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Original Article

Impact of prior coronary stenting on the outcome of subsequent coronary artery bypass grafting

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ABSTRACT

Background: The percentage of patients referred for coronary artery bypass grafting (CABG) who have previously undergone percutaneous coronary interventions (PCIs) is increasing. The purpose of this study was to review the outcomes of patients who had received coronary stenting before CABG, and to examine the validity of a mortality risk stratification system in this patient group.

Methods: From 2010 to 2012, 439 patients who underwent isolated CABG at our medical center were reviewed. The patients were divided into two study groups: those who had previously received coronary artery stenting (97 patients, 24.7%), and those who had not (342 patients, 75.3%). The patients who received balloon angioplasty were excluded.

Results: There were no significant differences in baseline characteristics. The prior stenting group had a lower risk of mortality, although the difference was not significant. The prior stenting group had fewer graft anastomoses ($p = 0.005$), and hence a significantly shorter cardiopulmonary bypass time ($p = 0.045$) and shorter aortic cross-clamping time. Surgical mortality was similar between the two groups. The durations of intensive care unit stay and hospitalization were also similar. The discriminatory power of the logistic European System for Cardiac Operative Risk Evaluation (EuroSCORE) was lower in both group.

Conclusions: Prior coronary stenting does not affect short-term mortality in patients subsequently undergoing CABG surgery. The EuroSCORE does not predict perioperative mortality well for the patients who undergo coronary stenting before CABG.

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At a glance commentary

Scientific background on the subject

More and more patients being referred for CABG have previously received a PCI. A less than favorable outcome in patients who receive PCI before CABG has been reported in several studies. The discriminatory power of current mortality risk stratification systems was not studied in these patients.

What this study adds to the field

Prior coronary stenting did not increase the risk of in-hospital mortality in patients subsequently undergoing CABG. However, the quality of CABG was not identical between the two groups. A heart team responsible for revascularization can never be emphasized too much.

A national report from the US showed a substantial decrease in coronary artery bypass grafting (CABG) surgery and a steady percutaneous coronary intervention (PCI) rate from 2001 to 2008 in US hospitals [1]. In addition, more patients being referred for CABG have previously received a PCI. It has been reported that 6–13% of patients with bare metal stent implantation require CABG surgery within 1 year, and that 13–26% of patients require CABG surgery within 10 years [2,3]. Furthermore, with the increasing popularity of drug-eluting stents, the percentage of patients with prior PCIs referred for CABG will only increase.

A less than favorable outcome in patients who receive PCI before CABG has been reported in several studies [4–6]. Inflammatory reactions caused by the presence of intracoronary stents involving distal coronary arteries and myocardium could possibly affect the optimal site of CABG [7,8]. In contrast, some studies have concluded that previous PCI does not increase the risk of mortality in subsequent CABG [9,10]. However, few studies have evaluated the impact of previous PCI on the discriminatory power of current mortality risk stratification systems including the Society of Thoracic Surgeons' risk model (STS) and the European System for Cardiac Operative Risk Evaluation (EuroSCORE) to predict post-CABG outcomes. The aim of this study, therefore, was to review real-world outcomes of isolated CABG at our medical center and to compare the STS and EuroSCORE systems in predicting postoperative mortality in patients undergoing isolated CABG who had previously received a PCI.

Materials and methods

Study design and data collection

We performed a systemic review of our open heart electronic database. This post-hoc analysis was approved by our Institutional Review Board (IRB104-8747B). Informed consent was waived due to the retrospective nature of the study design. Over a 36-month period from January 2010 to December 2012, 439 patients who underwent isolated CABG at our medical center were reviewed. The patients were divided into two study groups based on whether they had received prior coronary artery stenting (prior stenting group, 97 patients, 24.7%) or not (no stenting group, 342 patients, 75.3%). Patients who had received balloon angioplasty were excluded, and those who had undergone concomitant procedures including valvular surgery and aortic surgery were also excluded. All cases of isolated CABG including elective, emergency, urgent, and redo cases were reviewed.

