Utilization of a Double-Wire Technique to Treat Long Extended Spiral Dissection of the Right Coronary Artery

Evaluation of Incidence and Mechanisms

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SUMMARY

While coronary artery dissection caused by a guiding catheter, which is one of the most commonly occurring complications during diagnostic cardiac catheterization or coronary intervention, has various forms, extensive antegrade and retrograde dissections of the right coronary artery (RCA) are rarely observed during these procedures.

Within the last three years, we retrospectively reviewed our experience with 12,600 consecutive patients who underwent either diagnostic cardiac catheterization or coronary angioplasty, and found that 17 (0.14%) of the patients displayed extensive antegrade and retrograde RCA dissection. The antegrade dissection always propagated to the distal RCA either on bifurcation of the posterior descending artery and posterolateral artery (PLA) or to the proximal PLA. The retrograde dissection was always observed close to the ostium of the RCA or extending to the ostium of the RCA. TIMI-0 flow in the RCA was immediately observed in all the patients. Chest pain associated with an electrocardiogram showing ST-segment elevation was soon observed in most of the patients. The true lumen could be entered successfully using a single wire in 8 of 17 patients. However, a double-wire technique was required for 7 patients. This technique involved first advancing a wire along to the false lumen and then pulling back the guiding catheter away from the ostium of the RCA for a few millimeters followed by anchoring with the wire. Another wire was then gently inserted into the true lumen from the dissection entrance point, which was located near or at the ostium of RCA, and carefully advanced to the distal RCA. Coronary stenting was successfully deployed in 15 patients. However, the procedure failed in 2 patients. Furthermore, this complication caused 7 patients to have acute myocardial infarctions, 2 patients to develop atrial fibrillation, and 1 to die from ischemic enterocolitis due to cardiac embolism after 7 months of follow-up. In conclusion, with an increase in experience, we now better understand this complication. However, this complication, which is a formidable challenge for coronary intervention, may be a life-threatening complication, and patients with this complication may face the potential risk of a nonfatal
myocardial infarction, or even a long-term fatal outcome in the long-term. Accordingly, it is important to learn how to promptly manage this complication. (Int Heart J 2005; 46: 35-44)

**Key words:** Extensive dissection of right coronary artery, Double-wire technique, Coronary stenting

**RIGHT** coronary artery dissection induced by a guiding catheter is occasionally observed during diagnostic cardiac catheterization or coronary intervention.1-3) Most of these dissections are usually localized and mild, and can either be treated with stenting without difficulty or left to heal without any sequela. However, a guiding catheter inducing simultaneously antegrade dissection to the ostium and retrograde dissection to the distal portion of the right coronary artery (RCA) is very unusual during coronary artery angiographic examination or intervention procedures.4) Extensive dissection of the RCA may be life-threatening, and patients with this clinical setting may face the potential risk of nonfatal myocardial infarction, emergency surgery, or even a fatal outcome.4,5) Therefore, learning and mastering how to promptly manage this complication is crucial for interventional cardiologists.5) However, coronary intervention for this complication is usually a formidable challenge for cardiologists if the dissection point is at or near the ostium of the RCA. This is because the guiding catheter is always engaged into the proximal RCA beyond the dissection point and into the false lumen. Furthermore, the wire cannot always enter the true lumen because it is easy to advance the wire to the false lumen. This subsequently causes the procedure to fail in this clinical setting.

This study reviewed our experience with 17 patients undergoing either diagnostic cardiac catheterization or percutaneous coronary intervention (PCI) via a transradial artery (TRA) approach with simultaneous antegrade and retrograde dissection of the RCA. This study investigated the incidence, potential risk, and clinical outcomes of extensive dissection of the RCA, and clarified the strategic management for such patients.

