brain aneurysms, internal carotid artery (ICA) stenosis, or both. We also compared the DE-BR-CTA findings with those of DSA.

Materials and methods

Subjects

This study was performed after obtaining approval of the local institutional review board. Written informed consent was obtained from all patients. We prospectively selected 12 patients (7 male, 5 female; 36–78 years, mean 64 years) who underwent both DE-BR-CTA and DSA within 30 days of each other. Nine patients were suspected of intracranial unruptured aneurysms with MR angiography. Five patients were suspected of ICA stenosis. Of these five, three patients had a stroke and in two patients the asymptomatic stenosis was found during the evaluation for aneurysm.

CTA protocol

CTA was performed using a dual-source CT system (SOMATOM Definition, Siemens, Germany). CT parameters in the dual-energy mode were 140 and 80 kV tube voltage, 80 and 360 effective mAs, respectively, 0.5-s rotation time, 64×0.6-mm collimation with z-flying focal spot, and a pitch of 0.6. The 140 and 80 kV images (dual-energy images) were reconstructed separately in sections that were 0.75 mm wide at 0.5 mm increments using a D30 kernel for a field of view of 180 mm. Contrast material (350 mg I/ml) was injected for 20 s via the antecubital vein, followed by a 25 ml saline flush. Injection rate and dose depended on the patient's weight: 3.0 ml/s, 60 cc for patients weighing less than 60 kg; 3.5 ml/s, 70 cc for patients weighing less than 70 kg; and 4 ml/s, 80 cc for those over 70 kg. The delay time of the CT data acquisition after the injection was determined using a bolus tracking software at the basilar artery or ICA.

DSA was performed using a biplane DSA unit with rotational 3D DSA (INTEGRIS BV3000, Philips Healthcare, Best, Netherland).

Image processing and analysis

The dual-energy images were transferred to a workstation (Multi Modality Workplace; Siemens Medical Solutions, Germany), and the prototype of a commercial software (Syngo 2008G) was used to create a DE-BR-CTA from which the bone voxels had been removed ("head bone removal" application). The combined images of both energy data were reconstructed and used for diagnostic reading (conventional CTA).

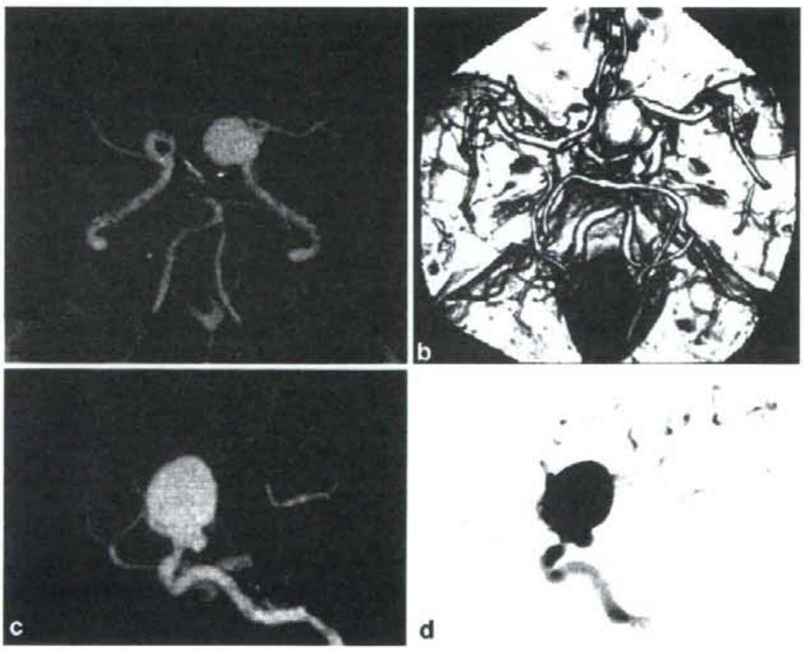

Fig. 1 Right ICA large aneurysm of a 75-year-old female patient. MIP images of DE-BR-CTA (**a**, **c**) delineate the general shape and configuration of aneurysm as well as DSA (**d**). VR image of conventional CTA (**b**) did not show the caudal side of aneurysm with bone

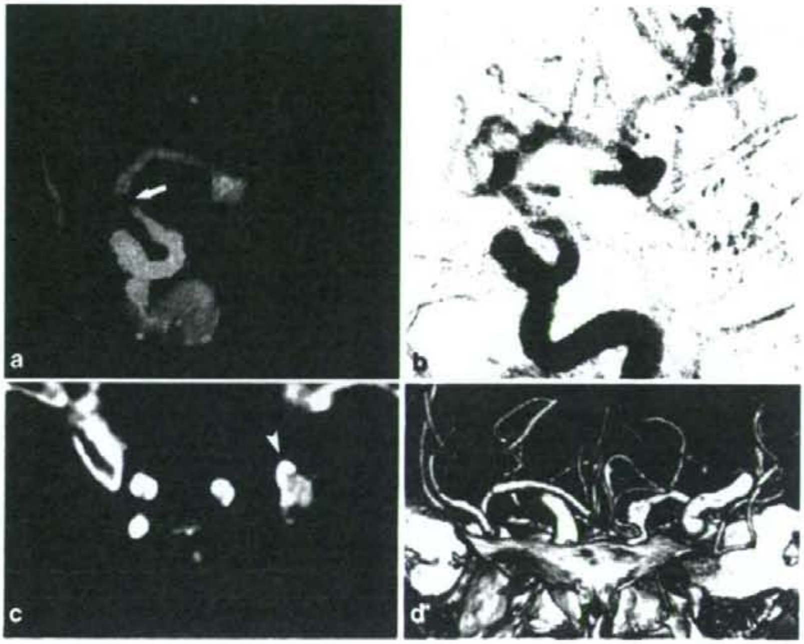

Fig. 2 Left MCA calcified aneurysm and bilateral ICA stenosis with hard plaque in a 77-year-old female patient. MIP image of DE-BR-CTA (**a**) removed the calcifications of ICA and aneurysm and revealed the same aneurysm shape as with DSA (**b**). However, the DE-BR-CTA (**a**) shows a short defect at the severe stenotic site at ICA terminal (*arrow*). CTA source images (**c**) show dense calcifications around the whole circumference of the ICA and anterior wall of the left MCA aneurysm (*arrowheads*). VR image of conventional CTA (**d**) showed the dense calcification at bilateral ICA and aneurysms, but failed to reveal details

Two neuroradiologists blinded to all clinical information independently reviewed the DE-BR-CTA in maximum-intensity projection (MIP) and the conventional CTA in volume-rendering (VR) technique on a 3D workstation. Disagreements regarding final conclusions were resolved by consensus.

The quality of the dual-energy bone removal was rated according to a four-point scale. "Excellent" was defined as clearly visible vasculature and no bone remnants, "good" as discernable vasculature and containing only tiny bone remnants, "moderate" as containing larger bone remnants that did not however disturb the vessel visualization, and

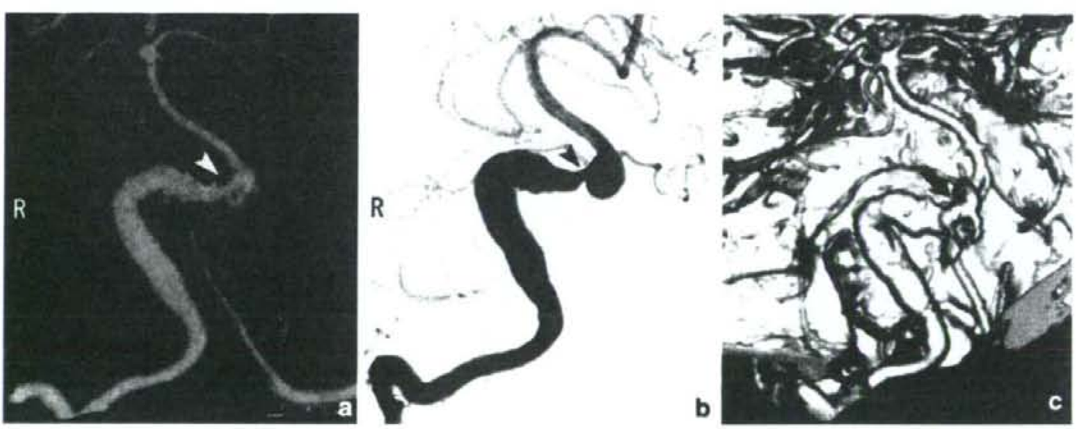

Fig. 3 Right vertebral artery fusiform aneurysm with calcification in a 55-year-old male patient. MIP image of DE-BR-CTA (**a**) removed the calcification of aneurysm and revealed the distal-end stenosis (*arrowhead*) of the aneurysm as with DSA (**b**). VR image of conventional CTA (**c**) showed the calcification (*arrow*), but the stenosis is hard to see

"poor" as including large bone remnants or artifacts covering parts of the vessels.

Further, the visibility of the ophthalmic artery in DE-BR-CTA was rated according to a four-point scale. "Excellent" was defined as the ophthalmic artery being visible from the origin to the intra-orbital portion, "good" as one artery being visible and the other with only the origin or other short segments being detected, "poor" as the long segment of the ophthalmic artery being detected, and "not visible" as the ophthalmic artery not being discernable at all.

For the evaluation of aneurysm, conventional CTA and DE-BR-CTA were compared for the detection and delineation of aneurysms and compared to the DSA results.

For the evaluation of ICA stenosis, the DE-BR-CTA and DSA were compared and the degree of stenosis was calculated using the Warfarin-Aspirin Symptomatic Intracranial Disease Study method [10], which is the ratio of the diameter of the maximum stenotic site to the diameter of the proximal normal ICA.

