneous transluminal renal angioplasty using CO₂ angiography in combination with iodinated contrast agents. The patient’s renal function and blood pressure improved, however, CO₂ gas-induced mild ischemic colitis occurred. We discuss the possibility of the use of combined iodinated contrast angiography and CO₂ angiography to avoid contrast-induced nephropathy and the complications peculiar to CO₂ angiography.

Key words: renal artery stenosis, renal artery stenting, CO₂ angiography


Introduction

Atherosclerotic renal artery stenosis (RAS) is often associated with resistant hypertension, cardiac disturbance syndrome, and progressive renal insufficiency (1). Percutaneous transluminal renal angioplasty (PTRA) is therefore thought to be necessary for these patients; this procedure has been reported to be safe (2, 3). However, the efficacy of this angioplasty procedure remains controversial. Recently, the Cardiovascular Outcomes in Renal Atherosclerotic Lesions (CORAL) study reported that PTRA offered no significant benefits in the treatment of atherosclerotic RAS (4). On the other hand, the Scientific Sessions of the Society for Cardiovascular Angiography and Interventions (SCAI) expressed an opposing view regarding this trial because the study excluded the patients who may have benefitted the most from PTRA (5). Contrast-induced nephropathy (CIN) is one of the most serious complications caused by iodinated contrast angiography. Because the feasibility and safety of CO₂ angiography-guided renal artery stenting have been reported (6, 7), CO₂ angiography is expected to reduce CIN. We herein present the case of a patient in whom resistant hypertension and renal dysfunction were improved by PTRA using CO₂ angiography in combination with iodinated contrast angiography.

Case Report

A 76-year-old woman was transferred to our hospital with dyspnea. She was hospitalized repeatedly due to unexplained heart failure with cardiac tamponade. The patient had a history of resistant hypertension and chronic renal failure. On admission, her blood pressure was 200/80 mmHg and her pulse rate was 90 bpm. Her percutaneous oxygen saturation (SpO₂) level, under the administration of 10 L/min of oxygen, was 94%. A physical examination revealed coarse crackles in all lung fields. A chest radiograph showed a flash pulmonary edema and cardiomegaly (Fig. 1). An electrocardiogram indicated sinus tachycardia with negative T waves in V3-V6 (Fig. 2); transthoracic echocardiography showed a moderate amount of pericardial effusion with a normal left ventricular ejection fraction. The patient’s serum levels were as follows: blood urea nitrogen, 46.5 mg/dL;
triamine-pentaacetate renography demonstrated a non-functional left kidney and stenosis of the right renal artery. Thus, her renal function was solely dependent on the right kidney, which was affected by RAS. Because the RAS of the right kidney was diagnosed as being hemodynamically significant, we planned to perform renal artery revascularization.

We performed CO₂ angiography-guided endovascular therapy to avoid CIN (Fig. 4). However, we could not fully evaluate the severity of lesion stenosis under CO₂ angiography, so we used iodinated contrast agents (20 mL) to a limited extent in the initial and final angiography as well as CO₂ (60 mL) as a contrast agent for indexing the procedures. The initial angiography showed stenosis (>70%) in the right renal artery. We inserted a 6-French guiding catheter from the right brachial artery near the right renal artery. Using a no-touch technique, a guidewire was passed distal to the stenotic lesion. Intravascular ultrasound revealed severe stenosis (90% area stenosis) in the proximal right renal artery. A PALMAZ Genesis stent (5.0×17 mm) was deployed in this lesion. During the procedure, she experienced induced vapor lock phenomenon. After subsequent treatment with fasting and an intravenous drip, the patient’s condition promptly improved. On the next day, her hematochezia disappeared. Oral intake was resumed without the recurrence of hematochezia. She was discharged one week after PTRA.

Figure 1. A chest radiograph on admission. The chest radiograph shows flash pulmonary edema and cardiomegaly.

Figure 2. An electrocardiogram on admission. The electrocardiogram shows sinus tachycardia with negative T waves in V3-V6.

Figure 3. Magnetic resonance angiography of the renal artery. Non-contrast-enhanced magnetic resonance angiography shows severe stenosis of the proximal right renal artery (white arrowhead), and total occlusion of the left renal artery (white arrow).

Creatinine, 1.94 mg/dL, and B-type natriuretic peptide, 493.7 pg/mL. Judging from these findings, the patient’s condition was diagnosed as hypertensive acute heart failure. We initially treated the patient with noninvasive positive pressure ventilation, the continuous injection of nitroglycerin and loop diuretics. Her oxygenation status improved promptly, and her dyspnea disappeared, but the pericardial effusion remained. Further, her systolic blood pressure remained at over 160 mmHg despite her taking three types of antihypertensive drugs [nifedipine CR (60 mg/day), telmisartan (80 mg/day), and furosemide (20 mg/day)], furthermore, her urine volume declined and her renal function worsened when her blood pressure was reduced to 120 mmHg after the continuous venous infusion of nicardipine. A renal artery duplex ultrasound examination showed right RAS [peak systolic velocity (PSV): 249 cm/sec, renal/aorta ratio: 5.5], while the right and left kidney sizes were 70 and 65 mm, respectively. To avoid CIN, we performed non-contrast-enhanced magnetic resonance angiography, which revealed 90% stenosis of the proximal right renal artery and total occlusion of the left renal artery (Fig. 3). Tc-diethylene-
Transthoracic echocardiography showed that the pericardial effusion had resolved.