**METHODS**

**Study patients:** Between January 2001 and February 2004, 12,600 patients underwent cardiac catheterization at Chang Gung Memorial Hospital in Kaoshiung, Taiwan. It was determined that none of the 12,600 patients had developed simultaneous antegrade and retrograde dissections of the left coronary artery caused by a guiding catheter. However, it was observed that three (0.03%) of
9,000 patients who underwent diagnostic cardiac catheterization simultaneously developed antegrade and retrograde dissection of the RCA. Moreover, it was found that 14 (0.39%) of 3,600 patients who underwent PCI developed simultaneous antegrade and retrograde dissection of the RCA. All of these dissections occurred on engagement of the RCA by the guiding catheters. Therefore, the total incidence of this complication was 0.14% during diagnostic cardiac catheterization and intervention in our hospital.

**Procedure and protocol:** The indications for catheterization in these patients were stable angina, unstable angina, acute myocardial infarction (AMI), postmyocardial infarction angina, or congestive heart failure. A TRA approach using a 6-F arterial sheath has routinely been utilized for coronary angiographic study at our hospital since 1996, except where Allen’s test was positive. The diagnostic guiding catheters were selected according to operator discretion. A 6-F Kimny Miniradi (Boston Scientific, Scimed, Maple Grove, MN) was used for diagnosis in over 95% of the patients. Although the interventional guiding catheters were also selected according to operator discretion, the 6-F Kimny Miniradi was generally selected first for both elective and primary PCI if it did not provide good guiding catheter support, a 7-F standard interventional guiding catheter was required for the intervention procedures, or the femoral arterial approach was utilized. The reason for this is that the 6-F Kimny Miniradi guiding catheter could almost always be utilized for both diagnostic and intervention purposes in a single procedure, and could provide deep seating and good support.

A procedural related infarction was defined as an increase in creatine kinase level to over twice the upper limit of the normal range. Procedural success was defined as a reduction in residual stenosis of < 20% by stent deployment at the desired position, followed by Thrombolysis in Myocardial Infarction (TIMI) grade 3 flow in the RCA. An unsuccessful procedure was defined as TIMI grade 2 flow in the distal RCA. Multivessel disease was defined as stenoses of > 50% in ≥ 2 major epicardial coronary arteries.

**Double-wire technique:** A 6F or 7F JR 4 standard guiding catheter was selected. After the dissected RCA was carefully engaged using the guiding catheter, a wire was used to find the true lumen. If the true lumen could not be found, this implied that the entrance point of the true lumen might be very close to the ostium or possibly arose from the ostium of the RCA. If so, the first wire should be passed through into the false lumen and carefully advanced to the distal RCA. Thereafter, the guiding catheter was disengaged and anchored by the first wire near the ostium of the RCA. Another wire was then utilized and an attempt was made to find the true lumen (Figure 1).
RESULTS

Baseline characteristics, types of guiding catheters causing dissection, and angiographic findings (Table I): The mean patient age was below 60 years old in our patients. Over 76% of the patients were male. Hypertension and smoking were the most common risk factors for coronary artery disease, followed by hypercholesterolemia and diabetes mellitus. Less than 12% of the patients had had a previous myocardial infarction. Six of these 17 patients had suffered an AMI in our emergency room, and received primary PCI. Moreover, two of the 17 patients who experienced a recent inferior wall myocardial infarction with postinfarct angina underwent elective PCI.

The types of guiding catheters which induced RCA dissection are shown in the Table. Among these guiding catheters, a 6-F Kimny Miniradi was the guiding catheter that most commonly caused RCA dissection.