Kappa statistics were used to assess interobserver reliability. Kappa values above 0 were considered to indicate positive agreement: less than 0.4, positive but poor agreement; 0.41–0.75, good agreement; and more than 0.75, excellent agreement.

Results

Dual-energy bone removal was successful in all patients and the post-processing of DE-BR-CTA took an average of 53 s, excluding data transfer and saving time. The quality of dual-energy bone removal was rated "excellent" for two of the patients, "good" for eight patients, and "moderate" for two patients.

Of the 24 ophthalmic arteries, the visibility of 7 was rated "excellent," 14 were rated "good," 1 was rated "poor," and 2 arteries were rated "not visible." The two ophthalmic arteries that were not visible in DE-BR-CTA were found by DSA to be occluded. Interobserver reliability between two readers was good for quality of bone removal (k=0.60) and visibility of ophthalmic arteries (k=0.65).

Aneurysms were located in the vertebral artery (two patients), basilar artery (one patient), ICA (two patients),

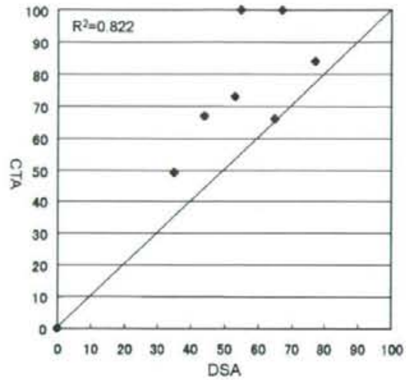

Fig. 5 Scatterplots illustrate percentages of carotid artery stenosis at DE-BR-CTA versus DSA. Good correlation was noted between the two methods (R^2=0.822), but the stenosis diagnosed by CTA was higher than that by DSA for most cases

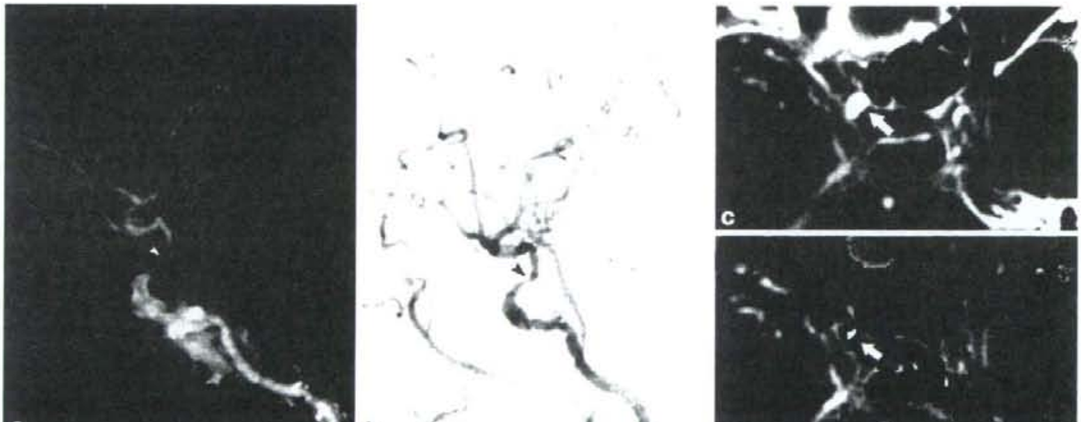

Fig. 4 Right ICA severe stenosis of a 67-year-old female patient. C2 portion of ICA had severe stenosis (*arrowhead*) demonstrated by DE-BR-CTA (**a**) and DSA (**b**). The ophthalmic artery is not visualized by DE-BR-CTA or by DSA. CTA source images (**c**) show dense calcifications around the whole circumference of the right ICA, and these calcifications were removed after DE bone-removal post-processing (**d**)

middle cerebral artery (MCA; three patients) and anterior communicating artery (ACOM; one patient).

Three aneurysms (two ICA and one MCA) adjacent to the skull base were only partially visible in conventional CTA but were fully visible in DE-BR-CTA (Fig. 1). For three aneurysms with calcifications [two MCA and one vertebral artery (VA)], the calcifications were removed by the head bone removal applications, and the intraluminal shape of the aneurysms was visualized precisely with results confirmed by DSA (Figs. 2, 3).

In five patients with ICA stenosis by calcification at the intercavernous or paraclinoid portion, the eight stenotic lesions were not visible in conventional CTA. However, after bone removal post-processing with dual energy, all stenotic lesions became clearly visible on the MIP images (Figs. 2, 4). The agreement of percent stenosis for the two methods is represented in the scatterplots shown in Fig. 5. The correlation between DSA and CTA was good (R^2= 0.822), and the majority of discordant points were above the line of correlation, indicating an overestimation of stenosis found on DE-BR-CTA compared to DSA.

Discussion

Our study shows that bone removal brain CTA using dual-energy data was useful to evaluate aneurysms and ICA stenosis with a short calculating time, and the results with DE-BR-CTA were comparable to those with DSA.

Dual-energy CT was developed during the late 1970s for tissue characterization using single-source, single-slice CT [11, 12] and mainly applied for bone densitometries [13, 14]. However, the limitation of CT hardware and software technology hampered expansion to further clinical applications [15].

Dual-source CT with dual-energy mode can acquire two different energy data into a single acquisition. Dual-energy CT imaging makes it possible to differentiate between certain materials, since X-ray absorption is material specific and dependent on the energy of the X-rays. Dual-energy CT for tissue characterization was reported for urinary stone differentiation [16–18], visualization of the knee ligament [19], and differentiation of iodine from bone and calcification [9].

Multi-slice CTA has a high sensitivity and specificity for the detection of intracranial aneurysm [1, 20].

Subtraction methods for bone removal in cerebral CTA have been reported for the evaluation of skull base aneurysm or extracranial ICA, such as simple subtraction from enhanced data to noncontrast data [4, 21]. More recently, selective bone removal or "matched mask bone elimination" have been widely used for bone-subtraction CTA where the bone mask image as well as the 3D registration to the enhanced CT acquisition were determined by a low-dose unenhanced CT acquisition [6–8].

In our study, DE-BR-CTA removed the bone structures very well, and the three aneurysms adjacent to the skull base were fully visible from all directions, in contrast to the partial view in conventional CTA.

Calcification of the aneurysmal wall makes surgical clipping difficult, so this information was important for deciding treatment strategies [22]. Conventional CTA images revealed calcifications but neither VR nor MIP images allowed a precise evaluation of the intraluminal aneurysmal shape. By comparison, the geometry of intraluminal aneurysms was clearly visible on DSA, yet calcifications could not be displayed. We found that calcifications of three aneurysms were removed by dual-energy bone removal, therefore the wall and luminal information of the aneurysms could be analyzed with both DE-BR-CTA and conventional CTA.

The advantage of the dual-energy bone removal method compared to CT digital subtraction methods is that it avoids the additional preliminary unenhanced CT acquisition. Single data acquisition reduces the radiation dose to the patient and also shows no misregistration artifacts. Subtraction methods use position adjustment, but if a patient moves between the two consecutive acquisitions, it becomes difficult to achieve a perfect match between the two images.

For the evaluation of intracranial stenosis and occlusion, DSA has been considered the reference standard [10]. The correlation between degree of intracranial stenosis based on CTA and DSA was excellent [23], and CTA has a higher sensitivity and positive predictive value than MRA [24]. Evaluation of ICA stenosis at the petrosal portion of carotid siphon or in cases of calcified plaque has not been reported previously, because CTA did not allow 3D visualization of ICA with these conditions. In contrast, DE-BR-CTA removed bone and calcifications and was able to measure the degree of stenosis.

As described above, we quantitatively evaluated ICA stenosis on MIP image. The correlation coefficient between DE-BR-CTA and DSA results was good, but stenosis tends to be overestimated in DE-BR-CTA compared to DSA. In our study, two severe stenotic arteries were misclassified as occluded (100% stenosis) with DE-BR-CTA. The main reason for this overestimation is blooming effects from calcifications. The poor enhancement of an artery with severe stenosis compared to a nonstenotic artery also makes it difficult to draw a clear demarcation between calcification and iodine. This problem might be resolved by optimization of demarcation parameters and reconstruction kernel.

Conclusion

Dual-energy bone removal using dual-source CT is able to eliminate bone and calcification from CTA images using only a single contrast-enhanced scan. DE-BR-CTA is a useful tool to evaluate intracranial aneurysms and stenosis.

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Angiographic documentation of aortoiliac occlusion in Leriche's syndrome

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A 65-year-old man with familial hypercholesterolemia presented with intermittent claudication. Computed tomography (CT) angiography documented severe stenosis of the right common iliac artery and complete occlusion of the left common iliac artery (Figure 1). Although catheter intervention was recommended, the patient chose a conservative medical therapy.

Eight months later, the patient came back for worsening claudication and development of erectile dysfunction. Follow-up CT angiography revealed complete occlusion of the infrarenal abdominal aorta and bilateral common iliac arteries (Figure 2).

Leriche's syndrome (1,2) is an aortoiliac occlusive disease in men, with associated signs and symptoms of thigh, hip or buttock claudication, atrophy of the leg muscles, impotence and a reduced femoral pulse. The main cause of this syndrome is an atherosclerotic obstruction of aortoiliac arteries. It typically begins at the distal aorta or common iliac artery origins, and slowly progresses proximally and distally over time. This progression is quite variable, but it may ultimately extend to the level of the renal arteries or result in total aortic occlusion. Serial CT angiographies performed in the present patient demonstrated that the process of aortic occlusion in this syndrome was indeed the result of a retrograde propagation of a thrombotic occlusion initiating in the bilateral iliac lesions.

