Comparison of Hemodialysis Patients and Non-hemodialysis Patients with Respect to Clinical Characteristics and 3-year Clinical Outcomes after Sirolimus-eluting Stent Implantation: Insights from the Japan Multi-center Post-marketing Surveillance Registry

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Abstract

Aims: Long-term outcomes after sirolimus-eluting stent (SES) implantation in hemodialysis (HD) patients have remained controversial. We investigated the impact of HD on outcomes after SES implantation.

Methods and Results: We analyzed the data on 2,050 patients who underwent SES implantation in a multi-center prospective registry in Japan. Three-year clinical outcomes were compared between the HD group (n = 106) and the non-hemodialysis (NH) group (n = 1,944). At the 3-year clinical follow-up, the rates of unadjusted cardiac mortality (HD: 16.3% vs. NH: 2.3%) and target-lesion revascularization (TLR) (HD: 19.4% vs. NH: 6.6%) were significantly higher in the HD group than the NH group ($p < 0.001$) but the difference in stent thrombosis between both groups (HD: 2.0% vs. NH: 0.7%) did not reach statistical significance. Using Cox's proportional-hazards models with propensity score adjustment for baseline differences, the HD group had higher risks of TLR (HD: 16.3% vs. NH: 6.1%; hazard ratio, 2.83; 95% confidence interval [CI], 1.62 to 4.93: $p = 0.0003$) and cardiac death (HD: 12.3% vs. NH: 2.3%; hazard ratio, 5.51; 95% CI, 2.58 to 11.78: $p < 0.0001$). The consistent results of analyses, whether unadjusted or adjusted for other baseline clinical and procedural differences, identify HD as an independent risk factor for cardiac death and TLR.

Conclusions: Percutaneous coronary intervention with SES in HD patients has a higher incidence of repeat revascularization and mortality compared with those in NH patients. HD appears to be a strong independent risk factor of mortality and repeat revascularization even after SES implantation.

Key Words: drug-eluting stent, percutaneous coronary intervention, hemodialysis, long-term outcome

Introduction

Annual data reports show that the prevalence of end-stage renal disease (ESRD) is increasing in the United States and Japan (1, 2). Approximately half million patients were either on dialysis or had undergone transplant, and approximately 350,000 (70%) of these patients were dialysis patients in the United States (1). Approximately 250,000 patients were on dialysis in Japan (2). Compared with the previous year, there was a moderate increase in the number of dialysis patients both in the United States and Japan (increases of 3.4% and 4.0%, respectively). In addition, the number of patients returning to dialysis after a failed kidney transplant also increased reaching 5,578 patients in the year 2006 (a 34% increase since 2000) in the United States (1). Patients with ESRD have a high mortality rate (annually 20-30% in the United States and 10% in Japan) and the appropriate choice of treatments for these patients is an important medical issue worldwide (1, 2).

ESRD while on hemodialysis (HD) is an important risk factor for mortality and clinical outcome after percutaneous coronary intervention (PCI) in patients with coronary artery disease (3-8). Furthermore, PCI in HD patients is more complex and difficult to perform than in non-HD (NH) patients because of massive coronary calcification and presence of multiple lesions (9, 10). Previous randomized trials have

shown that the use of sirolimus-eluting stents (SES, Cypher™ stent; Johnson & Johnson/Cordis, Miami, USA) markedly reduce the risk of in-stent restenosis compared with standard bare-metal stents (BMS). However, patients with ESRD have been excluded from previous randomized trials (11-14). The use of SES has been recently reported to remarkably reduce restenosis after implantation in patients at high risk for in-stent restenosis compared with BMS in the real world (15-20). However, it remains unclear whether the use of SES after PCI in HD patients has long-term efficacy and safety similar to those of NH patients. In the present study, the 3-year clinical outcome after PCI with SES in HD patients was compared with that of NH patients in the Japan multi-center post-marketing surveillance registry.

Methods

Study Design and Patients Selection. We analyzed the medical records of 2,050 consecutive patients who underwent PCI with SES at 50 institutions in Japan from September 2004 to September 2005. Only patients treated with SES during this period were included in the study. Patients were divided into HD (n = 106) and NH (n = 1,944) groups. Risk factors and history of previous cardiovascular disease were reviewed. Diabetes mellitus (DM) was defined as hyperglycemia requiring insulin and/or oral hypoglycemic drug treatment, according to Japan Diabetic Society diagnostic criteria

for DM (fasting blood glucose > 126 mg/dL, or random blood glucose or 2-h blood glucose in a 75-g oral glucose tolerance test of > 200 mg/dL). Hyperlipidemia was defined as receiving lipid-lowering therapy and/or the presence of a total serum cholesterol ≥ 220 mg/dL or serum triglycerides ≥ 150 mg/dL. Hypertension was defined as receiving medication to lower blood pressure or measured blood pressure values of ≥ 140 mmHg systolic or ≥ 90 mmHg diastolic on two or more occasions. Left ventricular ejection fraction (LVEF) was measured by echocardiography or angiography during hospitalization.

