INTERVENTIONAL CARDIOLOGY AND SURGERY

Directional atherectomy facilitates the interventional procedure and leads to a low rate of recurrent stenosis in left anterior descending and left circumflex artery ostium stenoses: subgroup analysis of the *FLEXI-CUT* study

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Objectives: To examine by retrospective analysis of data from the *FLEXI-CUT* monocentre registry whether atherectomy can effectively simplify complex stent implantation in ostial bifurcation lesions by reducing the procedure to stenting of the left anterior descending (LAD) or left circumflex (LCX) artery ostium alone.

Patients and methods: All patients who had been enrolled in the prospective *FLEXI-CUT* study (directional atherectomy with adjunctive balloon angioplasty) were retrospectively analysed on the basis of significant LAD or LCX ostial stenosis ($\geq 70\%$ stenosis) deriving from an undiseased left main stem. The primary combined end point was the rate of target lesion revascularisation (TLR) and binary restenosis; secondary end points were procedural success and major adverse cardiac events (MACE) at the six-month follow up.

Results: Of 30 patients enrolled with significant LAD or LCX ostium stenosis, 29 were effectively treated with directional atherectomy (96.7% procedural success). All patients underwent single-vessel stenting procedures of solely the LAD or LCX ostium. At follow up, binary stenosis was 25% (6 of 24), TLR (angiographic plus clinical) 10.3% (3 of 29) and total MACE 6.9% (2 of 29).

Conclusions: Directional atherectomy with single-vessel stenting procedures facilitates the interventional treatment of LAD and LCX ostium stenosis, and leads to remarkably low TLR and binary stenosis at follow up.

Routine stent implantation has by now practically superseded atherectomy as the primary interventional strategy for most patients undergoing percutaneous coronary intervention (PCI). Procedural complexity and long-term recurrence, however, remain major concerns when stents are implanted in complex lesion subsets such as long lesions, chronic total occlusions, calcified or non-dilatable lesions and bifurcation lesions.^{1–2}

The best techniques for the treatment of ostial left anterior descending (LAD) and left circumflex artery (LCX) bifurcation lesions have yet to be determined, and the yield of debulking techniques (that is, directional atherectomy) must be re-evaluated for the drug-eluting stent era. In comparison with procedures for non-bifurcation lesions, PCI of ostial bifurcation lesions is associated with lower procedural success rates, an increased subsequent rate of major adverse cardiac events (MACE) and restenosis.^{3–5} With regard to the technical aspects of the interventional procedure, conventional balloon angioplasty (even with implantation of a drug-eluting stent) often achieves suboptimal results when stent coverage is directed solely to the LAD or LCX lesion, and when the previously undiseased left main stem or the adjacent vessel becomes stenosed due to displacement of plaque or protruding stent ends. Additional stent implantation of the left main stem or adjacent vessel is therefore often unavoidable and entails risks of complex stenting procedures and the probability of recurrent stenosis and adverse effects (for example, subacute stent thrombosis). These developments can be life threatening in left main disease.⁶ The complex stenting strategies discussed here usually include double-wire kissing balloon predilatation and postdilatation techniques with stent implantation in the left main and LAD

or LCX ostium by T, Y, culotte, trousers, skirt, kissing, crush or touching stent techniques.⁶ Although drug-eluting stents have reduced recurrent stenosis in normal lesion subsets to less than 10%,^{7–8} recurrent stenosis remains considerably high in bifurcation lesions, and published data on drug-eluting stents have shown a target lesion revascularisation (TLR) rate of still about 19% with the use of the various complex stenting procedures available.⁹ Ostial bifurcation disease renders complex stenting strategies necessary, often affects the parent vessel, necessitates crossing stent struts with a guidewire and leads to a region of double or triple stent layers. The undesirable increased local dose of drug associated therewith poses the potential harm of delayed re-endothelialisation and may entail additional adverse effects, the nature of which are yet unknown.