The baseline characteristics, demographic data, preoperative status, and preoperative medications were recorded. Perioperative risk was stratified by using both the STS and EuroSCORE systems. Logistic EuroSCORE and EuroSCORE II values were calculated using online software.

Procedure

All surgeries were performed after standard sternotomy. On-pump or off-pump CABG was performed depending on the preference of the surgeon. Surgical details including the number of distal anastomoses, cardiopulmonary bypass time and aortic cross-clamping time were recorded and analyzed.

Measurements and statistical analysis

The primary endpoint was all-cause in-hospital mortality. Continuous variables were presented as mean ± one standard deviation (SD) unless stated otherwise. Categorical variables were presented as numbers and proportions. The Kolmogorov–Smirnov test was used to examine normal distribution, and the Student's *t*-test was used to compare the means of continuous variables. If the variables were not normally distributed, the Mann–Whitney *U* test was used. Categorical data were compared using the chi-square test or Fisher's exact test.

The predicted risk of postoperative mortality was calculated using logistic EuroSCORE and STS scores, and the calculated mortality rate was compared with the actual mortality rate. Receiver operating characteristic (ROC) curves were plotted for both scoring systems to determine the best outcome risk model in these patients. Discrimination was assessed by comparing areas under two ROC curves (AUROC) using a nonparametric approach proposed by Delong et al. (1988). The AUROC analysis calculated cutoff values, sensitivity, specificity, and overall correctness.

Results

Characteristics of the study population

The study population included 439 patients, 97 (24.7%) of whom had previously undergone coronary stenting and 342 (75.3%) had not. The baseline characteristics including preoperative demographic data, preoperative status, and preoperative risk scores are listed in Table 1. There were no significant differences in age, gender, or underlying disorders between the two groups. There were also no significant differences in the percentage of patients in a critical condition

Table 1 Baseline characteristics of patients.

	All Patients (n = 439)	Stenting (n = 97)	No stenting (n = 342)	*p*-value
Preoperative demographic data				
Age (years)	63.68 ± 0.53	65.25 ± 1.07	63.19 ± 0.60	0.105
Gender, female (n (%))	88 (20.0%)	22 (22.7%)	66 (19.3%)	0.464
Diabetes mellitus (n (%))	234 (53.3%)	56 (57.7%)	178 (52.1%)	0.375
Hypertension (n (%))	349 (79.5%)	77 (79.4%)	272 (79.5%)	0.974
Peripheral arterial disease (n (%))	42 (9.6%)	10 (10.3%)	32 (9.4%)	0.779
Smoke (n (%))	255 (58.1%)	57 (58.8%)	198 (57.9%)	0.879
Old stroke (n (%))	69 (15.7%)	16 (16.5%)	53 (15.5%)	0.812
Atrial fibrillation (n (%))	41 (9.3%)	10 (10.3%)	31 (9.1%)	0.711
COPD (n (%))	45 (10.3%)	7 (7.2%)	38 (11.1%)	0.217
Serum Creatinine (mg/dL)	2.11 ± 0.13	1.93 ± 0.23	2.16 ± 0.15	0.455
End stage renal disease, dialysis (n (%))	57 (13.0%)	12 (12.4%)	45 (13.2%)	0.839
Preoperative condition				
CHF Fc III/IV (n (%))	75 (17.1%)	12 (12.3%)	63 (18.4%)	0.613
Ejection fraction (EF)	52.11 ± 0.80	52.79 ± 1.66	51.96 ± 0.91	0.669
EF 30–50% (n (%))	150 (34.2%)	31 (32.0%)	119 (34.8%)	0.358
EF <30% (n (%))	49 (11.2%)	9 (9.2%)	40 (11.7%)	0.759
Recent MI (n (%))	214 (48.7%)	46 (47.4%)	168 (49.1%)	0.768
Unstable angina (n (%))	167 (38.0%)	41 (42.3%)	126 (36.8%)	0.332
Ventilator support (n (%))	33 (7.5%)	9 (9.3%)	24 (7.0%)	0.457
Inotropic agent support (n (%))	39 (8.9%)	10 (10.3%)	29 (8.5%)	0.577
Preoperative IABP (n (%))	57 (13.0%)	8 (8.2%)	49 (14.3%)	0.074
Preoperative ECMO support (n (%))	11 (2.5%)	2 (2.1%)	9 (2.6%)	0.752
Preoperative medications				
Betablocker (n (%))	289 (65.8%)	61 (62.9%)	228 (66.7%)	0.490
ARB/ACEI (n (%))	225 (51.3%)	49 (50.5%)	176 (51.5%)	0.831
Statin (n (%))	271 (61.7%)	56 (57.7%)	215 (62.9%)	0.360
Clopidogrel (n (%))	250 (57.0%)	54 (55.7%)	196 (57.3%)	0.774
Aspirin (n (%))	260 (59.2%)	36 (60.8%)	224 (65.5%)	0.889
Preoperative scores				
STS-risk of mortality	8.39 ± 0.69	6.35 ± 1.05	8.88 ± 0.83	0.060
STS-risk of mortality and morbidity	30.00 ± 1.26	27.12 ± 2.32	30.65 ± 1.47	0.201
EuroSCORE	15.02 ± 0.90	13.11 ± 1.56	15.46 ± 1.06	0.214
EuroSCORE II	7.36 ± 0.50	6.09 ± 0.87	7.71 ± 0.59	0.125