Procedures. PCI was performed following the current clinical practice standards after obtaining written, informed consent. Patients received single or multiple SES for various lesions with or without predilatation or the use of ablative devices for plaque modification. Intravascular ultrasound was employed for guiding the procedure in 72.3% (1,482/2,050) of cases. After SES implantation, angiographic optimization was performed by high-pressure dilatation to achieve an acceptable angiographic result with < 30% residual stenosis. All patients received aspirin 81 - 200 mg/day before the procedure and it was continued indefinitely. Additional antiplatelet therapy with 200 mg ticlopidine daily was instituted in all patients except only 2 patients treated with 75 mg clopidogrel daily. They were advised to continue for at least 3 months. The rates of

aspirin and ticlopidine (or clopidogrel) usages at the end of the 3-year follow-up were 85.1% and 41.3%, respectively. Glycoprotein IIb/IIIa inhibitor was not used because it is not approved in Japan.

Outcome definitions. After discharge, patients were clinically followed up by medical appointment at 3 months, 8 months, 1 year, 2 years, and 3 years. Death was defined as all cause or cardiac mortality. At 8 months, the protocol-mandated angiography was performed. MI was defined as evidence of two or more of the following: 1) typical chest pain > 20 minutes not relieved by nitroglycerin, 2) serial electrocardiogram recordings showing changes from baseline in ST-T and/or Q-waves in two or more contiguous leads, and 3) total serum creatine phosphokinase level greater than twice the upper limit of normal. If no information to judge classification of MI was available, it was classified as unknown MI. Target-lesion revascularization (TLR) and target-vessel revascularization (TVR) were defined as repeated percutaneous or surgical intervention of the treated lesion or vessel, respectively, and were clinically driven. Target-vessel failure was defined as TVR, MI, or cardiac death that could not be clearly attributed to a vessel other than the target vessel. Major adverse cardiac events (MACE) were defined as death, MI, emergency coronary artery bypass graft surgery (CABG), or repeat revascularization. The occurrence of stent thrombosis (ST), definite and probable, was

assessed according to the Academic Research Consortium definitions (17).

The primary end point for this analysis was cardiac death or TLR during the time frame from stent implantation until the end of the 3-year follow-up. The secondary end point for this analysis was the occurrence of all-cause death, ST, MI, TVR, target vessel failure, or MACE during the time frame from stent implantation until the end of the 3-year follow-up.

Clinical follow up. A dedicated data coordinating center performed the data management and analyses. Follow-up information of the study population was obtained from outpatient clinic visits, a review of the medical records, or a telephone interview with the patient. The follow-up rates of angiography at 8 months and of clinical outcomes at 1-, 2- and 3-years were 85.4%, 97.9%, 97.1%, and 94.7%, respectively. All MACE were confirmed by independent board physicians who were not involved in the procedures.

Statistical analysis. The clinical and angiographic characteristics and the proportion of MACE were compared between the 2 groups. Continuous data were expressed as mean ± SD. The Student's t-test was used to compare continuous variables and the Fischer's exact test was used to compare categorical variables. A p value < 0.05 was considered to be of statistical significance. Event-free survival curves were constructed using

Kaplan-Meier curves. These curves were compared using the log-rank test. To adjust for potential confounders, a propensity score analysis was performed by use of logistic regression models. It was reported that the bias of propensity score model depended on the strength of the association of exposure with the outcome, however it did not depend on the number of events per confounder variables (21). Therefore, we tested all available variables that were thought could be of potential relevance, such as age, gender, indication of PCI, previous MI, previous PCI, previous CABG, diabetes, insulin-treated diabetes, hyperlipidemia, hypertension, family history of coronary artery disease, current smoker, obesity, cerebrovascular disease, peripheral vascular disease, multi-vessel disease, target vessel, ACC/AHA classification type B2/C, in stent restenosis, bifurcation, eccentric, lesion angulation ≥45°, moderate/ severe calcification, ostial, total occlusion, chronic total occlusion, intravascular ultrasound (IVUS) usage, direct stenting, Rotablator, total stent length, number of SES deployment, number of lesion, post dilatation, reference vessel diameter, lesion length, and percent diameter stenosis (%DS) after procedure. The score was then incorporated into subsequent proportional-hazards models as a covariate. Cox's proportional-hazards models adjusted with the propensity score were also used to assess the relative risks of cardiac death and TLR. Propensity score adjusted event-free survival curves were also constructed. We

conducted Cox's proportional hazard model to identify independent risk factors of cardiac death and TLR in all patients, the HD group and the NH group to 3-years. The variables of multivariate analysis were determined by stepwise selection with an entry and exit criterion for each candidate of P<0.100 from patients' background and lesion characteristics. Quantitative coronary analyses were performed using the CASSII software (Pie Medical) or QCA-CMS software (MEDIS). All analyses were performed using SAS version 9.1 for Windows (SAS Institute, Cary, North Carolina).