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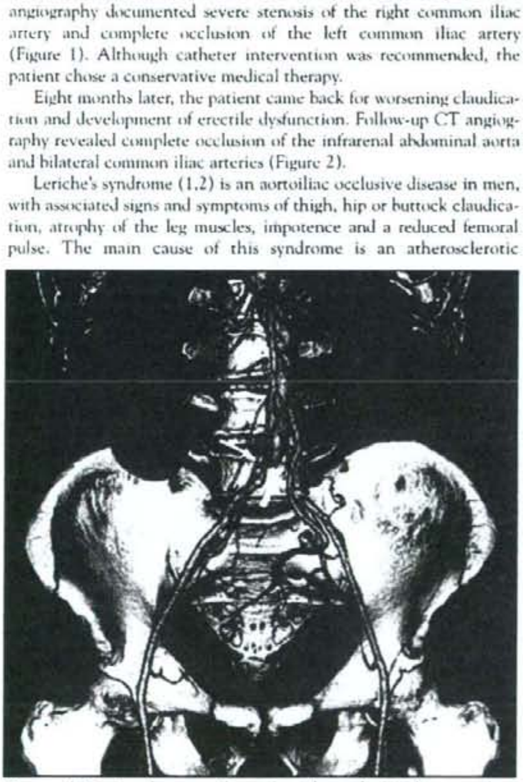

Figure 1) *Computed tomography angiography at the initial presentation, showing severely stenosed right common iliac artery (small arrow) and completely obstructed left common iliac artery (large arrow)*

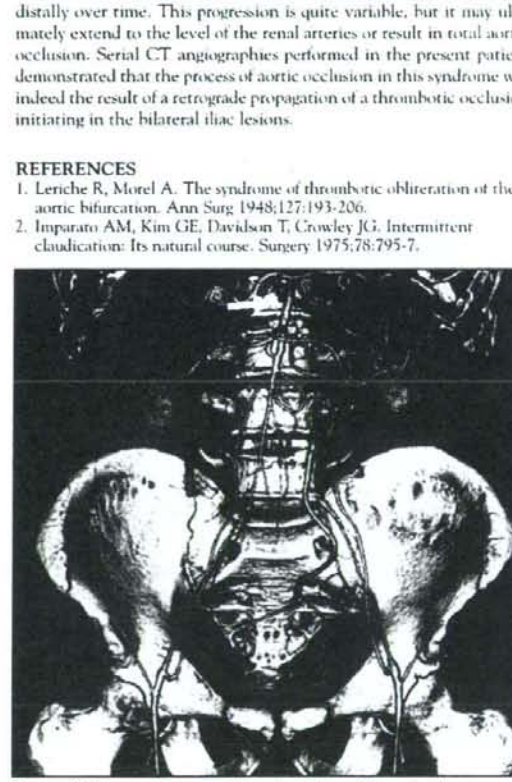

Figure 2) *Computed tomography angiography at follow-up, showing completely obstructed infrarenal aorta (arrow) and bilateral common iliac arteries*

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Long-Term Outcome After Percutaneous Peripheral Intervention vs Medical Treatment for Patients With Superficial Femoral Artery Occlusive Disease

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Background Percutaneous peripheral intervention (PPI) for superficial femoral artery (SFA) stenosis is associated with a high restenosis rate. Whether PPI improves the long-term outcome of patients with SFA occlusive disease remains to be determined.

Methods and Results A review was done of 107 patients with SFA occlusive disease. Fifty-five patients received PPI for SFA (ie, PPI group) and 52 patients received conservative medical therapy (ie, control group). Clinical records were searched for adverse events (eg, death, limb amputation, re-hospitalization, new onset of coronary artery disease and cerebrovascular disease) for an average of 30.6±17.7 months. At follow-up, only 5 patients (9.1%) in the PPI group experienced improved limb symptoms compared with baseline, and 6 patients (10.9%) showed ischemic skin ulcer or gangrene. In addition, 2 of these 6 patients were unsuccessful PPI cases complicated with distal embolization and perforation. In the control group, 3 patients (5.8%) presented with improved limb symptoms, and an equal number of patients had worsening of symptoms. Although 2 patients showed ischemic skin ulcers at follow-up, both patients had these lesions at baseline. Adverse events were observed more frequently in the PPI group than the control group (69.1% vs 46.2%, $p<0.05$). This was mainly due to a higher frequency of re-hospitalization in the PPI group than in controls (52.7% vs 15.4%, $p<0.001$).

Conclusions The current study demonstrates that PPI for patients with SFA occlusive disease does not provide superior long-term benefits compared with conservative medical therapy, and that medical therapy will continue to remain the primary treatment strategy for this group of patients. (*Circ J* 2008; **72:** 734–739)

Key Words: Angioplasty; Claudication; Peripheral vascular disease; Restenosis

Patients with lower extremity peripheral artery disease (PAD) experience substantial functional disability due to claudication, rest pain, and the loss of tissue integrity in the distal limbs.[1–4] Exercise rehabilitation, drug therapy, and percutaneous or surgical revascularization are the current therapeutic options for these patients.[2,5]

The outcome of percutaneous peripheral intervention (PPI) depends on the anatomic location of the target lesions. For example, PPI for suprainguinal lesions provides a low morbidity and excellent long-term vessel patency,[6] whereas PPI for infrainguinal lesions is associated with a high restenosis rate. In fact, for superficial femoral arteries (SFA), restenosis occurs in up to 60% of cases at 1 year after PPI.[7–9] Therefore, PPI for infrainguinal lesions has been confined to unusual circumstances, such as when patients are high risk for surgical treatment.[10]

In recent years, with continuing advances in imaging techniques, angioplasty equipment, and endovascular expertise, patients with SFA occlusive disease have undergone a shift in management to include PPI as a primary treatment strategy.[9,11–14] Yet, there are no data to support the assumption that PPI for SFA results in lasting benefit in these patients.

Accordingly, in the current study, we retrospectively reviewed the long-term outcome of patients with SFA occlusive disease. The results indicate that for these patients, PPI does not provide superior long-term benefit compared with conservative medical therapy, suggesting that medical therapy still remains a viable primary treatment strategy for this group of patients. To our knowledge, this is the first report that directly compares the long-term outcome of PPI with medical therapy for patients with SFA occlusive disease.

Methods

Study Participants

The patient population consisted of 641 patients who were admitted consecutively to the National Cardiovascular Center in Japan for the treatment of PAD between January 2000 and December 2004. All patients received angiographic assessment by magnetic resonance imaging, computed tomography, or digital subtraction angiography. Of the 641 patients, 107 were identified to have SFA stenosis as a culprit lesion, and were included in the study (Fig 1). Of these 107 patients, 55 patients then underwent PPI (ie, PPI group) for SFA, and the remaining 52 patients received medical therapy and were used as controls (ie, control group). All 107 patients were primary cases, and those who had previ-

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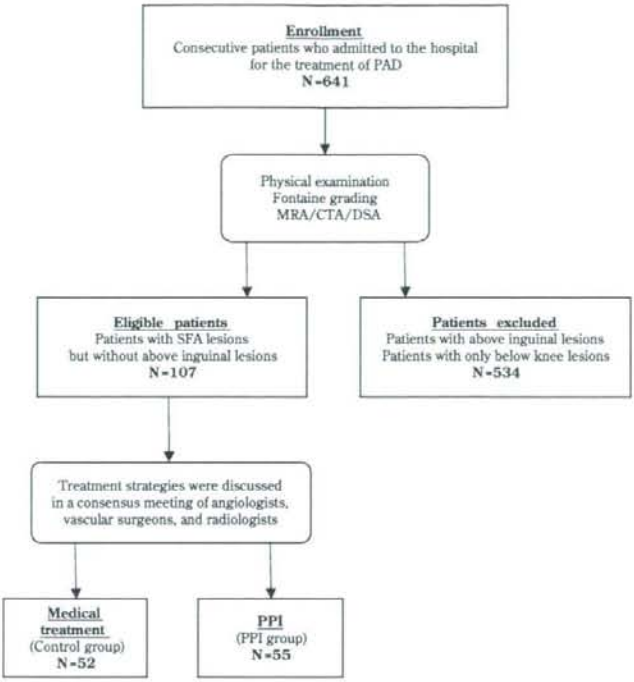

Fig 1. Flowcharts of patients. PAD, peripheral artery disease; MRA, magnetic resonance angiography; CTA, computed tomographic angiography; DSA, digital subtraction angiography; SFA, superficial femoral artery; PPI, percutaneous peripheral intervention.

ously undergone PPI or bypass surgery were excluded.

PPI Procedure

Indications for PPI were made by several cardiologists, surgeons and interventional radiologists at our hospital after considering patients' clinical status. Briefly, angiography was reviewed and SFA lesions were categorized under the modified TransAtlantic Inter-Society Consensus (TASC) system (Table 1). PPI was considered when a patient had Fontaine grade II symptoms with the lesion morphologies of TASC types A and B, or when a patient had Fontaine grade III or IV symptoms (ie, critical limb ischemia). PPI was also considered regardless of the lesion morphologies if a patient did not tolerate claudication symptoms under optimal drug therapy.

All PPI procedures were performed under systemic administration of heparin. Conventional balloon angioplasty was carried out as a primary strategy. Stent implantation was not routinely performed, but was considered when the lesions showed either flow-limiting dissections, a stenosis diameter of >30%, or acute closure. Procedural success was defined as having a stenosis diameter of <30%, pressure gradients of the lesion of <10 mmHg, or improvement in ankle–brachial pressure index (ABI) of >0.10. When there were no contraindications, patients undergoing PPI were prescribed aspirin as well as at least one other antiplatelet or anticoagulant agent. If worsening or recurrence of limb symptoms was observed during the follow-up period, patients received ultrasound and/or angiographic assessment to ascertain restenosis of the dilated lesions.