Mechanical removal of the occlusive plaque by ablative devices preceding stent placement is a logical option for preventing plaque shift.¹⁰ In this context, directional atherectomy with the *FLEXI-CUT* atherectomy catheter (Guidant Corp, Santa Clara, California, USA) has proved to be one of the most effective techniques for plaque removal^{11–12}—that is, with the use of adjacent stent placement.¹³ The primary advantage of minimising plaque burden in ostial LAD or LCX lesions, furthermore, is that it may facilitate the interventional procedure: after the occluding plaque is removed, a previously complex lesion can effectively be transformed into a single-vessel lesion requiring a stenting procedure in solely

Abbreviations: LAD, left anterior descending artery; LCX, left circumflex artery; MACE, major adverse cardiac events; PCI, percutaneous coronary intervention; TIMI, Thrombolysis in Myocardial Infarction; TLR, target lesion revascularisation

the LAD or LCX ostium. Moreover, minimising plaque burden facilitates stent placement itself and helps to lower wall stress, which, in turn, is one of the major triggers of neointimal hyperplasia and restenosis.¹⁴

To evaluate whether atherectomy can effectively help to simplify the complex stenting procedure by reducing it to solely the LAD or LCX ostium, we retrospectively analysed the data of all patients who had been enrolled in the *FLEXI-CUT* monocentre registry (which had been established to evaluate the indications, safety and effectiveness of directional atherectomy in a real-world setting).

PATIENTS AND METHODS

Study population

All patients who had been enrolled in the *FLEXI-CUT* study for symptomatic ostial LAD or LCX bifurcational lesions were included in this subgroup analysis. Patients were eligible for enrolment if the following conditions were met: the target lesion involved the ostium of the LAD or LCX (≥ 3.0 mm); the stenosis was located within 3 mm of the bifurcation; the diameter of stenosis was $> 70\%$ with evidence of ischaemia; and the feasibility of directional atherectomy was good. Patients were considered for enrolment regardless of lesion length. High-degree and calcified lesions were also included. Patients were excluded if they had childbearing potential; known contraindications for aspirin, heparin or ticlopidine/clopidogrel; or a history of myocardial infarction within the previous week. Angiographic follow up was requested at six months.

Patients were enrolled in the *FLEXI-CUT* study between July 2000 and December 2003. All patients gave written informed consent, and the study was conducted according to the principles of the Declaration of Helsinki.

Data collection

Investigators completed case report forms and maintained data in a central cohort database kept at the institution with pertinent information on the following: patients' demographics, clinical presentation, angiographic findings, procedural success, directional atherectomy angioplasty procedure, adjunctive treatment, short term results, procedural complications, hospital course and complications. Angiograms were evaluated by the investigators by visual assessment at baseline, immediately after directional atherectomy, and after adjunct balloon angioplasty and stent placement. The morphology of the target lesion, presence of calcium, degree of plaque burden, percentage diameter stenosis and TIMI (Thrombolysis in Myocardial Infarction) grade flow were documented. Adverse cardiac events including death, acute or late vessel closure, reinfarction, perforation, dissection, distal embolisation and no reflow phenomena encountered during the procedure and hospitalisation were recorded.

Directional atherectomy protocol

A dose of 100 mg of aspirin was given before directional atherectomy and daily thereafter. Heparin was given intravenously as an initial bolus of 7500–10 000 U, followed by incremental bolus doses to maintain an activated clotting time between 250–300 s during the procedure. Intracoronary glyceryl trinitrate was given before and during the procedure at the operator's discretion. The size of the atherectomy catheter was chosen on the basis of the target vessel reference diameter, target lesion morphology and degree of stenosis. Directional atherectomy was performed as previously described.¹¹ The interventionists were asked to make at least 12 cuts in the various quadrants (concentric lesions), centred towards the plaque (eccentric lesions) and in the direction of the remaining plaque, after the first six cuts had been made. The anticipated 12 cuts were made in at least two subsets by

collecting plaque material from the atherectomy system. The balloon inflation pressure for optimal application of the atherectomy device into the atheroma should reach 4–6 atm for at least the last six cuts. The goal of the atherectomy procedure was to achieve $< 20\%$ residual diameter stenosis by a visual estimate. Adjunctive coronary balloon angioplasty and bare metal stenting were performed to achieve near-zero angiographic residual stenosis. A stent inflation pressure of at least 10 atm was chosen to achieve full stent expansion on radiography. Intravascular ultrasound guidance before directional atherectomy, after directional atherectomy and after adjunctive stenting was used in a subset of patients—that is, in all patients where directional atherectomy debulking was incomplete and at the interventionist's discretion.