Angiographic findings demonstrated that the incidence of multivessel disease exceeded 58% in our patients. The dissections were always antegrade to distal RCA and retrograde to the very proximal RCA or to the ostial RCA (Figure 2). The dissection point was always located near or at the ostium of the RCA. The incidence of atherosclerotic plaque lesions in the proximal RCA, by which the dissection point was found, exceeded 76% of the patients. Angulation ($\geq 90^\circ$) between the proximal RCA was found to be present in almost 85% of the sampled patients. Various degrees of calcification of the proximal RCA were observed under the fluoroscope in half of the patients.
Clinical outcomes of the patients: Stenting implantation was successfully performed in 15 (88.2%) patients. A total of 45 stents were used in these patients. The procedure failed in two patients, including one woman and one man, owing to failure at finding the true lumen. Moreover, atrial fibrillation occurred in these two patients after the procedure, and warfarin was administered to prevent a cardiac embolism resulting from this complication. A coronary artery bypass was recommended to these two patients, but they refused. Although all of the patients were uneventfully discharged, this procedural complication caused at least 7 patients to experience AMI.
Three months later, repeated PCI was attempted in these 2 patients. Recanalization and stenting were successful in the man but not in the woman. Although warfarin was continuously given to the woman due to persistent atrial fibrillation, she died from ischemic enterocolitis 7 months later due to cardiac embolism. Repeated cardiac catheterization was suggested to the other 15 patients, however, only 8 underwent a cardiac catheterization study again. Other patients who were free from chest pain refused this suggestion. Restenosis was found in 4 (50%) of the 8 patients. Repeat target vessel revascularization was successfully performed in these 4 patients.

Figure 2. A: Right coronary angiography showed significant stenosis of the mid right coronary artery (RCA) (black arrow head). B: The guiding catheter induced antegrade dissection to the ostium (black arrows) of the RCA and retrograde dissection to the proximal posterolateral artery (black arrow heads) with persistent dye stasis. C: During coronary stenting (black arrow heads). D: Good angiographic results after successful stenting.
While coronary dissection of the RCA, one of the most frequent complications during diagnostic cardiac catheterization or interventional procedures, has various forms, simultaneous antegrade dissection to the distal RCA and retrograde dissection to the ostial RCA is rarely observed during these procedures. This study reviewed our experience and found that 3 patients undergoing diagnostic cardiac catheterization and 14 patients undergoing PCI simultaneously developed antegrade and retrograde dissection of the RCA. All of these dissections developed during engagement of the RCA by the guiding catheters. Therefore, the incidence of this complication was 0.14% at our hospital during the above procedures.

Due to the continuous development of new devices and technical refinements, and increasing operator experience, the TRA approach has become one of the most popular methods for either diagnostic cardiac catheterization or PCI in the real world. This is because the TRA approach can provide several additional benefits in comparison to the traditional femoral arterial approach, including less discomfort during and after the procedure, less bleeding and vascular complications, shorter hospitalization, ability to perform the procedure in outpatient departments without difficulty, and the ability of the patient to walk immediately following the procedure. Therefore, it is not surprising that various kinds of guiding catheters have been designed to comply with the TRA approach.

The structural features of the guiding catheter, anatomical features of the coronary arteries, and operator experience and technical skill are the most important factors determining coronary dissection during either diagnostic cardiac catheterization or interventional procedures. In the present study, we found that the 6-F Kimny Miniradi was the most common guiding catheter causing severe RCA dissection during the procedures. We propose the following as reasonable explanations as to why this guiding catheter had a higher incidence of this life threatening complication than the other guiding catheters. First, this difference may occur because the 6-F Kimny Miniradi was the most frequent guiding catheter used for both diagnosis and intervention in a single procedure in our hospital. Second, although the 6-F Kimny Miniradi has a soft tip and more softener than the JL4 standard guiding catheter, structurally this guiding catheter resembles the JL4 standard guiding catheter. Therefore, when this guiding catheter was used to engage the RCA, the guiding catheter must be turned 180 degrees from the left side to the right side. This may create a relatively large tensile force, subsequently leading the guiding catheter to rapidly jump into the RCA ostium. Therefore, at the moment the guiding catheter jumps into the RCA, a vigorous force would be applied to the vessel wall. As a consequence, this could cause severe dissection.
of the proximal or ostial RCA. Third, atherosclerotic plaque lesion and calcification were observed in the proximal RCA in over half of the patients. The proximal RCA thus may lose its elasticity and become brittle. Accordingly, when the guiding catheter jumps into the ostial or proximal RCA that is running at a fast speed, a dissection is certainly more likely to occur. Finally, an angulation within the proximal RCA that was present in most of our patients may be another explanation for the dissection. The clinical observations improved our understanding of the fact that the guiding catheter was frequently against the point of angulation. Since the physical properties of an applied pressure are inversely proportional to the area where a constant force is applied, a smaller area should experience greater pressure. Undoubtedly, this would also lead to the development of a dissection of the RCA.