Abbreviation: COPD: chronic obstructive pulmonary disease; CHF: congestive heart failure; EF: ejection fraction; MI: myocardial infarction; IABP: intra-aortic balloon pump; ECMO: extracorporeal membrane oxygenation; ARB: angiotensin II receptor blockers; ACEI: angiotensin-converting enzyme inhibitors.

Table 2 Stent details.

Duration from stenting to CABG	
<1 year	32 (32.9%)
1–5 years	20 (20.6%)
5–10 years	19 (19.6%)
>10 years	18 (18.5%)
Unknown	8 (8.2%)
Stenting times	
Once	88 (90.7%)
More than two times	9 (9.3%)
Stented artery	
LM	5 (5.2%)
LAD	44 (45.4%)
LCx	34 (35.1%)
RCA	41 (42.3%)
Unknown	9 (9.3%)
Stented vessel number	
1	63 (64.9%)
2	20 (20.6%)
3	5 (5.2%)
Unknown	9 (9.3%)

Abbreviation: CABG: coronary artery bypass grafting; LM: left main; LAD: left anterior descending; LCx: left circumflex artery; RCA: right coronary artery.

before surgery including those who were using inotropic agents, ventilator support and extracorporeal membrane oxygenation support between the two groups. Slightly fewer patients who had previously received stenting received intra-aortic balloon pumps (IABP) before surgery (8.2% versus 14.3%). There was no significant difference in the preoperative use of medications. The prior stenting group had a lower risk of mortality (6.35% versus 8.88%) according to the STS score, though the difference was not significant. There were also no significant differences in logistic EuroSCORE and EuroSCORE II scores.

Coronary stent details

The stenting details are presented in Table 2. Thirty-two patients (32.9%) underwent CABG within 1 year after receiving coronary stents, and 88 patients (90.7%) received coronary stents once before undergoing CABG. Left anterior decending (LAD) was stented in 44 patients (45.4%), followed by right coronary artery (RCA) (41 patients, 42.3%) and left circumflex artery (LCx) (34 patients, 35.1%).

Table 3 Surgical data according to different surgical method (expression as mean ± standard error).