Long-Term Outcome

Clinical records of 107 patients were retrospectively reviewed to determine whether long-term outcome differed between patients undergoing PPI and those receiving conservative medical therapy. Specifically, for each patient, baseline demographic information, limb symptom (Fontaine grade), ABI, comorbidities, atherosclerotic risk factors, and oral medications were identified. When SFA showed diffuse or multiple lesions, the lesion showing the most severe degree of TASC category was assigned as the lesion category for that patient. These baseline clinical variables were statistically analyzed and correlated with long-term adverse events, which included death, limb amputation, re-hospitalization due to worsening of limb symptoms, new onset of coronary artery disease, and new onset of cerebrovascular disease. The information relating to long-term outcome was obtained by means of patients attending an outpatient clinic.

Table 1 Modified TASC Morphologic Stratification of Femoropopliteal Lesions

*Type A**	*Single stenosis <3 cm in length*
Type B	*Single stenosis or occlusion 3–5 cm long* *Multiple stenoses or occlusions each <3 cm*
Type C	*Single stenosis or occlusion >5 cm* *Multiple stenoses or occlusions each 3–5 cm long*
Type D	*Complete superficial artery occlusion* *Complete popliteal or proximal trifurcation occlusion*

**Type A does not apply for superficial femoral artery lesions according to the original TASC morphologic stratification.*
TASC, TransAtlantic Inter-Society Consensus.

Definitions

Resting ABI was calculated as the quotient of absolute

Table 2 Patient Characteristics

	Control (n=52)	PPI (n=55)	p value
Age (years)	71.8±7.5	70.6±6.6	NS
Male	41 (78.8%)	51 (92.7%)	NS
Fontaine grade	2.15±0.33	2.07±0.18	NS
I	1 (1.9%)	1 (1.8%)	
II	46 (88.5%)	51 (92.7%)	
III	1 (1.9%)	1 (1.8%)	
IV	4 (7.7%)	2 (3.6%)	
Major risk factors and comorbidities			
Current smoker	44 (84.6%)	53 (96.4%)	NS
Hypertension	45 (86.5%)	52 (94.5%)	NS
Dyslipidemia	29 (55.8%)	38 (69.1%)	NS
Diabetes mellitus	34 (65.4%)	39 (70.9%)	NS
Chronic renal impairment	3 (5.8%)	7 (12.7%)	NS
Hemodialysis	1 (1.9%)	4 (7.3%)	NS
History of CAD	26 (50.0%)	28 (50.9%)	NS
History of CVD	2 (3.8%)	5 (9.1%)	NS
TASC lesion characteristics (types A and B)	18 (34.6%)	42 (76.4%)	<0.001
ABI on admission	0.61±0.17	0.61±0.15	NS
ABI on discharge	0.61±0.17	0.81±0.20	<0.001
Mean number of antiplatelets and anticoagulants on discharge	1.87±0.81	2.27±0.78	<0.05
Aspirin	31 (59.6%)	46 (83.6%)	NS
Cilostazol	18 (34.6%)	28 (50.9%)	NS
Ticlopidine	4 (7.7%)	21 (38.2%)	<0.001
Beraprost	24 (46.2%)	18 (32.7%)	NS
Sarpogrelate	8 (15.4%)	12 (21.8%)	NS
Limaprost	8 (15.4%)	7 (12.7%)	NS
Warfarin	4 (7.7%)	6 (10.9%)	NS

PPI, percutaneous peripheral intervention; NS, not significant; CAD, coronary artery disease; CVD, cerebrovascular disease; ABI, ankle-brachial pressure index. Other abbreviation see in Table 1.

ankle pressure and brachial pressure. Each patient's ABI was measured upon admission and at follow-up. In patients receiving PPI, ABI was also measured after PPI. Hypertension was defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg, or as taking antihypertensive medications. Dyslipidemia was defined as having a fasting cholesterol of ≥220 mg/dl, low-density lipoprotein of ≥140 mg/dl, high-density lipoprotein of <40 mg/dl, triglycerides of ≥150 mg/dl, or currently taking lipid-lowering medications. Diabetes mellitus was defined as a fasting plasma glucose of ≥126 mg/dl, hemoglobinA_{1c} of ≥6.5%, or currently taking antidiabetic medications. Coronary artery disease was defined as a history of angina pectoris, myocardial infarction, or prior coronary revascularization. Cerebrovascular disease included a history of stroke, transient ischemic attack, or carotid artery revascularization. Chronic renal impairment was defined as a serum creatinine level of ≥2.0 mg/dl, or being on hemodialysis.

Statistical Analysis

Data were expressed as the mean value ± standard deviation. Statistical significance was evaluated using paired and unpaired Student's t-test for comparisons between 2 means, and chi-square test for categorical data. Event-free survival was estimated using the Kaplan–Meier survival method with log-rank statistics. Statistical significance was defined as a p-value of <0.05.

Results

Patient Population

Of the 107 patients with SFA occlusive disease, 55 patients received PPI (ie, PPI group) and 52 underwent conservative medical therapy (ie, control group). Indications for PPI in these 55 patients included critical limb ischemia in 3 patients, and intermittent claudication in 51. Another patient was asymptomatic under pharmacologic therapy; however, PPI was performed based on the patient's request.

Age, gender, follow-up period, Fontaine grade, atherosclerotic risk factors, comorbidities, and ABI on admission were not statistically different between the groups. With regard to lesion characteristics, patients receiving PPI showed less severe types of lesions (ie, TASC types A and B lesions rather than types C and D lesions) compared with those receiving conservative medical therapy (p<0.01) (Table 2).

Short-Term Outcomes of PPI

PPI was successfully performed in 50 of 55 patients (90.9%). Forty patients were treated by balloon angioplasty alone, and 10 received stent implantation, including 7 Palmatz stents, 4 Easy Wall stents, and 1 Smart stent. Indications for stent implantation were residual stenosis of >30% in 5 patients and flow limiting dissection in 5. Procedural failure was observed in 5 patients, of whom 3 patients were on chronic hemodialysis. The reasons for the failure were unsuccessful wire crossing in 4 patients, and wire perforation in 1 patient. Lesion characteristics of the failed cases were TASC type B lesion in 2 patients, type C in 2, and type D in 1. Four of the 5 patients had chronic total occlusions of SFA.

Upon discharge, a significantly greater number of antiplatelet and anticoagulant agents were prescribed in the PPI group than in the control group (2.27±0.78 vs 1.87±0.81, p<0.05). This was mainly due to the higher number of patients taking ticlopidine in the PPI group compared with the control group (38.2% vs 7.7%, p<0.001). ABI in the PPI group significantly improved from 0.61±0.15 to 0.81±0.20

Table 3 Long-Term Outcomes

	Control (n=52)	PPI (n=55)	p value
Follow-up period (months)	29.6±16.8	31.6±18.1	NS
Fontaine grade at follow-up	2.12±0.18	2.18±0.60	NS
I	0 (0%)	5 (9.1%)	
II	48 (92.4%)	43 (78.2%)	
III	2 (3.8%)	1 (1.8%)	
IV	2 (3.8%)	6 (10.9%)	
ABI at follow-up	0.60±0.19	0.61±0.17	NS
Patients with any events	24 (46.2%)	38 (69.1%)	<0.05
Death from any cause	3 (5.8%)	3 (5.5%)	NS
Amputation	2 (3.8%)	3 (5.5%)	NS
Re-hospitalization related to PAD	8 (15.4%)	29 (52.7%)	<0.001
Bypass surgery	2	5	
PPI	5	15	
Medical therapy	1	9	
New onset of CAD	13 (25.0%)	16 (29.1%)	NS
New onset of CVD	9 (17.3%)	6 (10.9%)	NS

PAD, peripheral artery disease. Other abbreviations see in Table 2.

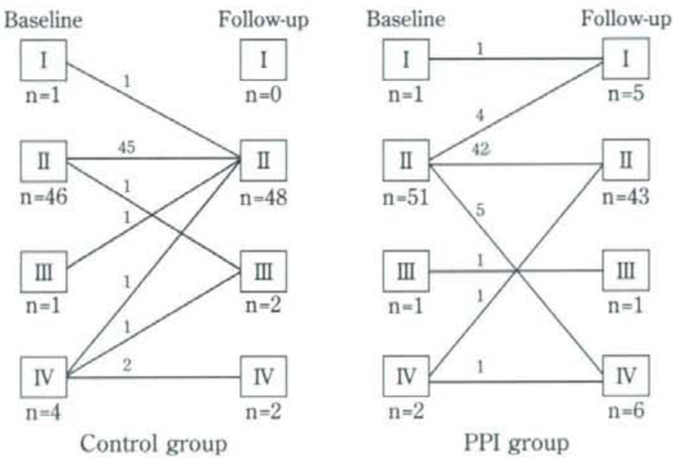

Fig 2. Fontaine grade at baseline and at the last follow-up. PPI, percutaneous peripheral intervention.

(p<0.001), which was also higher than that of the control group (0.61±0.17, p<0.001) (Table 2).