The precise mechanism responsible for the simultaneously propagating antegrade and retrograde RCA dissection remains uncertain. We believe that several mechanisms may be responsible for this distinctive complication in our patients. First, repeated contrast injections caused the progression of an existing dissection. This mechanism, derived from the angiographic observations in the subject patients, was also proposed by previous investigators. Second, the blood supply to the RCA is well known to occur during both the systolic and diastolic phases. Therefore, it is not surprising that these shearing forces of blood flow during systole and diastole may also explain the antegrade and retrograde propagation of the dissection. This resembles the mechanism that causes aortic dissection in hypertensive patients. Third, side branches rising from the epicardial vessels may be able to retard the propagation of coronary dissection. However, the consistently fewer side branches in the RCA compared to the left anterior descending artery (LAD) could partially explain why such severe dissection occurs in the RCA but not in the LAD in the present study. Finally, some factors, including calcification of the coronary arteries, hypertension, and aging which have been viewed as predisposing factors of aortocoronary dissection during coronary intervention, were present in most of our patients.

In this study, the entrance point of the dissection, which occurred either on the ostium of the RCA or the proximal RCA very close to its ostium, was identified in our patients. Normally in this situation, while the guiding catheter engages the RCA, the ostium of the guiding catheter usually goes beyond the entrance point of the dissection. Consequently, the operator can not find the true lumen during the procedure. Therefore, as expected, the procedure failed in the first 2 patients because the ostium of the guiding catheters engaged beyond the dissection point. These 2 patients thus experienced AMI and atrial fibrillation and 1 patient succumbed to the ischemic enterocolitis due to the complication of cardiac embolism. However, this procedural failure encouraged the development of
a double-wire technique which was utilized successfully on subsequent patients with this clinical setting.

Based on our experience, in a clinical setting of severe extensive dissection of the RCA, finding the true lumen is the turning point for procedural success. Our experience suggests the double-wire technique is highly effective for patients in this clinical situation. In the double-wire technique, the guiding catheter can be disengaged and is anchored by the first wire near the ostium of the RCA. Another wire is then utilized and an attempt is made to find the true lumen.

While confirming whether a wire is advanced into a true or false lumen is sometimes difficult, several recommendations from our experience could be taken into consideration. First, the operator should try to advance the wire into the distal RCA beyond the bifurcation. If the wire can be advanced smoothly into either the posterolateral artery (PLA) or into the posterior descending artery (PDA), this may indicate that the wire was already in the true lumen. Second, if a feeling of resistance is present and a bending of the wire tip is observed during the advance, this may indicate the wire was in a false lumen. Third, after the wire passed through tough resistance, freedom of the tip in any direction was observed under the fluoroscope, possibly indicating the wire had already passed through the RCA and into the pericardium. Finally, after the wire was advanced into the distal RCA, dilatation of the obstruction with a small size balloon could be attempted. A situation in which small branches of the RCA were then filled by contrast medium injection after the dilatation may indicate that the wire was in the true lumen.

In conclusion, although TRA application of a 6-F Kimny Miniradi is useful in daily clinical practice for both diagnosis and coronary intervention in a single procedure, an unusual but serious RCA dissection will be encountered. This complication may be a life-threatening complication and represents a formidable challenge for cardiologists during catheter-based interventional procedures. Therefore, it is important to learn how to promptly manage this complication. We suggest that a double-wire technique is a prerequisite method for entering the true lumen in this clinical setting.

REFERENCES