	All patients (n = 439)	Stenting (n = 97)	No stenting (n = 342)	*p*-value
Surgical detail				
Emergent operation (n (%))	123 (28.0%)	24 (24.7%)	99 (28.9%)	0.417
Redo operation (n (%))	7 (1.6%)	1 (1.0%)	6 (1.8%)	0.617
Numbers of distal anastomosis	2.98 ± 0.03	2.77 ± 0.08	3.04 ± 0.04	0.005
Cardiopulmonary bypass time (minutes)	118.28 ± 2.79	110.19 ± 5.38	120.57 ± 3.22	0.045
Aortic cross-clamping time (minutes)	88.82 ± 3.22	76.68 ± 4.43	91.51 ± 3.76	0.076

Table 4 Postoperative outcomes.

Postoperative outcomes	All Patients (n = 439)	Stenting (n = 97)	No stenting (n = 342)	*p*-value
Surgical mortality (n (%))				
In-hospital mortality	47 (10.7%)	8 (8.2%)	39 (11.4%)	0.376
30 day mortality	42 (9.6%)	7 (7.2%)	35 (10.2%)	0.374
APACHE II score	13.3 ± 0.3	13.5 ± 0.6	13.2 ± 0.3	0.745
SOFA score	6.76 ± 0.12	6.61 ± 0.28	6.78 ± 0.14	0.577
ECMO (n (%))	32 (7.3%)	6 (6.2%)	26 (7.6%)	0.510
Re-exploration for bleeding (n (%))	15 (3.4%)	2 (2.1%)	13 (3.8%)	0.406
Stroke (n (%))	7 (1.6%)	2 (2.1%)	5 (1.5%)	0.678
Tracheostomy (n (%))	13 (3.0%)	3 (3.1%)	10 (2.9%)	0.931
Ventilator duration (hours)	37.7 ± 4.0	36.9 ± 9.8	38.0 ± 4.4	0.913
Acute kidney injury (n (%))	180 (41.0%)	35 (36.1%)	145 (42.4%)	0.260
ICU duration (days)	5.18 ± 0.43	4.18 ± 0.53	5.43 ± 0.53	0.224
Hospital stays (days)	20.22 ± 1.09	17.96 ± 1.60	20.87 ± 1.32	0.267

Abbreviation: APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA score: The Sepsis-related Organ Failure Assessment score; ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit.

Table 5 In-hospital mortality by patient groups.

	Stenting	No stenting	*p*-value
All cases (n = 439)	8.2% (n = 97)	11.4% (n = 342)	0.376
Elective (n = 320)	5.1% (n = 78)	8.3% (n = 242)	0.778
Emergency (n = 119)	21.1% (n = 19)	19.0% (n = 100)	0.560

Surgical data

The surgical details are presented in Table 3. There were no significant differences in the number of emergency or redo operations between the two groups. The total number of distal anastomoses was significantly lower in the prior stenting group (2.77 ± 0.08 versus 3.04 ± 0.04; $p = 0.005$). Therefore, compared to the no stenting group, the prior stenting groups had a shorter aortic cross-clamping time and significantly shorter cardiopulmonary bypass time (110.1 ± 5.4 min versus 120.6 ± 3.2 min; $p = 0.045$). The total number of distal anastomoses was significantly lower in the prior stenting group (2.77 ± 0.08 versus 3.04 ± 0.04; $p = 0.005$).

Postoperative outcomes

The postoperative outcomes are presented in Table 4. The in-hospital mortality by patient groups are presented in Table 5. The in-hospital mortality rate was lower in the prior stenting group, although the difference did not reach significance. There were no differences in APACHE II and SOFA scores, which measure severity in the intensive care unit, between the two groups. There was also no difference in the percentage of patients requiring extracorporeal membrane oxygenator support after surgery. There were no significant differences in preoperative morbidities including re-exploration for bleeding, stroke, tracheostomy, and acute kidney injury. The duration of ICU stay and hospitalization were also similar.

Scoring systems and the prediction of in-hospital mortality in the patients with or without previous PCI

The areas under the ROC curves are shown in Figs. 1 and 2. In the no prior stent group, the AUC of the STS and EuroSCORE curves were 0.885 and 0.847 ($p = 0.0024$), respectively. In the prior stent group, the AUC of the STS score and EuroSCORE were 0.876 and 0.853 ($p = 0.3276$), respectively [Figs. 1 and 2].