Long-Term Outcomes

Long-term outcomes of patients in both groups are shown in Table 3. The average follow-up periods were 30.6±17.7 months for all patients; 31.6±18.1 months for the PPI group and 29.6±16.8 months for the control group (p=NS). Five patients (9.1%) in the PPI group showed no limb symptoms at follow-up (including 1 patient who had been asymptomatic before PPI), whereas all the control group patients had limb symptoms. On the other hand, 6 (10.9%) of the PPI patients showed ischemic skin ulcer/gangrene at follow-up; 5 of the 6 had been at Fontaine grade II at baseline, and in 2 of these 5 patients PPI was unsuccessful due to distal embolization and perforation. In contrast, in the control group only 2 patients showed such ischemic skin lesions at follow-up. Both of these patients had these lesions at baseline (Fig 2). As a result, the average Fontaine grade at follow-up was not different between the PPI and control groups (2.18±0.60 vs 2.12±0.18, p=NS). The finding that patients receiving PPI showed no long-term improvement in the Fontaine grade compared with medical treatment was further supported by the results of the ABI measurements. At follow-up, ABI of the PPI group returned to the baseline level from 0.81±0.20 to 0.61±0.17, and no statistically significant differences were observed between the PPI and control groups (0.60±0.19, p=NS).

Overall, long-term adverse events were more frequent in the PPI group than the control group. Specifically, adverse events were observed in 69.1% (ie, 38/55) of PPI patients compared with 46.2% (ie, 24/52) of control patients (p<0.05). The increased number of adverse events observed in the PPI group was mainly due to a high frequency of re-hospitalization due to worsening of limb symptoms (52.7% [ie, 29/55] vs 15.4% [ie, 8/52], p<0.001). Among 29 re-hospitalized patients from the PPI group, 15 patients received repeat PPI and 5 had bypass surgery. Restenosis was observed in 36% (18/50) of patients who underwent successful PPI (32.5% [ie, 13/40] after balloon angioplasty and 50% [ie, 5/10] after stent implantation); all 18 patients were re-hospitalized. In the control group, among the 8 patients who were re-hospitalized, 5 patients received PPI and 2 underwent bypass surgery. Fig 3 shows the Kaplan–Meier survi-

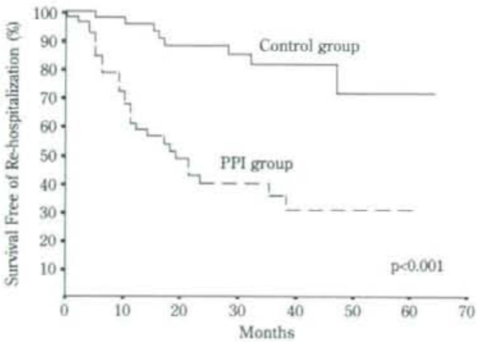

Fig 3. Kaplan–Meier survival curve of patients free from re-hospitalization. The estimated survivals free from re-hospitalization in patients receiving medical therapy (control group: solid line) and percutaneous peripheral intervention (PPI group: broken line) were 95.6% compared with 60.9% at 1 year; and 88.1% compared with 40.0% at 2 years, respectively.

val curve free from re-hospitalization. The survival rate was significantly higher in the control group (solid line) than the PPI group (broken line) ($p<0.001$). The estimated survivals free from re-hospitalization in the control and PPI groups were 95.6% compared with 60.9% at 1 year; and 88.1% compared with 40.0% at 2 years, respectively. Frequencies of death, limb amputation, new onset of coronary artery disease, and new onset of cerebrovascular disease were not statistically different between the 2 groups.

Discussion

Patients with SFA occlusive disease have undergone a shift in management to include PPI as a primary treatment strategy.[9,11,12,14–16] Yet, there are no data showing that PPI provides lasting benefit that is superior to conservative medical therapy.

PPI has been shown to provide an excellent short-term outcome in patients with SFA occlusive disease. The technical success rate of PPI for femoropopliteal artery stenoses exceeds 90% (range, 73–100%).[17] Even for chronic total occlusions, advances in technology have provided high recanalization rates (range, 68–83%).[18] However, long-term patency of balloon-dilated lesions is suboptimal. For example, Muradin et al recently reported the results of a meta-analysis showing that the combined 3-year patency rates after balloon dilation for femoropopliteal lesions was 61% for patients with stenoses and claudication, 43% for those with stenoses and critical limb ischemia, and 30% for those with occlusions and critical limb ischemia.[19] The 3-year patency rates after stent implantation were similar, ranging from 63% to 66%, and were independent of clinical indication and types of lesions.[19] The short- and long-term results of PPI in the present study are comparable to these previous studies. Procedural success was achieved in >90% of patients, and ABI increased by >30%. Restenosis, however, developed in as many as 36% of patients, reducing the long-term success of PPI. As a result, no long-term benefits, including survival and prevention of limb amputation, were achieved when compared with conservative medical therapy. In addition, more than half of the patients receiving PPI were later re-hospitalized. It should be noted that about two-thirds of patients from the PPI group who were re-hospitalized were found to have restenosis. Thus, it is assumed that frequent restenosis after PPI contributed to the increased incidence of re-hospitalization. Although one could argue that more advanced atherosclerosis of the SFA lesions contributed to the more frequent incidence of re-hospitalization in the PPI group, this assumption cannot be supported since patients in the PPI group had less severe lesions than the control group at baseline.

Prospective studies comparing the long-term outcome of PPI compared with medical therapy are limited.[17] Perkins and colleagues reported that despite significant initial improvement in ABI after PPI, there was no significant difference in patients' walking distance between those who had undergone PPI compared with exercise therapy after 70 months of follow-up.[20] Whyman et al also examined the outcome of PPI in patients treated with low-dose aspirin, exercise training, and smoking cessation.[21] After 2 years of follow-up, neither walking distance nor ABI were significantly different between patients who had or had not undergone PPI. It must be noted that these studies included patients with suprainguinal as well as infrainguinal lesions, and were not intended to determine the outcome of PPI for SFA lesions. Considering the fact that PPI for suprainguinal lesions is generally associated with a lower restenosis rate than that for infrainguinal lesions, it appears that PPI for SFA lesions does not achieve a better outcome compared with medical treatment. The current study underscores this assumption by showing that, despite a favorable short-term outcome, PPI does not provide superior long-term benefits compared with conservative medical therapy in patients with SFA occlusive disease, and suggests that medical therapy may continue to remain the primary treatment strategy for this group of patients.

The use of stents in SFA has not been shown to be more beneficial than plain old balloon angioplasty.[16,22–24] Thus, the TASC recommends the use of stents only for short SFA lesions and advise that they be used only in bail-out situations. In the present study, based on this recommendation, stents were used only for bail-out situations, and the long-term outcome was comparable to that of the balloon angioplasty. Schillinger et al recently reported that the use of self-expandable nitinol stents for SFA lesions yielded results that were superior to those of balloon angioplasty.[7] The rate of restenosis on angiography was 24% in the stent group and 43% in the balloon angioplasty group, and at the 1-year follow-up, the rate on duplex ultrasonography was 37% and 63%, respectively. The advantages of nitinol stents include improved radial force, the ability to recover their shape after being crushed, and reduced foreshortening, which allows precise placement. Whether the use of newer-generation stents ultimately leads to better long-term outcomes beyond that presently offered by medical treatment awaits further investigation.

Conclusions

The current study demonstrates that despite a favorable short-term outcome, PPI does not provide superior long-term benefits compared with conservative medical therapy in patients with SFA occlusive disease, suggesting that medical therapy will continue to remain the primary treatment strategy for this group of patients.

Acknowledgments

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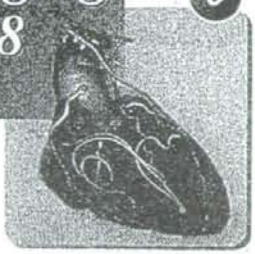

⑤ dual source CTを用いた冠動脈CT angiography

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2管球搭載型CT（dual source CT；DSCT）により，あらゆる心拍数の患者に，83msという高い時間分解能での冠動脈CTが可能となった。本稿では，DSCTを用いた冠動脈CT angiography（CTA）について解説する。

心電図同期機能を搭載したマルチスライスCT（multislice CT；MSCT）の登場により，心臓のCT検査が容易に行えるようになってきた。検出器の多列化がさらに進み，管球の回転が高速化することで，撮影時間の短縮，時間分解能が向上し，冠動脈CTが日常検査として数多く施行されている[1]。しかし，冠動脈は拍動しているうえに，径も細く，全例によい画像が得られるとは限らない。特に，時間分解能の限界により心拍の速い患者では良好な画像が得られないことも多く，検査を低心拍数の患者に限定することや，高心拍数の患者ではβブロッカーの使用も必要となっている[2]。このような状況のなかで，MSCTのさらなる進化形として，1つのCT装置に二組の管球ー検出器システムを搭載したDSCTが登場し，心臓領域への利用が期待されている[3]。本稿では，DSCTの特徴，冠動脈CTAへの応用，その限界について述べる。

DSCTの概要

2005年，世界初のDSCT，SOMATOM Definition（Siemens）が開発され，日本にも2006年から導入された。われわれの施設では2007年から運用をはじめている（図1）。

名前のとおり，DSCTには2つの管球ー検出器システムが搭載されている（図2）。同じSiemens社製の64列MSCT（SOMATOM Sensation）と同様の管球ー検出器システム（Aシステム）と，そのおよそ半分の管球ー検出器システム（Bシステム）が，それぞれ直交した状態で配置されている。通常のCT検査においては，64列MSCTとして，Aシステムのみ使うシングルスソースモードを用いる。

2つのシステムを同時に使うdual sourceモードとしては，時間分解能を向上させ，主に心臓に用いられるcardiacモード，2つの異なる管電圧の画像を同時に得ることのできるdual energyモード，肥満患者など高線量の撮影が可能なdual powerモードがある。

なぜDSCTなのか

MSCTの時間分解能（図3）

CTの時間分解能は，管球回転時間に依存し，管球が高速で回転すればするほど，時間分解能が向上する。シングルスライスCTの時代は1秒ほどであった管球回転時間が，現時点でのMSCTでは，最速で0.3秒前後まで高速化されてきた。CTでは，患者のまわりを管球ー検出器システムが回転し，その1回転分のデータから画像を再構成することが多い。これをフル再構成という（図3a）。この