Study end points and definitions

The primary combined study end point was binary stenosis (percentage of patients with $\geq 50\%$ angiographic restenosis) and rate of TLR at the six-month follow up (intention to treat). The secondary combined end point was procedural (atherectomy) or angiographic success and the rate of MACE.

MACE was defined as (1) cardiovascular death; (2) unstable angina pectoris, defined as crescendo, rest or postinfarction angina; or (3) myocardial infarction—that is, ST or non-ST elevation myocardial infarction with a rise of creatine kinase concentrations greater than twice the normal laboratory values with any abnormal MB fraction during the follow-up period.

Directional atherectomy success was defined as complete crossing of the target lesion by the atherectomy system and diameter stenosis of $\leq 20\%$ after directional atherectomy. Procedural success was defined as a final reduction of lumen diameter stenosis to $< 20\%$ and TIMI 3 flow in the absence of major in-laboratory and in-hospital complications (death, emergency bypass surgery, development of new non-ST elevation myocardial infarction or ST elevation myocardial infarction, and target vessel revascularisation). Perforation was defined as persistent extravascular collection of contrast medium beyond the vessel wall with or without associated clinical complications. Dissection was considered to be major if it limited flow or was associated with death, myocardial infarction or the need for bypass surgery, and minor if it did not lead to clinical complication.¹⁵ Acute closure was defined as reduced antegrade flow (TIMI < 1) caused by acute occlusion of the target lesion. Intracoronary thrombus was defined as intraluminal lucency, filling defect or staining consistent with the angiographic appearance of thrombus.¹⁶ ST elevation myocardial infarction was diagnosed as a rise of creatine kinase MB above normal laboratory values and the development of ST elevations on the ECG. Non-ST elevation myocardial infarction was defined as a creatine kinase rise of 2.5 times the laboratory normal value with a positive MB, with or without persistent ST segment or T wave changes on the postprocedural ECG. Groin site complications included the need for blood transfusion or surgical intervention.

Statistical analysis

Data were statistically analysed at the Institute for Biometrics, Ernst Moritz Arndt University, Greifswald, Germany, with the SPSS Windows statistical package (SPSS Inc, Chicago, Illinois, USA). Categorical variables, described as absolute numbers and frequency of a characteristic or event, were assessed by the χ^2 or Fisher's test. Student's *t* test was applied for comparison of continuous measures, with description by standard deviations. Changes in TIMI grade, TLR, rate of binary stenosis and percentage diameter stenosis were determined by a Wilcoxon signed rank test. A value of $p < 0.05$ was considered significant.

Table 1 Patient characteristics

Number	30
Men	22 (73.3%)
Age (years)	63.6 (9.1)
Range	47–81
Coronary risk factors	
Diabetes	8 (26.7%)
Current or former smoker	16 (53.3%)
Dyslipoproteinaemia	26 (78.8%)
Hypertension	24 (80.0%)
Family history of CAD	9 (30.0%)
Reduced systolic LV function (EF <50%)	4 (13.3%)
Angina pectoris (CCS class)	
0	4 (13.3%)
1	2 (6.7%)
2	13 (43.3%)
3	6 (20.0%)
4	5 (16.7%)
Number of diseased vessels	
1	13 (43.3%)
2	11 (36.7%)
3	6 (20.0%)

Values are mean (SD) (continuous data) or absolute number (%) (nominal data).

CAD, coronary artery disease; CCS, Canadian Cardiovascular Society; EF, ejection fraction; LVEF, left ventricular.