Results

Clinical findings. The patients' baseline clinical characteristics are summarized in Table 1. There were no significant differences in mean age, gender distribution, and the prevalence of previous MI and previous PCI between the 2 groups. There was a higher prevalence of LVEF < 30% ($p < 0.001$), previous CABG ($p = 0.015$), DM ($p < 0.001$), and peripheral vascular disease ($p = 0.003$) in the HD group, while patients in the NH group had a higher prevalence of obesity ($p < 0.001$) and hyperlipidemia ($p < 0.001$). Furthermore, the HD group had a higher incidence of multi-vessel disease ($p = 0.015$).

Angiographic characteristics. The angiographic and procedural characteristics are shown in Table 2. The HD group had a significantly higher incidence of RCA lesions while the NH group had a significantly higher incidence of LAD lesions. The HD group

had a significantly higher incidence of ACC/AHA classification type B2/C lesions, eccentric lesions, and moderate/severe calcification lesions. In terms of procedural characteristics, the HD group had greater use of rotational atherectomy and a higher mean maximum deployment pressure while it had a lower frequency of direct stenting. There were no significant differences in the frequency of IVUS usage, overlapping stenting, diameter of stent, total stent length, and stent/patient and stent/lesion ratios.

Quantitative coronary analyses at baseline and at 8 months of follow-up. There was a significant difference of the angiographic follow-up rate between HD and NH groups (HD: 71.7% vs. NH: 86.2%; $p<0.001$). The HD group had a larger mean minimal luminal diameter with a larger mean reference diameter at baseline. Mean minimal luminal diameter after procedure, %DS before and after procedure, and acute gain were similar for both groups. After 8 months of follow-up, the HD group had a smaller mean minimal luminal diameter and larger %DS. Consequently, mean late loss and binary restenosis rates in the HD group were higher than those in the NH group (late loss: 0.49 ± 0.89 mm vs. 0.14 ± 0.56 mm; binary restenosis: 26.4% vs. 8.2%, respectively; $p < 0.001$ for both).

Clinical follow up at 3 years. The clinical outcomes are presented in Table 4. At the 3-year follow-up, the primary outcomes of cardiac mortality and TLR rates, and the

secondary outcomes of all-cause mortality, MACE, TVR, non-target lesion TVR, and TVF were all significantly higher for the HD group than the NH group. On the other hand, there was no statistically significant difference in MI rate between the 2 groups at 3 years. The difference in stent thrombosis between both groups (HD: 2.0% vs. NH: 0.7%) did not reach statistical significance at 3 years. Figure 1 shows the 3-year Kaplan-Meier plots of event-free survival for TLR (Fig.1a), cardiac death (Fig. 1b), all-cause death (Fig. 1c) and MACE (Fig.1d) after SES implantation for the HD group and the NH group.

Propensity score adjustment. Univariate analysis revealed HD as a risk factor for cardiac death (hazard ratio [HR], 8.48; 95% confidence interval [CI], 4.77 to 15.10: $p < 0.0001$) and TLR (HR, 4.42; 95% CI, 2.84 to 6.90: $p < 0.0001$). Using Cox's proportional-hazards models with propensity score adjustment to further investigate the impact of the baseline characteristic of HD, HD was found to be a strong factor of cardiac death (HR, 5.51; 95% CI, 2.58 to 11.78: $p < 0.0001$) and TLR (HR, 2.83; 95% CI, 1.62 to 4.93: $p = 0.0003$). Figure 2 shows comparisons of propensity score–adjusted 3-year cumulative incidence curves for cardiac death and TLR for the HD and the NH groups. The HD group had a significantly higher risk of TLR (HD: 16.3% vs. NH: 6.1%; $p = 0.0003$; Fig 2a) and a significantly higher risk of cardiac death (HD: 12.3% vs.

NH: 2.3%; $p < 0.0001$; Fig 2b). In short, hemodialysis was an independent strong predictor of cardiac events such as cardiac death or TLR after SES implantation.

Independent risk factors of cardiac death and TLR to 3 years of follow-up. The multivariate analysis of independent risk factors for all patients showed that hemodialysis (HR, 7.23; 95% CI, 3.47 to 15.06; $p < 0.001$), LVEF < 30% (HR, 4.48; 95% CI, 2.14 to 9.38; $p < 0.001$), age ≥ 75 years (HR, 2.23; 95% CI, 1.20 to 4.17; $p = 0.012$), previous MI (HR, 2.15; 95% CI, 1.14 to 4.04; $p = 0.018$), moderate/ severe calcification (HR, 2.01; 95% CI, 1.04 to 3.92; $p = 0.039$), and acute myocardial infarction (HR, 3.59; 95% CI, 1.05 to 12.26; $p = 0.042$) increased the risk of cardiac death to 3 years, while hemodialysis (HR, 4.67; 95% CI, 2.85 to 7.66; $p < 0.001$), reference diameter < 2.5 mm (HR, 1.79; 95% CI, 1.24 to 2.60; $p = 0.002$), lesion length > 30mm (HR, 1.82; 95% CI, 1.14 to 2.93; $p = 0.013$) and ostial lesion (HR, 1.67; 95% CI, 1.09 to 2.55; $p = 0.018$) increased the risk of TLR to 3 years.