Two-year survival rate

The two-year mortality rates were 12.4% in the prior coronary stenting group versus 15.8% in the no coronary stenting group (log rank-test: ns, Fig. 3).

Discussion

Hassan et al. studied 6032 patients, and they found that prior PCI was an independent predictor of postoperative in-hospital mortality (odds ratio 1.93; $p = 0.003$) [4]. Massoudy et al. found that multiple previous PCIs increased the risk of in-hospital mortality (OR, 1.0; CI, 1.3–2.7; $p = 0.016$) and the incidence of major adverse cardiac events (MACE) (OR, 1.5; CI, 1.2–1.9; $p = 0.0019$) after subsequent CABG in their multicenter study with 29,928 patients [6]. In addition, Mannacio et al. also found

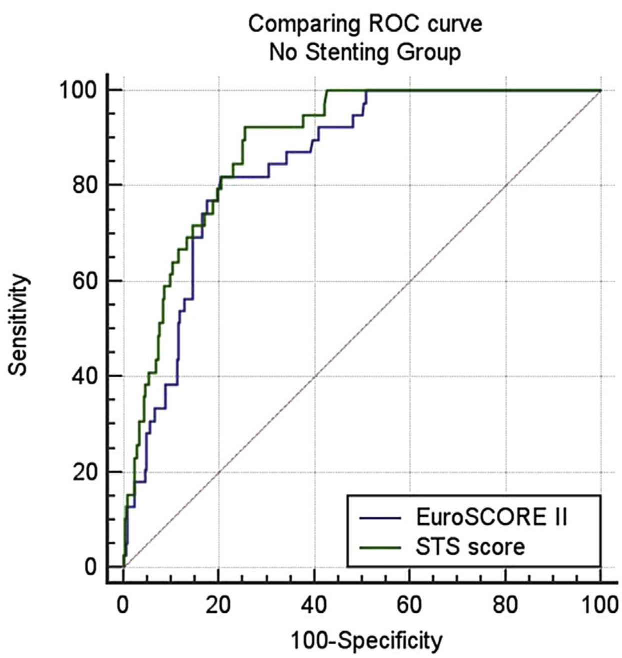
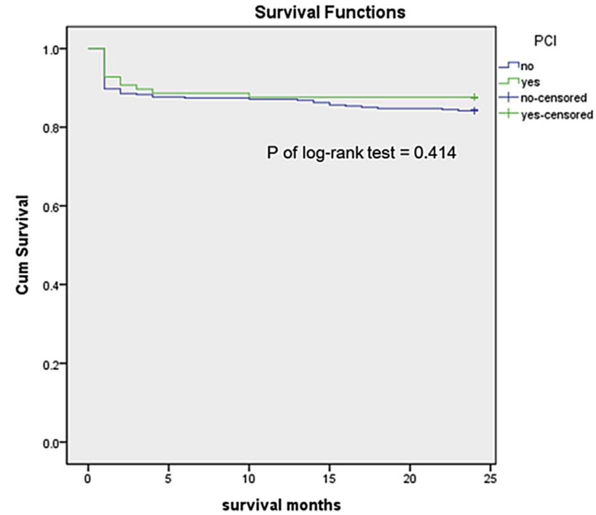


Fig. 1 Receiver operating characteristics curve for STS score mortality and EuroSCORE II in patient with no history of previous coronary stenting.



No. at risk	1	4	6	9	12	15	18	22	24
PCI	90	86	86	86	85	85	85	85	85
Non-PCI	307	300	299	299	299	293	290	289	289

Fig. 3 Two-year survival rate.

that a history of previous PCI was significantly associated with increased MACE (odds ratio 2.1; $p < 0.001$) and in-hospital mortality (odds ratio, 2.8; $p = 0.003$) [11]. However, Velicki et al. studied a low risk patient group (EuroSCORE between 1 and 4), and found that prior PCI did not increase subsequent morbidity or mortality in CABG patients [12]. Sánchez et al. also showed that previous PCI was not an independent risk factor for in-hospital mortality in their study with 63,420 patients [10].