Angiographic analysis

We routinely performed coronary angiography. We measured the interpolated reference diameter, lesion length and diameter stenosis before and after intervention and at follow up from angiograms after intracoronary administration of glyceryl trinitrate. Quantitative coronary arteriography (CMS system, V.4.0; MEDIS, Rotterdam, The Netherlands) was performed by independent interventionists at a core angiographic laboratory at Greifswald University, Germany, who were blinded to the clinical data and outcome of the procedures.

RESULTS

Clinical characteristics

Directional atherectomy of a LAD or LCX ostium stenosis was performed in 30 patients. Table 1 shows baseline characteristics of this population. Table 2 lists morphological features of the target lesions.

Table 2 Angiographic lesion characteristics at baseline

Number	30
LAD	20 (66.6%)
LCX	10 (33.3%)
Lesion type (AHA/ACC)	
A	0
B1	11 (36.7%)
B2	6 (20.0%)
C	13 (43.3%)
Concentric	22 (73.3%)
Eccentric	8 (26.7%)
Diameter stenosis (%)	87.7 (8.7)
Range	70–99
Lesion length (mm)	8.8 (3.6)
Range	2–15
Median	8
Reference diameter (mm)	3.2 (0.3)
Range	2.8–4.0

Values are mean (SD) (continuous data) or absolute number (%) (nominal data).

ACC, American College of Cardiology; AHA, American Heart Association; LAD, left anterior descendant artery; LCX, left circumflex artery.

Procedural results

Table 3 lists related procedural information. Owing to vessel morphology, including calcifications and tortuosity, a relatively large proportion (80%) of lesions were treated with the smaller 3.0–3.4 mm atherectomy catheter. Atherectomy and angiographic success was achieved in 29 patients (96.7%). In one patient (3.3%), it was necessary to abort the procedure before the possibility of making any atherectomy cuts, owing to treatment-resistant angina pectoris and haemodynamic intolerance, which resulted from inadequate myocardial perfusion after the 6 French device was positioned in the left main stem. In three patients (10%), the procedure was carried out with the use of an intra-aortic balloon pump, due to anticipated myocardial ischaemia with consecutive haemodynamic intolerance. In five patients (16.7%), the atherectomy device was applicable only after predilatation (≤ 2 mm balloon) of the target lesion. In six patients (20.7%), furthermore, stent implantation was not necessary, as adjunctive balloon angioplasty alone had produced stent-like angiographic results.

Figure 1 shows the reduction in plaque burden achieved by atherectomy. By quantitative coronary arteriography the angiographic occlusion was reduced significantly from 87.7 (8.7)% to 14 (10.5)% after atherectomy, and to 0% final residual stenosis after adjunctive balloon angioplasty, with or without stent placement.

Overall, the rate of atherectomy-induced complications was very low. Type A–C dissections occurred in 56.7% of the patients; no major dissections (type D or worse) were observed. No patient had vessel perforations, vessel occlusions, distal embolisation and peri-interventional MACE. No patient had plaque shift or protrusion of plaque or stent struts into the left main stem or adjacent vessel.

Follow up

Table 4 shows the results at the six-month follow up. Clinical follow up was available for all patients in whom directional atherectomy was completed. Angiographic follow up was obtained in 24 of the 29 directional atherectomy-treated patients (82.8%). Five patients declined angiography at follow up because they had no symptoms. Three of the 24 patients with angiography at follow up experienced recurrent stenosis at the target lesion (TLR 12.5%), of whom two had no stents implanted initially due to a stent-like result after adjunctive balloon angioplasty. Of note was that procedure-related disease did not recur in the left main stem or the opposite vessel in any of the patients with TLR. Binary stenosis was present in six patients (25%). Three of the 29 successfully treated patients had angina pectoris during

Table 3 Procedural data

Number	30
Procedural success	29 (96.7%)
FLEXI-CUT size (mm)	
3.0–3.4	24 (80.0%)
3.5–4.0	6 (20.0%)
Predilatation	5 (16.7%)
Number of cuts	10.7 (4.3)
Range	0–20
Adjunct balloon angioplasty	29 (96.7%)
Adjunct stent implantation	23 (76.7%)
Stent length (mm)	14.1 (3.1)
Range	8–24
Stent diameter (mm)	3.6 (0.4)
Range	3.0–4.5
IVUS-guided atherectomy	4 (13.3%)
Provisional Gp IIb/IIIa inhibitor use	2 (6.7%)

Values are mean (SD) (continuous data) or absolute numbers (%) (nominal data).