The multivariate analysis of independent risk factors for the HD group showed that LVEF < 30% (HR, 4.41; 95% CI, 1.44 to 13.50; $p = 0.009$) increased the risk of cardiac death to 3 years, while moderate/ severe calcification (HR, 4.29; 95% CI, 1.51 to 12.15; $p = 0.006$), male (HR, 3.59; 95% CI, 1.10 to 11.77; $p = 0.035$) and DM (HR, 8.99; 95% CI, 1.17 to 69.3; $p = 0.035$) increased the risk of TLR to 3 years.

The multivariate analysis of independent risk factors for the NH group showed that moderate/ severe calcification (HR, 3.49; 95% CI, 1.66 to 7.35; p = 0.001), LVEF < 30% (HR, 4.07; 95% CI, 1.50 to 11.05; p = 0.006), age ≥ 75 years (HR, 2.51; 95% CI, 1.20 to 5.22; p = 0.014), previous MI (HR, 2.63; 95% CI, 1.18 to 5.88; p = 0.019), and acute myocardial infarction (HR, 4.11; 95% CI, 1.17 to 14.40; p = 0.027) increased the risk of cardiac death to 3 years, while reference diameter < 2.5 mm (HR, 2.19; 95% CI, 1.45 to 3.31; p < 0.001), lesion length > 30 mm (HR, 1.98; 95% CI, 1.21 to 3.22; p = 0.006) and ostial lesion (HR, 1.65; 95% CI, 1.02 to 2.65; p = 0.041) increased the risk of TLR to 3 years. The event risk factors for HD patients after SES implantation were different from those of NH patients.

Discussion

In the present study, we have demonstrated that, 1) SES implantation in HD patients is clinically feasible and safe with a high rate of initial success, and low rates of ST and MI in the long-term; 2) Nonetheless, HD patients still have significantly higher rates of cardiac events (death and TLR) compared with NH patients; 3) Predictors of cardiac events after PCI in HD patients are quite different from those in NH patients; and 4) Propensity score adjustment for baseline differences confirmed and lent further support to the finding that HD is a strong independent predictor of cardiac death and

TLR after SES implantation.

Clinical and Angiographic Characteristics. Overall, HD patients had lower LVEF, and higher incidence of DM, and multi-vessel disease, which are known to be negative prognostic factors, and had a high prevalence of peripheral vascular disease indicating extensive atherosclerosis in these patients. Our findings are consistent with those of several other studies which reported a higher prevalence of risk factors and comorbidities in HD patients (22, 23). On the other hand, HD patients had a lower incidence of hyperlipidemia and obesity in our study.

Although HD patients had a larger reference diameter, PCI in HD patients was more complex and difficult to perform because of a higher incidence of moderate to severe calcified lesions, eccentric lesions, and more frequent need of high pressure dilatation and rotational atherectomy compared with PCI of NH patients. Despite the high prevalence of more complex lesions, our study showed that PCI with SES in HD patients is highly feasible with a delivery success rate of 99.8%.

Long-term Clinical Efficacy. A previous case control study showed that SES use yielded better results than bare-metal stent for prevention of in-stent restenosis after 9 months in HD patients even with long stenting, but the differences were not statistically significant (24). Two non-randomized single-center observational studies

with small numbers of HD patients with follow-up of up to 1 year have been recently reported (25, 26). One study demonstrated a lower rate of in-stent restenosis and TLR and significantly fewer MACE in the SES group compared with the BMS group (25). In another study, there were no significant differences in restenosis, TLR, and MACE rates between SES and BMS in HD patients, although there was a lower percentage of HD patients with DM in this study than in the other studies (26). In short, the results have been variable among several studies and remain controversial (24-26). There was one study that compared HD and NH patients implanted with drug-eluting stents (DES, both SES and paclitaxel-eluting stents) in the real world but the study assessed clinical outcomes for 6 months only (27). To date, there are no data on the long-term efficacy and safety of DES in a study with a large number of HD patients. Although we did not compare SES with BMS in HD patients, TLR rates of 15.8% for the 1-year, 18.2% for the 2-year, and 19.4% for the 3-year follow-ups were acceptable and lower than those for bare-metal stents in previous studies in HD patients. This indicates that SES is sufficiently efficacious for HD patients; however, HD patients remain high-risk patients for repeat revascularization even after SES implantation.