**Discussion**

The effectiveness of PTRA remains controversial. The CORAL study evaluated the effectiveness of additional renal artery stenting (4). This trial revealed that medical therapy plus renal artery stenting in patients with atherosclerotic RAS was not effective for preventing clinical events such as cardiovascular death and progressive renal insufficiency. This negative result allowed us to recognize the difficulty in selecting patients for whom PTRA is effective. However, there are patients for whom PTRA is beneficial. The SCAI indicated that the patients who may have benefited from renal artery stenting were excluded from the CORAL study and that the RAS was not hemodynamically significant in some patients (5). The SCAI recommended renal artery stenting for patients with cardiac disturbance syndrome, resistant hypertension that was uncontrolled despite the use of three antihypertensive agents, or global renal ischemia due to bilateral RAS or unilateral RAS in a solitary functioning kidney. We considered that our case fit the type that was recommended by the SCAI. In our case, the patient’s renal function improved markedly after renal artery stenting, and blood pressure control became possible with only one antihypertensive drug. It is certain that there are patients, like our case, for whom PTRA is markedly effective.

However, if CIN occurred, it might have led to irreversible renal dysfunction and resulted in a poor prognosis (8). To improve the prognosis of patients with RAS, it is necessary to resolve renal ischemia without aggravating renal function. It is therefore important to reduce the volume of iodinated contrast agent to the extent that is possible to prevent CIN, which is a dose-dependent complication. The Japan multi-central Renal Artery Stent (J-RAS) study revealed the safety and efficacy of renal artery stenting in the treatment for hypertension in Japanese patients with atherosclerotic RAS (3). In the J-RAS study, however, progressive renal insufficiency [defined as a ≥30% reduction in the estimated glomerular filtration rate (eGFR) from baseline during a 12-month follow-up period] was seen in 4% of patients. Moreover, the eGFR decreased by ≥10% from baseline in 29% of the chronic kidney disease (CKD) patients. To reduce the incidence of CIN in patients with renal dysfunction, CO2 has previously been advocated as an angiographic contrast agent, and the safety and feasibility of CO2 angiography-guided renal artery stenting has been demonstrated (6, 7). In our case, the region of the right renal artery origin could not be clearly visualized by CO2 angiography. It was difficult to insert the guidewire into right renal artery; as a result, iodinated contrast angiography was necessary. In

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**Figure 4.** Percutaneous transluminal renal angioplasty. (A) Initial iodinated contrast angiography shows severe stenosis of the proximal right renal artery (white arrowhead). (B) Pre-intravascular ultrasound reveals severe stenosis (90% area stenosis) in the proximal right renal artery. (C) Stenting. (D) Final iodinated contrast angiography.
many cases, however, the insertion into the renal artery and the passage of the stenotic lesion may be possible with guidance by CO₂ angiography. On the other hand, because clear image information is needed at the time of positioning of stent implantation, the use of iodinated contrast angiography may be necessary - especially in ostial lesions. The amount of iodinated contrast media that was required was decreased by the appropriate use of CO₂ angiography in combination with iodinated contrast medium. As a result, this technique is expected to reduce the incidence of CIN.

However, CO₂ angiography can also cause complications. In our case, CO₂ angiography reduced the volume of iodinated contrast medium that was necessary and improved the patient’s renal function, but mild ischemic colitis occurred as a complication of CO₂ angiography. Ischemic colitis may be caused by the accumulation of CO₂, which can be trapped in the branch vessels such as the mesenteric arteries. This is referred to as the “vapor lock phenomenon”. Because we limited the amount of CO₂ gas that was used, the patient only suffered from mild ischemic colitis. The abundant use of CO₂ gas may lead to severe complications. The serious complications that may occur due to CO₂ angiography include death, nonfatal myocardial infarction, respiratory arrest and renal failure. Although serious complications are extremely rare, transient complications occur in 7.3% of patients (9); in particular, transient mesenteric ischemia has been shown to occur in 1.3% of patients (7). The use of higher CO₂ volumes is associated with an increased incidence of major complications (6). We did not inject an excessive amount of CO₂ and a comparison with a previous report revealed that the interval between each injection was adequate (10); however, atherosclerosis of the abdominal arteries is more likely to progress in elderly patients; thus ischemic colitis might occur relatively easily. Recently, a Japanese multicenter study to evaluate the safety and efficacy of CO₂ angiography-guided endovascular therapy was reported (11). The trial showed that the incidence of CIN was low (5.1%); however, CO₂ angiography-related complications occurred in 17.3% of patients. Most notably, 2 patients died due to CO₂-related non-occlusive mesenteric ischemia. It should be recognized that CO₂ angiography is associated with a high rate of complications. Other causes of ischemic colitis may include air contamination at the time of CO₂ angiography and distal embolism in the guiding of the catheter. Closely watching for signs of impending transient mesenteric ischemia, such as abdominal distension, nausea and abdominal pain, is the most important measure that can be implemented to prevent severe CO₂-related complications. When these symptoms are found, further CO₂ angiography should be discontinued until the symptoms completely resolve. In our patient, although CO₂ angiography caused mild ischemic colitis, it helped to prevent CIN and improve the patient’s renal dysfunction. Accordingly, to prevent CIN, when performing PT RA for patients with renal dysfunction, the combination of iodinated contrast angiography and CO₂ angiography should be considered; however, physicians should take care to prevent the onset of severe complications that can occur when CO₂ gas is used excessively.

The combination of iodinated contrast angiography and CO₂ angiography with small quantities of contrast medium and CO₂ may be useful for improving the renal function without causing any serious complications.

The authors state that they have no Conflict of Interest (COI).

References


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