IVUS, intravascular ultrasound; Gp, glycoprotein.

Figure 1 Quantitative coronary analysis of percentage diameter stenosis at baseline, after atherectomy, after adjunctive percutaneous coronary intervention (PCI) and at follow up (six months). Data are mean (SD).

follow up. One patient had stable angina resulting from an additional critical coronary stenosis, without evidence of recurrent disease in the target lesion, and was therefore not considered as MACE. In the remaining two patients (6.9%), the previously intervened target lesions were treated solely with adjunctive balloon angioplasty, without stent placement. No patient required emergency bypass surgery or had a procedure-related cerebrovascular accident.

DISCUSSION

Until now it has not been possible to determine the best device or interventional procedure for ostial bifurcational lesions of the LAD or LCX ostium. Most published studies did not take into sufficient account the extensive anatomical variability involved. Although there is a clear difference between a true bifurcation with disease in both branches and involvement of only one ostium of the branches, the unpredictable nature of procedure-related plaque shift makes the development of clear and conclusive guidelines very difficult. A flat angle of less than 90° at the carina makes it virtually impossible to implant a single stent only into the diseased vessel section while still achieving coverage of the entire plaque and while, at the same time, avoiding protrusion of stent struts or plaque shift into the left coronary main stem. Inadequate stent coverage consequently leads to plaque shift into the left main stem, however, aggravating a previously single lesion problem into a complex left main bifurcational disease and necessitating a complex stenting procedure.^{1 2 17}

This retrospective analysis of all patients treated with directional atherectomy for significant ostial LAD or LCX stenosis in the context of the *FLEXI-CUT* monocentre study showed that this interventional approach is feasible, safe and effective. Achieving the desired single-vessel PCI approach was possible in all cases, which implies a low rate of recurrent stenosis, even with the use of bare metal stents. The patients enrolled in the present analysis constitute a high-risk treatment group with reference to most balloon angioplasty or directional atherectomy registries. PCI procedures in these patients entail a considerable risk of interventional compromising the undiseased left main stem or opposite vessel, thereby creating a previously non-existent condition with all the associated negative sequelae such as reocclusion and restenosis. Nevertheless, the application of directional atherectomy technology was safe in this cohort of patients, and the presence of ostial atheromatous plaque did not adversely affect the left main coronary stem or the opposite vessel in any patient.

Directional atherectomy effectively reduced diameter stenosis without simultaneously protruding atherosclerotic plaque from the target lesion into the undiseased left main stem. Significant recurrent stenoses were not detected in

Table 4 Six-month follow-up results

Total number	29
TLR (angiographic)	3/24 (12.5%)
TLR (angiographic + clinical)	3/29 (10.3%)
Binary restenosis	6/24 (25.0%)
MACE	2/29 (6.9%)

MACE, major adverse cardiac events; TLR, target lesion revascularisation.

either the unaffected left main stem or the opposite vessel at follow up.

The plaque-ablating capabilities of directional atherectomy are based on its possibility of taking directional longitudinal cuts that result in significant reduction of the plaque burden. The major impact of minimising plaque burden in LAD or LCX ostium stenoses, however, was that it effectively aided in transforming a complex lesion into a considerably simpler single-vessel lesion.