In multivariate analysis, moderate to severe calcification was a predictor of TLR after SES implantation in HD patients. Although this post-marketing surveillance

study was not designed to evaluate the precise mechanism of restenosis, this result may be due to any one ore more of the following 4 factors: 1) Sirolimus is not effective or the sirolimus dose of SES is insufficient for calcified atherosclerotic lesions; 2) There is decreased efficacy due to a defect in the polymer; 3) Stent fracture; and 4) Stent under-expansion. The present study did not address in detail the factors involved in in-stent restenosis after SES implantation in HD patients. Therefore, there is no information regarding stent fracture for in-stent restenosis. Although mean minimal luminal diameter and %DS immediately after SES implantation was angiographically similar for HD and NH patients, there is no detailed data analysis with IVUS in the present study. It was reported that under-expansion of stent estimated with IVUS is an important predictor of TLR and ST after DES implantation (28). A contributory factor for TLR in HD patients could be stent under-expansion because of calcified lesions. In addition, we did not investigate restenosis-related stent fracture (29). Further prospective studies are needed to investigate after DES implantation in HD patients.

Long-term Clinical Safety. In this study, mortality was high in HD patients, albeit, similar to that of all studied HD patients in the Japanese population with or without cardiovascular complications (2). Considering the total population, there was no significant difference in ST rates between HD and NH patients, but in the present study

HD patients tended to have a higher ST rate. A previous study showed that renal insufficiency and dialysis are important predictors of ST after DES implantation for up to 9 months (30). Recently, the J-Cypher registry data showed that the frequency of early, late, and very late ST after DES implantation in the Japanese (31) was notably lower than in Western countries (32). We did not observe any early ST in either of the 2 groups although glycoprotein IIb/IIIa inhibitors were not used during the procedures because this drug is not approved in Japan. However, the J-Cypher registry data show that HD and end-stage renal disease without HD are independent predictors of late or very late ST for up to 2 years (31). Although there was no significant difference in ST rate between the 2 groups in the present study, further study is needed to investigate ST in this subset of patients on HD in the rest of the world.

Study limitations. This is a multi-center, nonrandomized registry, the results of which need to be validated with prospective randomized studies. We compared the results for HD and NH groups after adjustment of the patient's characteristics using a Propensity score because the characteristics and predictors of cardiac events of HD patients were quite different from those of NH patients. A post-marketing surveillance strategy could provide the regulatory authorities, clinicians, and patients with relevant data to guide the use of new devices. Furthermore, such a forward-looking strategy could prove useful

for utilization of the clinical trial registries established for pivotal trials (33). Therefore, a post-market surveillance study would likely highlight any problems arising after treatment with SES for HD patients by presenting a relatively large “real-life” experience of PCI in HD patients.

Conclusions

PCI with SES in HD patients is feasible but not comparable in efficacy profile to PCI with SES for NH patients, and it is associated with a higher incidence of repeat revascularization and higher mortality when compared with NH patients. HD appears to be a strong independent predictor of mortality and repeat revascularization after SES implantation.

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Disclosures

None

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Figure legends

Figure1. Three-year Kaplan-Meier event-free survival plots for target-lesion revascularization (TLR) (*a*), cardiac death (*b*), all-cause death, (c) and major adverse cardiac events (d) after sirolimus-eluting stent implantation for the hemodialysis (HD) group and the non-hemodialysis (NH) group.

Figure 2. Three-year propensity score adjusted cumulative incidence of TLR (*a*) and cardiac death (*b*) for the HD group and the NH group.

Figure 1.