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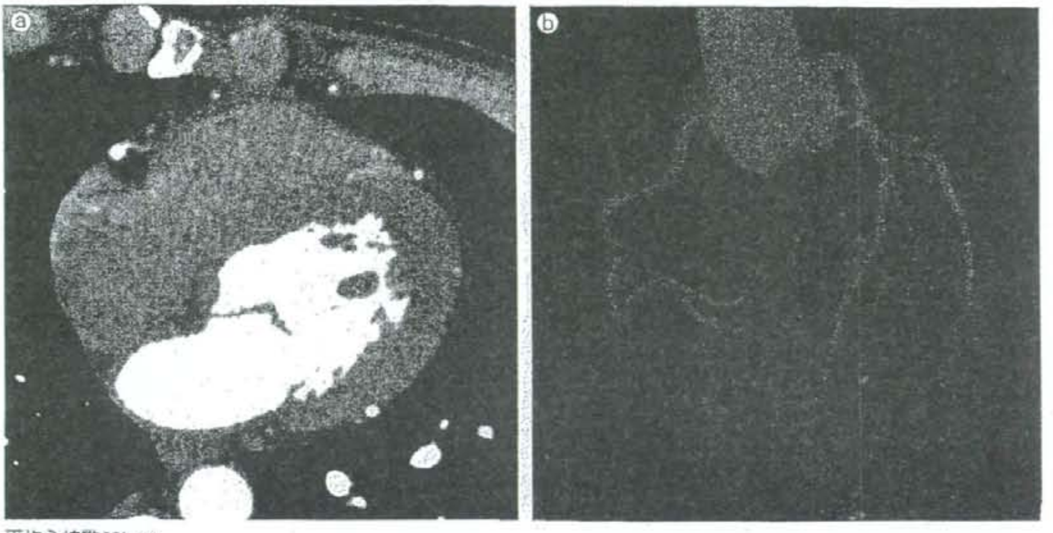
図1　DSCTによる冠動脈CTA（筆者の施設での第一症例）



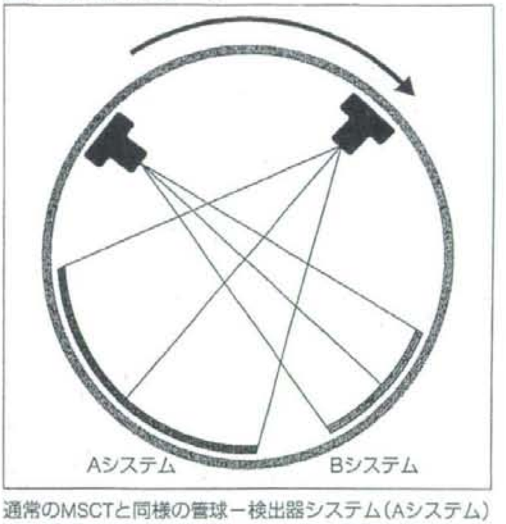
平均心拍数68bpm。
a：元画像
ぶれのない冠動脈が描出されている。
b：MIP像
連続性のよい良好なCTA。

場合の時間分解能は，管球－検出器システムの1回転分と等しくなる。

ハーフ再構成

この時間分解能では，心臓の静止画像を得ることは困難であり，再構成方法の工夫により時間分解能短縮が行われている。1回転分のデータを使うフル再構成に対して，ハーフ再構成とよばれる方法である（図3b）。例えば12時方向から照射されたデータと6時方向から照射されたデータは同じ情報を有するため，180°分のデータからも画像を作成することができ，この再構成法をハーフ再構成という（180°のデータでは中心点しか再構成できないため，厳密には180°と検出器分の角度を合わせたデータが必要）。これにより，時間分解能は管球回転時間の半分となり，0.33秒の装置では，0.17秒の分解能を得ることができる。低心拍数の患者では，拡張中期～後期に動きが遅い時間があるので，この時間分解能でも対応できるが，高心拍数になると，静止する時間が短くなり，CTの分解能をさらに向上させる必要がある。

図2　DSCTのシェーマ

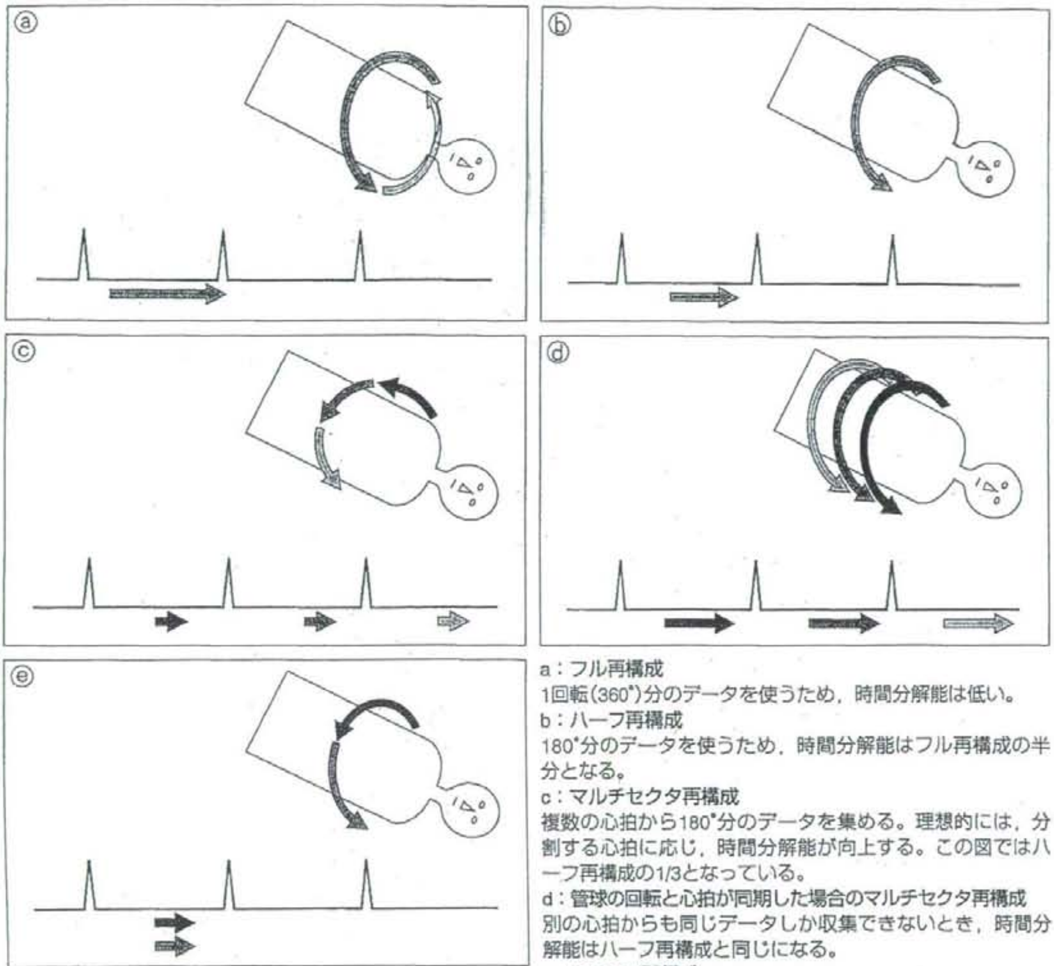


通常のMSCTと同様の管球－検出器システム（Aシステム）と，検出器の幅がその半分のBシステムが直交に配置されている。

マルチセクタ再構成

そのために，複数の心拍からのデータを収集し，合わせて180°分のデータを得る方法がある。これをマルチセクタ再構成という（図3c）。データの分割数が多いほど時間分解能が向上するが，いくつか問題がある。複数の心拍の情報から画像をつくるため，画像にぶれを生じる要因となる。また，データを重複して収集する必要があるため，被ば

図3　MSCTにおける再構成のシェーマ



a：フル再構成
1回転(360°)分のデータを使うため，時間分解能は低い。
b：ハーフ再構成
180°分のデータを使うため，時間分解能はフル再構成の半分となる。
c：マルチセクタ再構成
複数の心拍から180°分のデータを集める。理想的には，分割する心拍に応じ，時間分解能が向上する。この図ではハーフ再構成の1/3となっている。
d：管球の回転と心拍が同期した場合のマルチセクタ再構成
別の心拍からも同じデータしか収集できないとき，時間分解能はハーフ再構成と同じになる。
e：DSCTの再構成
直交する2つの管球－検出器システムが90°ずつ回転すれば，180°分のデータを得ることができる。時間分解能はハーフ再構成の半分となる。

くが多くなる。さらには，心拍と管球の回転が同期すると時間分解能が向上しないため(図3d)，苦手な心拍数が存在し，さらには，心拍数が変動するとさまざまな時間分解能の画像が存在することとなる。多くの装置では，低心拍の患者にはハーフ再構成を，高心拍の患者にはマルチセクタ再構成を使用しているが，高心拍への対応には限界があるため，βブロッカーの使用により心拍のコントロールをする必要がある。

DSCTの再構成

一方，DSCTにおいては，Aシステム，Bシステムのそれぞれが90°回転すれば，180°分のデータを得ることができる(図3e)。したがって，時間分解能は管球回転時間0.33秒の1/4，すなわち83msとなる。この83msという分解能はハーフ再構成にて得られているため，マルチセクタ再構成で問題となる心拍と管球の同期による時間分解能の低下は生じない。患者の心拍数に依存することなく，常に83msの時間分解能を得られることが，