Undeniably, in the present study the rate of recurrent stenosis with or without the necessity for repeat revascularisation procedures was remarkably low (even with the use of bare metal stents) in comparison with published data after normal balloon angioplasty in this lesion subset.¹⁰⁻¹² This may arise from the fact that, after elimination of the risk of plaque shift, restenosis in this lesion subset primarily results from plaque burden, which also has been considerably reduced by atherectomy. Moreover, TLR (in a total of three patients) was needed chiefly by two patients who had no stents implanted due to a stent-like result after adjunctive balloon angioplasty. On the basis of new data from the literature, the concept of standalone directional atherectomy procedures has accordingly been superseded by routine stenting during the study.¹⁸

In the present study, atherectomy was not possible in one patient, owing to inadequate myocardial perfusion during positioning of the relatively large (6 French) device in the left main stem. In patients in whom impaired myocardial perfusion due to the device was anticipated, a previously implanted intra-aortic balloon pump helped to cope with the problem. Difficulties in applying the relatively large device developed in only 16.7% of patients and were mainly caused by coronary morphology (that is, tortuous, calcified or severely stenosed lesions). We, in any case, succeeded in overcoming this shortcoming by predilatation with a small, low-profile balloon in all patients.

Limitations of the study

This study focused on a subgroup analysis of the feasibility, safety and effectiveness of directional atherectomy in preventing plaque shift and stent protrusion into the left main stem in the treatment of ostial LAD or LCX bifurcational lesions, as an adjunct to stent placement. Our data—although providing extraordinary and highly interesting findings regarding the safety and effectiveness of directional atherectomy in selected patients with this type of coronary artery disease—are nevertheless based on results from a non-randomised, observational monocentre study. Despite the considerable success of directional atherectomy as an adjunct to stenting, there is no proof that similar or improved results could not have been gained with a different therapeutic approach or treatment modality.

Summary

In a cohort of 30 symptomatic patients presenting with ostial LAD or LCX bifurcational lesions, directional atherectomy preceding balloon angioplasty, and subsequent stent placement in solely the LAD or LCX ostium, was successful in 96.7% of patients. Provisional or complex stenting procedures

due to plaque shift or stent protrusion were unnecessary in all patients. At follow up, binary stenosis was 25%, angiographic TLR 12.5% and total MACE 6.9%. Directional atherectomy before stent placement therefore extensively facilitates the interventional treatment of ostial LAD or LCX bifurcational lesions and helps to prevent complex stenting procedures, including their considerable side effects, potential risks and notable rate of recurrent stenosis, even in the drug-eluting stent era. The effectiveness, feasibility and safety of directional atherectomy before stent placement for ostial LAD or LCX bifurcational lesions is encouraging and we hope that it will act as an impetus to further investigation.