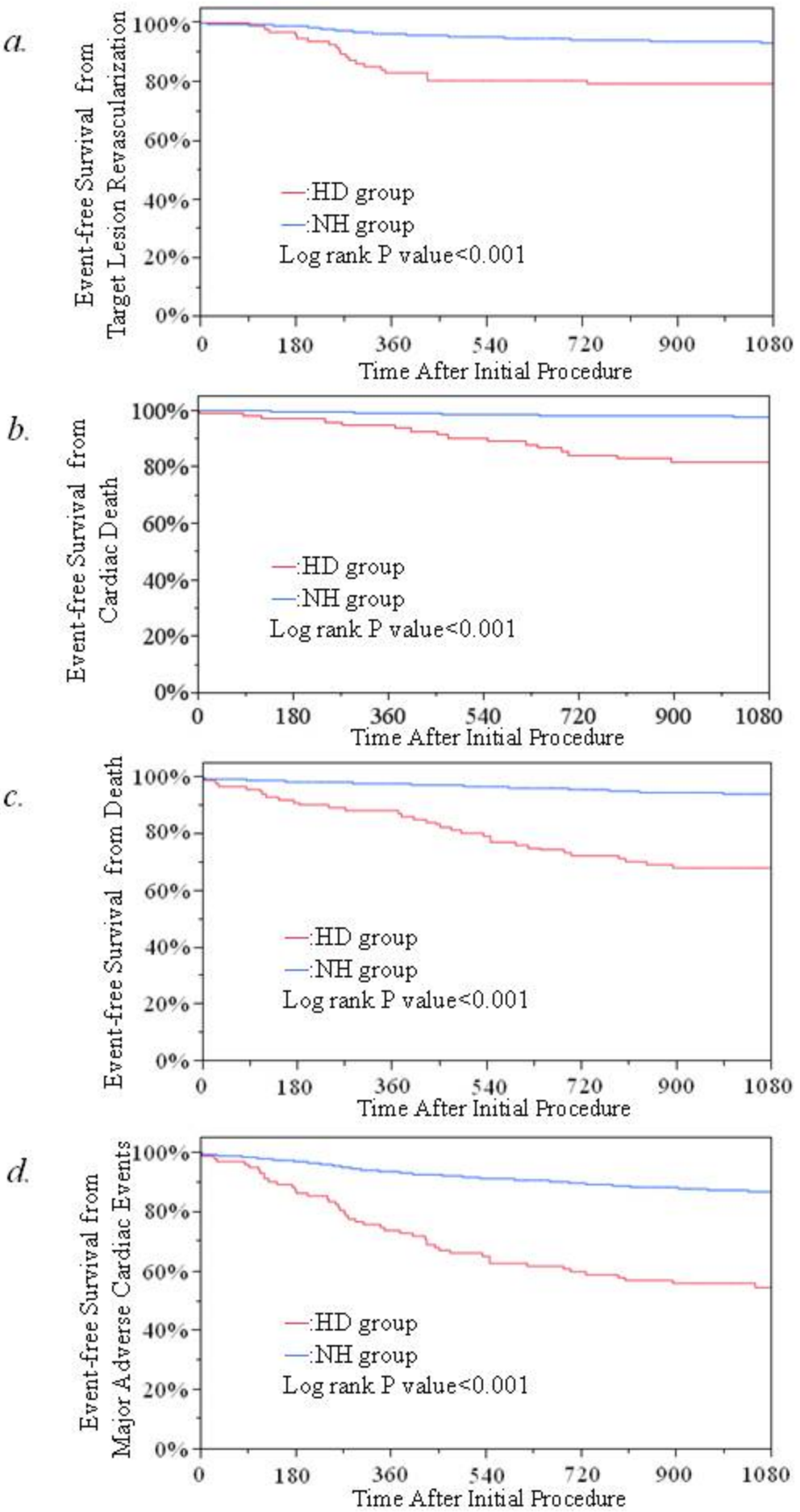
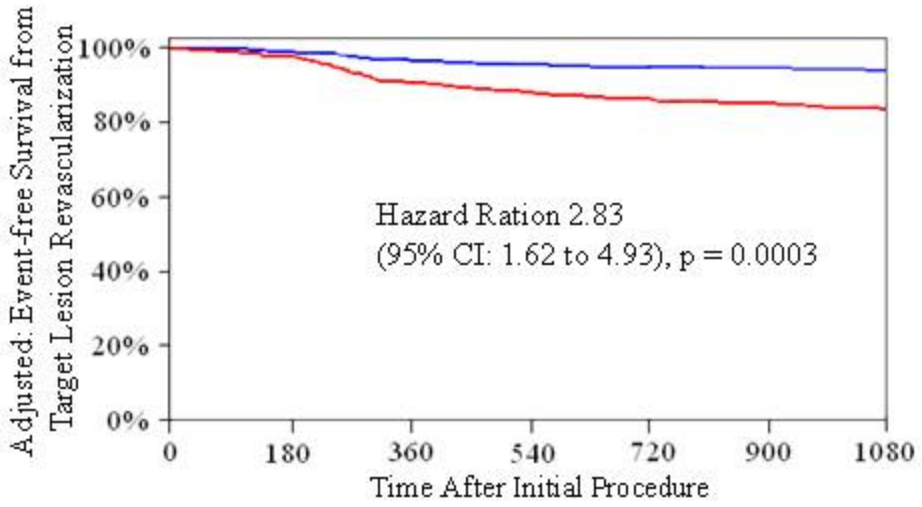

a.
Event-free Survival from Target Lesion Revascularization
100%
80%
60%
40%
20%
0%
:HD group
:NH group
Log rank P value<0.001
0
180
360
540
720
900
1080
Time After Initial Procedure
b.
Event-free Survival from Cardiac Death
100%
80%
60%
40%
20%
0%
:HD group
:NH group
Log rank P value<0.001
0
180
360
540
720
900
1080
Time After Initial Procedure
c.
Event-free Survival from Death
100%
80%
60%
40%
20%
0%
:HD group
:NH group
Log rank P value<0.001
0
180
360
540
720
900
1080
Time After Initial Procedure
d.
Event-free Survival from Major Adverse Cardiac Events
100%
80%
60%
40%
20%
0%
:HD group
:NH group
Log rank P value<0.001
0
180
360
540
720
900
1080
Time After Initial Procedure

Figure 2.

a.


Adjusted: Event-free Survival from Target Lesion Revascularization
100%
80%
60%
40%
20%
0%
Hazard Ration 2.83
(95% CI: 1.62 to 4.93), p = 0.0003
0
180
360
540
720
900
1080
Time After Initial Procedure

b.