DSCTの特筆すべき点である。

冠動脈CTへの応用

この優れた時間分解能により，DSCTは心臓の検査，特に冠動脈狭窄の診断に期待がされている。すべての心拍数において，83msの時間分解能が得られることから，βブロッカーを使用しない冠動脈CTが可能とされる[4]。

冠動脈CTAの実際とコツ

われわれの施設におけるDefinitionを用いた冠動脈CTAの実際を紹介する(図4)。DSCTを用いているため，高心拍数の患者においても検査を実施しているが，検査の流れとしては，ほかのMSCTによる冠動脈CTと大差はないと思われる。

検査のはじめに，今日の検査の大まかな内容を説明するとともに，造影剤に対する過敏症の有無を確認する。心電図を装着し，ルートを確保した後，硝酸薬を舌下投与する。高心拍数の患者に対してもβブロッカーは用いず，撮影時間も短いため酸素の投与はしない。心房細動症例も検査を行っている。BシステムのFOV(field of view)が26cmと設定されているため，このなかに心臓が入らないと，DSCTとしての時間分解能を発揮できない。

図4　検査の流れ

ポイント 心臓がガントリーの中心になるようにポジショニングをする。検査中の呼吸停止を安定させるため，腹部を圧迫し，数回の息止め練習を行った後，撮影に移る。

まず，胸部全体のスカウト像(トポグラム)を撮影し，これをもとに，心電図非同期の胸部単純CT，冠動脈CTAをつくるための心電図同期造影CT(冠動脈CT)を撮影する。胸部単純CTにより，冠動脈CTの厳密な撮影範囲設定も可能だが，呼吸のずれを考慮し,上下とも余裕をもたせている。具体的には，冠動脈が確認できる最も頭側のスライスの2cm上から，心臓が確認できる最も足側のスライスの2cm下までを，冠動脈CTの撮影範囲としている。

造影剤の到達と，CTの撮影タイミングを合わせるために，bolus tracking法(CARE Bolus)を用いている。胸部単純CTにてモニタをする断面(上行大動脈)を決める。モニタ中は呼吸停止をしていないため，呼気撮影に近い状態となる。同じ寝台位置ならば，吸気で撮影される胸部CTと比べて，少し足側の断面にずれる点に注意し，モニタの断面を決定する。

造影剤は，高濃度非イオン製造影剤(350mgI/m*l*または370mgI/m*l*)を使用している。まず，患者の体重により注入速度を決定する(毎秒0.06m*l*/kg，最低毎秒3m*l*，最高毎秒5m*l*)。Definitionでは患者の心拍数に合わせ,寝台速度の最適化が行われる。常にハーフ再構成が行われるため(2心拍から再構成を行うバイセグメント再構成も搭載されているが，筆者の施設では使用していない)，低心拍数の患者では寝台速度は遅くなり，高心拍数の患者では寝台速度は速くなる。撮影プログラムを最終決定するまでは，心拍に応じ，寝台速度が常に最適化されている。

ポイント 造影剤の設定を早めに行うと、実際の撮影と食い違うこともあるので、造影剤の設定はプログラムの最終決定後に行う。前述のとおり冠動脈CTの撮影範囲を決定すると，患者ごとの撮影時間が決まる。この撮影時間に6秒を加えた

時間を造影剤の注入時間とし，同じ速度の生理食塩水で後押しをする。

上行大動脈にて，造影剤の到達をモニタし，CT値が単純CTよりも100上昇した時点で，自動的に冠動脈CTの撮影がはじまる。寝台の移動，呼吸停止の指示が間にあるため，造影剤が目標値に達してから冠動脈CTの撮影開始まで約6秒を要する。これが，造影剤注入時間の，プラス6秒に相当している。心機能が低下し，通常よりも造影効果が低いと予想される例や，上行大動脈瘤患者で，撮影の開始が遅れると予想される場合には，注入速度を速くする，あるいは注入時間を延長するなどの工夫をしている。撮影後は，撮影範囲や造影効果などに問題がないことを確認し，検査を終了する。

ポイント 三次元処理用の元画像として，冠動脈が静止した画像を得る必要があるが，Definitionには，自動で拡張期と収縮期の最適時相を検索するプログラムが搭載されており，まず，これを用いた再構成を行う。つくられた画像をモーションアーチファクトに注意をしながら観察し，三次元像に適さないと判断した場合には，マニュアルにて冠動脈が静止した時相を探し出すこととなる。

マニュアルでの最適時相の画像を作成する方法として，ある一断面での多時相再構成を行い，アーチファクトの最も少ない最適時相を決定し，その時相での心臓全体の再構成を行う。具体的には，右冠動脈のAHA分類セグメント1または2と，左前下行枝がともに描出されている断面を選択し，R波を中心として，－500～＋500msまでを50msごとに再構成を行い，モーションアーチファクトの少ない時相を探す。さらにその時相の前後を，5msごとに細かく再構成し，最適時相を決定する。この方法では，心臓のなかの1つの断面しか観察していないので，ほかの断面ではアーチファクトが残り，冠動脈CTAとしては最適でない可能性もある。したがって，再構成像を再び観察し，三次元処理に不適当と判断した場合には，ほかの時相でも再構成を行うことや，ほかの断面での最適時相の検索も考える必要がある。

期外収縮が生じた場合，その心拍を再構成からはずす，あるいは基準としているR波をマニュアルで変更する，さらにはダミーのR波を追加するなどして，できるだけ連続性のよい画像を作成する。

心房細動で，RR間隔が一定でない場合，はじめから心臓全体の多時相再構成を行い，ワークステーション上で四次元像として観察し，最もずれの少ない時相を選択している（図5）。R波の直前と収縮末期に，良好な画像が得られる場合が多い。

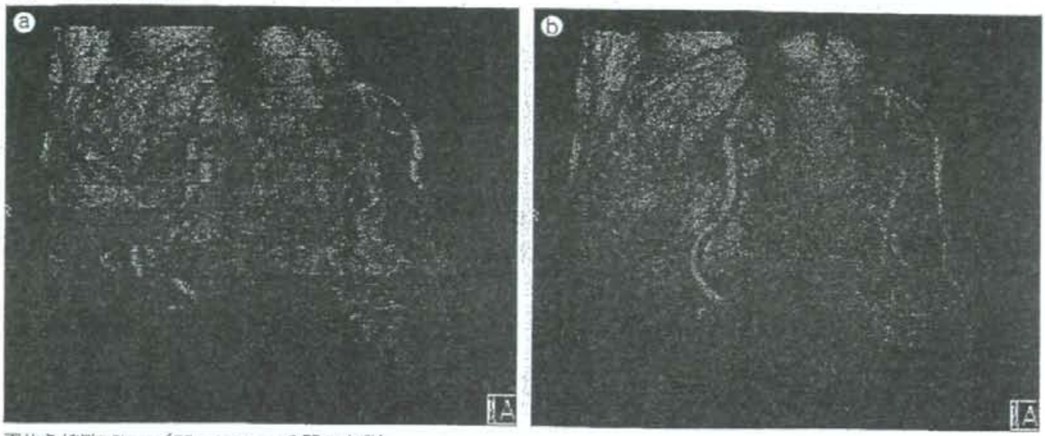
DSCTによる冠動脈CTAの診断能

DSCTによる冠動脈CTAの診断能を調べるため，心臓カテーテル検査(coronary angiography；CAG)との比較を行うため，日常診療のなかでCTとCAGを両方行う患者群として，大動脈瘤の術前患者を選択した。大動脈瘤患者においては，手術適応や術式の検討のため，胸腹部造影CTを行っている。そのCTに冠動脈CTを組み込むことで，患者の負担を減らした。また，冠動脈CTAにより，正常冠動脈と診断できる場合は，CAGを省略した。

研究に対し文章による同意が得られた大動脈瘤術前患者，連続20症例を解析した。男性：13例，女性：7例。平均年齢：70.4歳(40～83歳)。平均心拍数：66.0bpm(43～107bpm)。心房細動患者は除外した。

2mm以上の径を有する冠動脈のセグメントに対して，CTAでの評価可能なセグメントの割合を求めた。全244セグメント中，診断可能なセグメントは232セグメント(95.1%)であった。このうち，CAGとの比較ができたセグメントに関しては，50%を超える狭窄の有無を判断し，CAGと比較した。結果を表1に示す。心拍数のコントロールをしていない条件下で，高い診断能が得られた。

図5　心房細動症例



平均心拍数75bpm（55〜109bpmの間で変動）。
a：RR間隔の相対値で心時相を決定すると，1回ずつの拍動が異なるため，バンディングアーチファクトが多い画像となる。
b：R波からの絶対遅延により心時相を決める。多時相の再構成を行い，4Dにて，最もアーチファクトの少ない時相で再構成を行う。
aの画像でも，ハーフ再構成による高い時間分解能を実現しているため，1つ1つの心拍内では，比較的アーチファクトの少ない像が得られている。

表1　DSCTを用いたCTAの診断能：CAGとの対比

		CAG	
		狭窄なし	狭窄あり
CTA	狭窄なし	164	2
	狭窄あり	6	23

感度：92%，特異度：96.5%，正診断率：95.9%，陰性予測率：98.8%，陽性予測率：79.2%

DSCTによる冠動脈CTAの限界

DSCTを用いた冠動脈CTAは，高心拍数症例や心房細動症例においても実施可能で，良好な画像が得られることはすでに述べた。われわれの施設で検査を行わないのは，①造影CTの同意が得られない，②ヨード造影剤に対する過敏症，③呼吸停止ができない，のいずれかに該当する場合である。

いかに時間分解能が高いDSCTとはいえ，心臓全体を撮影するためには何心拍分かのデータが必要となる。そのため，呼吸停止ができないと心拍間のずれが顕著となり，診断が不可能になる。撮影したが，呼吸停止が不十分な場合，再構成をやり直しても良好な画像は得られない。MPRで横隔膜や胸骨に注意して，呼吸停止不良と判断した場合は，再構成や三次元像の作成に時間をかけすぎないようにしている。

