Despite technical improvements in percutaneous coronary interventions (PCI), treatment of bifurcation lesions remains difficult and is associated with an unfavourable outcome. Drug-eluting stents (DES) have dramatically reduced the restenosis rate in the main vessel, but with conventional T-stenting, a restenosis rate greater than 10% is still observed, mainly because of poor ostial coverage. Different techniques, such as V-stenting, culotte-stenting or crush stenting, allow full ostial coverage and may therefore achieve uniform drug distribution within the lesion. The crush technique results in a strong mechanical constraint on the side branch stent. A case of stent strut fracture-induced restenosis in a bifurcation lesion treated with the crush stenting technique is described. (Circ J 2006; 70: 936–938)

Key Words: Bifurcation lesion; Percutaneous coronary intervention; Restenosis; Stent fracture

Diagnostic invasive angiography was done in a 73-year-old man complaining of typical chest pain, and revealed a significant left main artery (LM) bifurcation lesion (Fig 1a). Elective percutaneous treatment of the lesion was performed, using the crush stenting technique. A stent was firstly implanted in the LM and left circumflex (LCX) arteries (Cypher 3.5×23 mm; 16 atmosphere), followed by a LM and left anterior descending stent (Cypher 3.5×23 mm; 20 atm), thus, “crushing” the LM–LCX stent. A wire was then inserted into the LCX through the LM–LCX stent with subsequent strut dilatation. A final kissing balloon dilatation (Crossail 3.5 and Cypher balloon 3.5; 22 atm) dilatation was also performed, with a good end-result (Fig 1b). The patient was discharged with standard medication (aspirin: 100 mg, daily, lifelong; ticlopidine: 100 mg, bd, lifelong).

Routine follow-up coronary angiography was performed and showed a severe ostial in-stent restenosis of the LCX (Fig 1c). The fluoroscopy images, hypermobility of the LM–LCX stent was observed. In fact, the stent was implanted from the LM to the LCX, limiting therefore the freedom of mobility of the circumflex artery, as this was the case at the index procedure. However, as shown in Fig 2, the angulation between the LM and LCX varied widely at follow-up coronary angiography, indicating strut fracture, which was visualized best on the end-systolic frame in the epicranial view (Fig 3). Baseline, the intravascular ultrasound reading showed moderate to severe calcification, and contiguous stent coverage could be seen (Fig 4). However, discontinuity of the stent strut over an arc of about 150 degrees at the ostium of the LCX could be observed at follow-up (Fig 5). Because of this moderate stent fracture and the need for mechanical scaffolding, the lesion was treated by stent in-stent implantation (Cypher 3.5×18 mm) with a final kissing balloon dilatation.

Discussion

Complex lesions are increasingly treated by PCI, thanks to the improvements in technologies. The introduction of DES has resulted in a dramatic reduction in restenosis; but
of the complex lesions, a bifurcation lesion still has a significant complication rate, mainly because of restenosis at the ostium of the side branch vessel.

In a bifurcation lesion, full lesion coverage is especially desirable with a DES, in order to get better drug distribution. The recently introduced crush stenting technique achieves such an aim, and has been increasingly used as a

Fig 2. Angiographic views of the bifurcation stents at systole (1a, 2a) and at diastole (1b, 2b). Post initial crush stenting treatment (1a, b), there is a limited mobility of the stents. At time of in-stent-restenosis detection (2a, b) there is hypermobility as shown by the wide change in angulation between the 2 stents. In Fig 2b, there is discontinuity of the stent (arrow), compatible with a stent fracture. LM, left main artery; LAD, left anterior descending artery; LCX, left circumflex artery.

Fig 3. Fluoroscopic views (epicranial) of the bifurcation stents at end-systole. Post initial crush stenting treatment (a), there is stent continuity. At follow-up (b), stent discontinuity (arrow) at the circumflex artery ostium on the side adjacent to the left main artery can be seen.

Fig 4. (Panel a) Baseline intravascular ultrasound (IVUS) recording at the bifurcation site. Moderate to severe calcification can be observed. (Panel b) Post stenting IVUS recording in the left circumflex artery (LCX) slightly distal of the bifurcation. Good apposition and expansion are seen. (Panels c, d) Final IVUS recording at the bifurcation of the LCX and left anterior descending artery (LAD). Stent strut continuity is observed (White arrows indicate stent strut around the LCX; the IVUS catheter lies in the LCX).

Fig 5. (Upper left panel) Longitudinal intravascular ultrasound (IVUS) recording. The first vertical white line correspond to the cross-sectional IVUS image ‘a’, the second vertical white line correspond to the IVUS image ‘b’, and the third vertical white line correspond to the IVUS image ‘f’. IVUS images ‘b–f’ are successive frames at the bifurcation site. In images a, b and f, the stent struts can be identified circumferentially. In images c, d, and e, stent struts are missing between 5 and 10 o’clock, indicating stent fracture (White arrows indicate stent strut around the circumflex artery; the IVUS catheter lies in the circumflex artery). LM, left main artery; LAD, left anterior descending artery; LCX, left circumflex artery.
treatment strategy for bifurcation lesions. However, in-stent restenosis secondary to intimal hyperplasia still occurs in more than 10% of cases, mainly in the ostium of the side branch vessel.

Vascular stent fractures are a frequent finding in peripheral arteries\(^5\,6\) and excessive mechanical stress because of extrinsic compression or extreme flexion of the vessel is the proposed cause. Coronary stent fractures in venous bypasses have also been reported\(^7\,8\). In grafts, the mechanical stresses can be very high, depending on the curvature of the graft, the presence of perigraft fibrosis, and the intrathoracic space available.

In the setting of coronary stenting, only a few case reports have been published, all involving stents implanted in the right coronary artery (RCA)\(^9\,11\). Fractures occurred around areas of increased rigidity (overlapping stents), higher radial forces (longer stents), hypermobile vessel, vessel tortuosity, calcified lesions, or post-dilatation with larger balloons at high pressures.

With the crush stenting technique, the side vessel stent is submitted to high mechanical constraint, firstly because of the crushing of its proximal portion, secondly because of the rewiring and strut dilatation at the ostial site. The mechanical constraints might result in micro-fracture of the stent strut. The etiological mechanisms for stent fracture in grafts or in the RCA are probably also of importance in the context of bifurcation stenting, and in particular for the crush stenting technique. Besides those mechanisms, we think that the angulation between the proximal main vessel and the side branch plays an important role because the degree of stent bending depends on this angulation. Furthermore, the degree of vessel movement may result in excessive flexing forces, leading to stent fracture. In the context of bifurcation stenting, lesions with these characteristics (sharp angle, excessive motion, calcification) may be better treated with other techniques involving less mechanical stress on the stent.

To our knowledge, this is the first report of a stent strut fracture in a bifurcation lesion treated with crush stenting, resulting in restenosis.

References