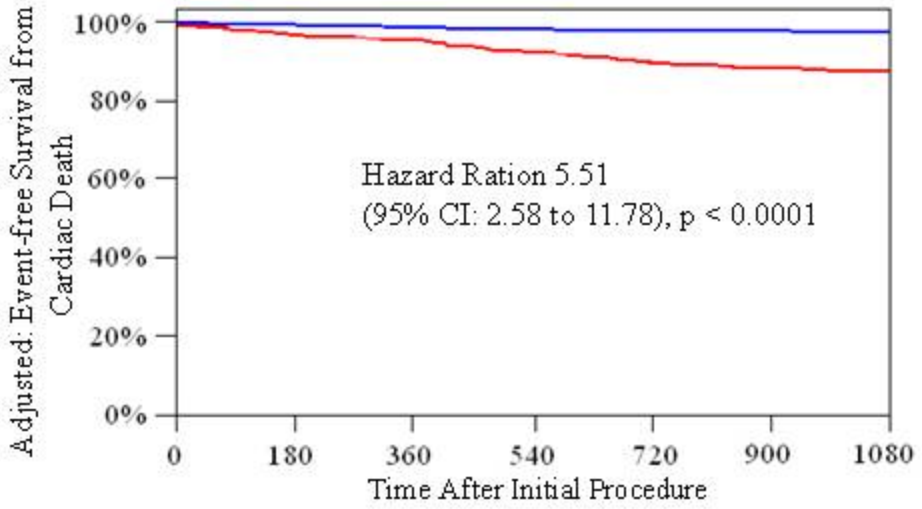

Adjusted: Event-free Survival from Cardiac Death
100%
80%
60%
40%
20%
0%
Hazard Ration 5.51
(95% CI: 2.58 to 11.78), p < 0.0001
0
180
360
540
720
900
1080
Time After Initial Procedure

Table1. Baseline clinical characteristics

	HD group	NH group	P Value
Number of patient	106	1,944	-
Age, years ± SD	66.5 ± 10.3	67.1 ± 10.1	0.546
Male sex, n (%)	78 (73.6)	1,471 (75.7)	0.643
Stable angina pectoris, n (%)	59 (55.7)	1,036 (53.3)	0.690
Unstable angina pectoris, n (%)	14 (13.2)	263 (13.5)	1.000
Myocardial infarction, n (%)	17 (16.0)	394 (20.3)	0.321
Acute myocardial infarction (≤ 72hours)	2 (1.9)	86 (4.4)	0.321
Acute myocardial infarction (> 72hours)	2 (1.9)	52 (2.7)	1.000
Old myocardial infarction	13 (12.3)	256 (13.2)	0.883
Silent ischemia, n (%)	16 (15.1)	239 (12.3)	0.367
Others, n (%)	0 (0.0)	12 (0.6)	1.000
CCS classification III or IV, n (%)	9 (8.5)	108 (5.6)	0.197
Ejection Fraction < 30%, n (%)*1	14 (16.1)	50 (3.0)	< 0.001*
Previous myocardial infarction, n (%)	35 (33.0)	743 (38.2)	0.305
Previous coronary angioplasty, n (%)	66 (62.3)	1,087 (55.9)	0.228
Previous coronary artery bypass graft surgery, n (%)	16 (15.1)	149 (7.7)	0.015*
Diabetes, n (%)	75 (70.8)	814 (41.9)	< 0.001*
Non-insulin treatment	41 (38.7)	641 (33.0)	0.244
Insulin treatment	34 (32.1)	173 (8.9)	< 0.001*
Hyperlipidemia, n (%)	34 (32.1)	1,129 (58.1)	< 0.001*
Hypertension, n (%)	76 (71.7)	1,353 (69.6)	0.745
Family history of coronary artery disease, n (%)	4 (3.8)	134 (6.9)	0.316
Current smoker, n (%)	22 (20.8)	371 (19.1)	0.704
Obesity, n (%)*2	17 (16.0)	740 (38.2)	< 0.001*
Cerebrovascular disease, n (%)	7 (6.6)	153 (7.9)	0.852
Peripheral vascular disease, n (%)	15 (14.2)	115 (5.9)	0.003*
Single-vessel disease patients, n (%)	50 (47.2)	1,156 (59.5)	0.015*
Multi-vessel disease patients, n (%)	56 (52.8)	788 (40.5)	0.015*

*1：Excluding unevaluated 318 patients (19 in HD group and 299 in NH group).

*2：Excluding unevaluated 7 patients in NH group.