バンディングアーチファクト

心臓全領域を同時に撮影しない限り，つまり，何心拍かかけて心臓をカバーする場合，異なる心拍間でのずれ（バンディングアーチファクト）が生じうる。ハーフ再構成とマルチセクタ再構成を比較した場合，複数の心拍から画像をつくるマルチセクタ再構成のほうが，バンディングアーチファクトは軽減する。DSCTにおいては，通常はすべてハーフ再構成を用い，さらに1枚1枚の分解能が高いため，バンディングアーチファクトが目立つ印象を受ける。

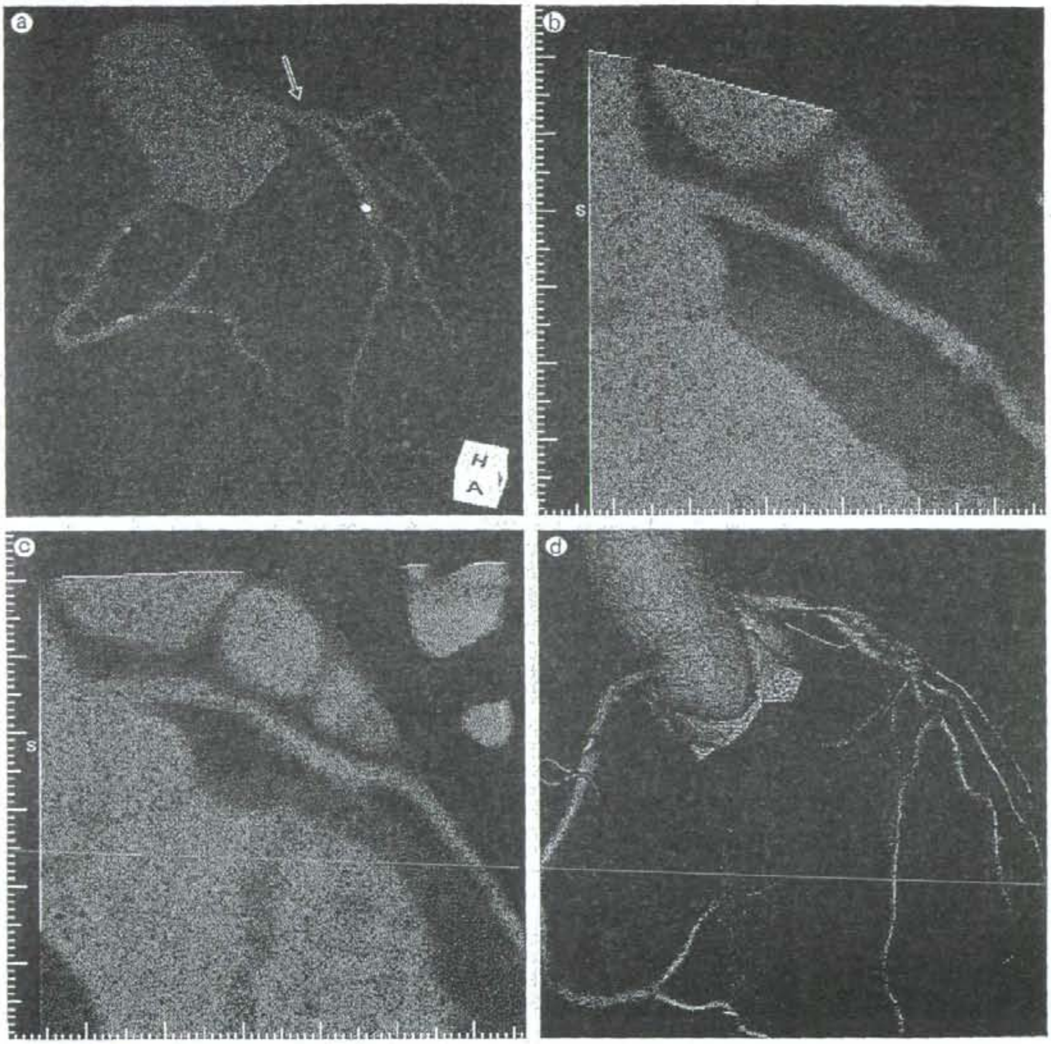
バンディングアーチファクトは，MIP（maximum intensity projection）やCPR（curved planar reformation）で狭窄様にみえるため，狭窄を認めた場合には，アーチファクトかどうかを必ず確認しなければならない。バンディングアーチファクトを確認しやすい方向，つまり正面や左右などから観察できるようにして，アーチファクトかどうかを確認する。バンディングアーチファクトの前

後とも狭窄がない場合，その部分は狭窄なしと判断したほうが正診率は高くなる(図6)。

▥石灰化とステント

DSCTに限らず，冠動脈CTに大きな障害となるのが，冠動脈の石灰化やステントである。石灰化やステントの近傍はビームハードニングアーチファクトやブルーミングアーチファクトにより，内腔の評価が困難となる。したがって，高度石灰化症例に冠動脈CTを行うかどうかは，検討の余地がある。われわれの施設では，PCI前の治療計画用，冠動脈バイパス術後のバイパス評価など，目的が明らかでその評価が可能な場合には検査を行っているが，冠動脈狭窄のスクリーニングとして

図6　バンディングアーチファクト

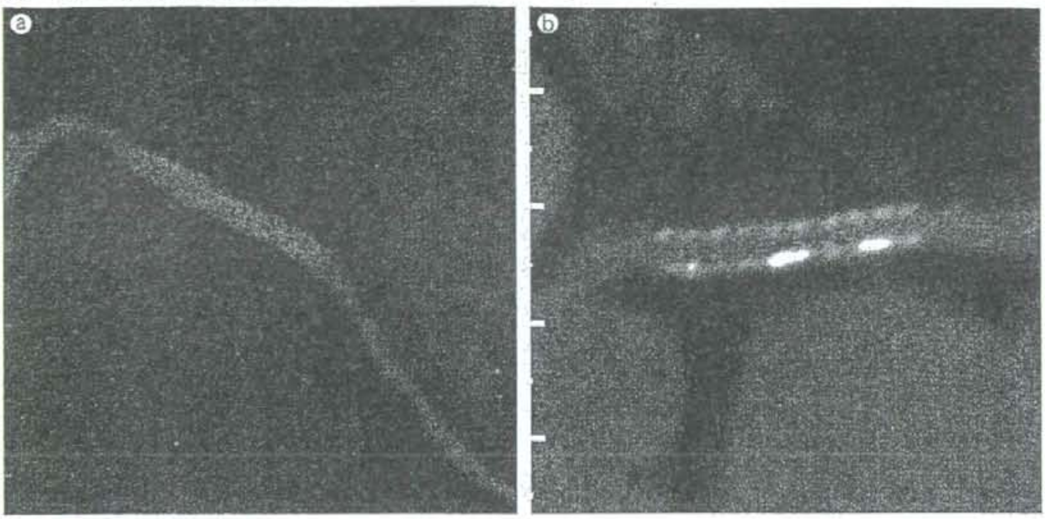


平均心拍数60bpm(48〜55bpmまで変動)。
a：MIP像
LCX起始部の狭窄が疑われる(↑)。
b，c：CPR
LAD近位部(b)，LCX起始部(c)に狭窄が疑われる。
d：VR像
大動脈から左冠動脈近位へと連なる段差を認める。バンディングアーチファクトによる偽狭窄と考えられる症例。

は不十分なので，単純CTのみで検査を終了することもある。

石灰化を伴う領域やステント内の診断能の向上は，これからの課題でもある[5]。ステント内の描出は，ステントの材質，ステントストラットの厚さ，ステント径により，左右される(図7)。アーチファクトを軽減するためには，時間分解能を向上し，石灰化やステントの「ぼけ」を軽減すること，空間分解能を向上し，石灰化やステントの部分容積効果を軽減することがあげられる。DSCTは高い時間分解能と空間分解能をもつため，石灰化症例に対しても比較的有利と考えるが，満足できる域には達していない。DSCTのdual energyモードを用い，石灰化除去の試みも行われているが，この場合，時間分解能を犠牲にする必要があり，研究段階にあるといえる。現時点でも行える工夫としては，再構成関数の調節がある。普通はMIPやCPR用に比較的スムースな関数(Definitionでは B26f)を用いているが，これは，ステントや石灰化の影響を大きく受ける。高分解能の再構成関数

図7 ステント留置例の冠動脈CPR



a：Multi-Link Vision 3.0mm径
ステント内が均一に造影され，再狭窄なしと判断できる。
b：Velocity 3.5mm径
ステント内の造影は不均一で，再狭窄の可能性が残る。

BLACKBOARD

冠動脈CTAをつくるには，①心臓CTを撮影する，②元画像を再構成する，③三次元画像処理を行う，などの要素が必要である。「よい冠動脈CTA」を得るためには，①よい状態の心臓を撮影する，②冠動脈が静止した時相を探し，再構成する，③三次元像処理に手間をかける，と，各段階での努力，工夫が必要となる。このうち，いずれかでもおろそかになると，「よい冠動脈CTA」は得られない。ここでの「よい心臓」とは，冠動脈が止まった像が得られる心臓をいい，心拍とCTの時間分解能の相対的な関係で良し悪しが決まる。従来のマルチスライスCTでは，時間分解能の制約から，患者の心拍数を調節し，よい状態の心臓をつくり出していた。DSCTは高い時間分解能を誇るため，患者の心拍に対する許容範囲が広く，「よい冠動脈CTA」を得るため非常に有用な手段の1つである。