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REFERENCES

- 1 Tan KH, Sulke N, Taub N, *et al*. Percutaneous transluminal coronary angioplasty of aorta ostial, non-aorta ostial, and branch ostial stenoses: acute and long-term outcome. *Eur Heart J* 1995;16:631-9.
- 2 Rocha-Singh K, Morris N, Wong SC, *et al*. Coronary stenting for treatment of ostial stenoses of native coronary arteries or aortocoronary saphenous venous grafts. *Am J Cardiol* 1995;75:26-9.
- 3 Sabri MN, Cowley MJ, DiSciascio G, *et al*. Immediate results of interventional devices for coronary ostial narrowing with angina pectoris. *Am J Cardiol* 1994;73:122-5.
- 4 Mathias DW, Mooney JF, Lange HW, *et al*. Frequency of success and complications of coronary angioplasty of a stenosis at the ostium of a branch vessel. *Am J Cardiol* 1991;67:491-5.
- 5 Zampieri P, Colombo A, Almagor Y, *et al*. Results of coronary stenting of ostial lesions. *Am J Cardiol* 1994;73:901-3.
- 6 Reimers B, Colombo A, Tobis J. Bifurcation lesions. In: Colombo A, Tobis J, eds. *Coronary artery stenting*. London: Martin Dunitz, 2000.
- 7 Stone GW, Ellis SG, Cox DA, *et al*. One-year clinical results with the slow-release, polymer-based, paclitaxel-eluting TAXUS stent: the TAXUS-IV trial. *Circulation* 2004;109:1942-7.
- 8 Moses JW, Leon MB, Popma JJ, *et al*. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. *N Engl J Med* 2003;349:1315-23.
- 9 Chieffo A, Stankovic G, Bonizzoni E, *et al*. Early and mid-term results of drug-eluting stent implantation in unprotected left main. *Circulation* 2005;111:791-5.
- 10 Moussa I, Moses J, Di Mario C, *et al*. Stenting after optimal lesion debulking (sld) registry. Angiographic and clinical outcome. *Circulation* 1998;98:1604-9.
- 11 Simonton CA, Leon MB, Baim DS, *et al*. 'Optimal' directional coronary atherectomy: final results of the Optimal Atherectomy Restenosis Study (OARS). *Circulation* 1998;97:332-9.
- 12 Baim DS, Cutlip DE, Sharma SK, *et al*. Final results of the Balloon vs Optimal Atherectomy Trial (BOAT). *Circulation* 1998;97:322-31.
- 13 Airolidi F, Di Mario C, Stankovic G, *et al*. Clinical and angiographic outcome of directional atherectomy followed by stent implantation in de novo lesions located at the ostium of the left anterior descending coronary artery. *Heart* 2003;89:1050-4.
- 14 Moussa I, Moses J, Colombo A. Debulking: removal of plaque prior to stenting. In: Colombo A, Tobis J, eds. *Coronary artery stenting*. London: Martin Dunitz, 2000.
- 15 Huber MS, Mooney JF, Madison J, *et al*. Use of a morphologic classification to predict clinical outcome after dissection from coronary angioplasty. *Am J Cardiol* 1991;68:467-71.
- 16 TIMI IIIA Investigators. Early effects of tissue-type plasminogen activator added to conventional therapy on the culprit coronary lesion in patients presenting with ischemic cardiac pain at rest. Results of the thrombolysis in myocardial ischemia (TIMI IIIA) trial. *Circulation* 1993;87:38-52.
- 17 Hinojara T, Rowe MH, Robertson GC, *et al*. Effect of lesion characteristics on outcome of directional coronary atherectomy. *J Am Coll Cardiol* 1991;17:1112-20.
- 18 Kawamura A, Asakura Y, Ishikawa S, *et al*. Stenting after directional coronary atherectomy compared with directional coronary atherectomy alone and stenting alone: a serial intravascular ultrasound study. *Circ J* 2004;68:455-61.

IMAGES IN CARDIOLOGY

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Multimodality in imaging calcific constrictive pericarditis

A 50-year-old woman presented with a six-month history of progressive dyspnoea and signs of right heart failure. Armoured heart was suspected by clinical examination, chest x-ray and two-dimensional echocardiography.

Tissue Doppler imaging (TDI) revealed an E'-velocity above the cut-off value (8 cm/s) indicating cardiac constriction.

ECG-synchronised contrast enhanced multislice computed tomography (MSCT) demonstrated severe calcifications expanding over nearly the entire heart in an inhomogeneous pattern. An inner and an outer shell representing epicardium and pericardium were differentiated. Encapsulated pericardial effusion was located above extended parts of the left and right ventricle including the atrioventricular groove (see panel).

Haemodynamics demonstrated elevated end-diastolic filling pressures and a dip-and-plateau phenomenon supporting the suspected diagnosis. The patient underwent pericardectomy which confirmed "pericarditis constrictiva calcarea".

Modern cardiac imaging techniques are helpful to differentiate constrictive from restrictive cardiac disease. MSCT demonstrated a large pericardial effusion whereas TDI showed an increased velocity of the mitral annulus. We propose the large pericardial effusion as a possible pathophysiologic mechanism responsible for the late onset of symptoms despite extensive calcification.

Multislice computed tomography (MSCT) based maximum intensity projection demonstrating the inhomogeneous pattern of epi- and pericardial calcification encapsulating a large pericardial effusion.

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