CCS, Canadian Cardiovascular Society

Table 2. Lesion characteristics and procedural indices

	HD group	NH group	P Value
Number of lesion	125	2,333	-
Number of stents	168	3,115	-
Lesion Located			
RCA	56 (44.8)	695 (29.8)	0.001*
LAD	35 (28.0)	1,040 (44.6)	< 0.001*
LCx	26 (20.8)	495 (21.2)	1.000
LMT	7 (5.6)	88 (3.8)	0.333
Other	1 (0.8)	15 (0.6)	0.567
ACC/AHA classification type B2/C, n (%)*1	111 (89.5)	1,869 (80.4)	0.010*
De novo, n (%)	93 (74.4)	1,852 (79.4)	0.177
In stent restenosis, n (%)	22 (17.6)	334 (14.3)	0.298
Bifurcation, n (%)	36 (28.8)	773 (33.1)	0.330
Eccentric, n (%)*2	79 (63.7)	1,221 (54.0)	0.041*
Lesion angulation ≥ 45°	23 (18.4)	357 (15.3)	0.373
Moderate/ severe calcification, n (%)	59 (47.2)	366 (15.7)	< 0.001*
Ostial, n (%)	28 (22.4)	383 (16.4)	0.085
Total occlusion, n (%)	8 (6.4)	267 (11.4)	0.107
Chronic total occlusion, n (%)	2 (1.6)	109 (4.7)	0.123
IVUS usage, n (%)	91 (72.8)	1,684 (72.2)	0.919
Direct stenting, n (%)	15 (12.0)	523 (22.4)	0.005*
Rotablator, n (%)	24 (19.2)	72 (3.1)	< 0.001*
Maximum deployment pressure, atm	16.9 ± 3.7	16.0 ± 4.1	0.002*
Used stent diameter, mm	3.03 ± 0.37	2.99 ± 0.36	0.173
Total stent length, mm	28.51 ± 15.17	28.78 ± 14.85	0.845
Stents/ patients ratio	1.6 ± 0.7	1.6 ± 0.8	0.837
Stents/ lesion ratio	1.3 ± 0.6	1.3 ± 0.6	0.872
Overlap stenting, n (%)	35 (28.0)	627 (26.9)	0.757
Post dilatation, n (%)	64 (51.2)	1,077 (46.2)	0.311

*1：Excluding unevaluated 10 lesions (1in HD group and 9 in NH group).

*2：Excluding unevaluated 72 lesions (1in HD group and 71 in NH group).

ACC, American College of Cardiology; AHA, American Heart Association; IVUS, intravascular ultrasound; LAD, left anterior descending artery; LCx, left circumflex artery; LMT, left main trunk; RCA, right coronary artery

Table 3. Results of quantitative coronary analysis at baseline and at 8-month of follow-up

	Dialysis	Non-dialysis	P Value
Number of lesions	125	2,333	-
Lesion length, mm	16.9 ± 8.7	17.5 ± 10.3	0.542
Reference diameter, mm	2.77 ± 0.65	2.55 ± 0.60	< 0.001*
Minimal luminal diameter, mm			
Before procedure	0.83 ± 0.51	0.74 ± 0.48	0.042*
After procedure	2.27 ± 0.68	2.25 ± 0.66	0.748
At 8 months	1.79 ± 0.86	2.12 ± 0.68	< 0.001*
%DS, %			
Before procedure	70.9 ± 15.9	71.2 ± 16.9	0.814
After procedure	19.4 ± 13.0	19.1 ± 13.7	0.784
At 8 months	37.5 ± 27.4	23.8 ± 18.0	< 0.001*
Acute gain, mm	1.43 ± 0.65	1.50 ± 0.68	0.271
Late loss, mm	0.49 ± 0.89	0.14 ± 0.56	< 0.001*
Binary restenosis (%)	26.4%	8.2%	< 0.001*

%DS, percent diameter stenosis

Table 4. Results of clinical follow-up at 3 years

	HD group	NH group	P Value
All events (to 3 years)			
Number of patient	98	1,844	
Major adverse cardiac events, n (%)	46 (46.9)	246 (13.3)	< 0.001*
Death, n (%)	32 (32.7)	107 (5.8)	< 0.001*
Cardiac+unknown	16 (16.3)	42 (2.3)	< 0.001*
Non-cardiac	16 (16.3)	65 (3.5)	< 0.001*
Myocardial infarction, n (%)	4 (4.1)	37 (2.0)	0.149
Q-wave	1 (1.0)	14 (0.8)	0.541
Non Q-wave	2 (2.0)	17 (0.9)	0.248
Unknown	1 (1.0)	6 (0.3)	0.304
Emergency CABG, n (%)	0 (0.0)	3 (0.2)	1.000
TLR, n (%)	19 (19.4)	122 (6.6)	< 0.001*
TVR, n (%)	27 (27.6)	219 (11.9)	< 0.001*
Non target-lesion TVR, n (%)	15 (15.3)	126 (6.8)	0.004*
Target-vessel failure, n (%)	40 (40.8)	267 (14.5)	< 0.001*
Stent thrombosis, n (%)			
Definite + Probable	2 (2.0)	12 (0.7)	0.155
- Early (0 to 30 days)	0 (0.0)	1 (0.1)	1.000
- Late (31 to 360 days)	1 (1.0)	6 (0.3)	0.309
- Very Late (361 to 1080 days)	1 (1.0)	5 (0.3)	0.267

CABG, coronary artery bypass graft; TLR, target-lesion revascularization; TVR, target-vessel revascularization