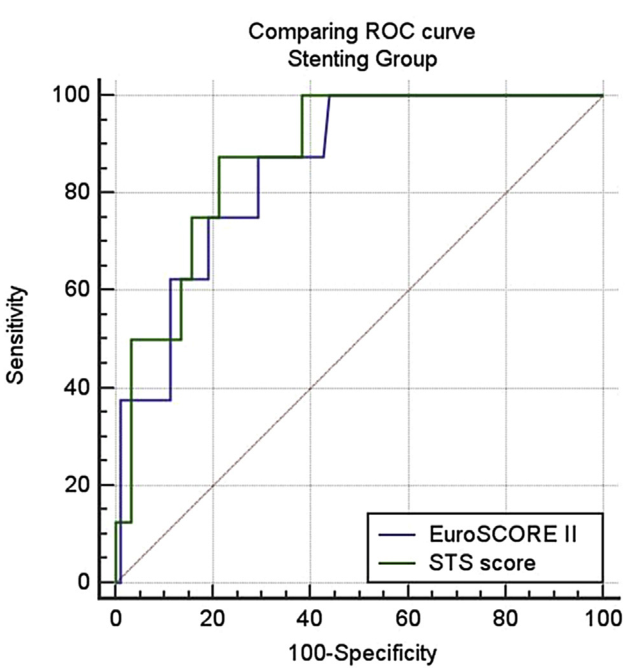


Fig. 2 Receiver operating characteristics curve for STS score mortality and EuroSCORE II in patient with history of previous coronary stenting.

In the current study, previous coronary stenting did not adversely affect subsequent CABG. This may be due to the following factors. First, our patients had a high rate of comorbidities. Nearly 54% of our patients had diabetes mellitus, more than 15% had a history of stroke, and 13% were undergoing hemodialysis before surgery. With regards to the risk of mortality, the STS scores in the prior and no stenting groups were 6.35 ± 1.05 and 8.88 ± 0.83, respectively, and the logistic EuroSCORE scores were 13.11 ± 1.56 and 15.46 ± 1.06, respectively. Carnero-Alcázar et al. reported standard EuroSCORE scores of 4.31 and 4.77 in their study group [13], compared to 3.52 and 3.39 in Velicki et al.'s study [12]. The EuroSCORE II scores in our study groups were 6.09 ± 0.97 and 7.71 ± 0.59, respectively, compared to 1.67 and 1.63 in their Velicki et al.'s study [12]. A higher risk of mortality could possibly blunt the adverse effect of prior coronary stenting.

Second, Massoudy et al. concluded that multiple previous PCIs increased in-hospital mortality [6]. The percentage of our patients who received multiple previous coronary stenting was low, and only nine patients (9.1%) in the previous coronary stenting group received coronary stenting more than once. This may explain why the short-term outcomes of the prior stenting group were not inferior in this study.

Third, many of our patients were taking clopidogrel before CABG compared to other studies, including 55.7% of the patients in the prior stenting group and 57.3% of the patients in the no stenting group. Niclauss et al. reported that 11% of patients in the prior PCI group and 3.5% of the patients in the isolated CABG group took clopidogrel [14], and Mehta et al. reported 3.4% and 15.9%, respectively, in their study groups [15]. Taking clopidogrel is known to lower the risk of stent thrombosis [16].

We observed significantly fewer cases of distal anastomosis in the prior stenting group compared to the no stenting group (2.77 ± 0.08 versus 3.04 ± 0.04; $p = 0.005$). Chocron et al. studied 2489 patient in the IMAGINE trial, and found that patients with prior PCI had significantly fewer cases of distal anastomosis (3.0 ± 1.1 versus 3.3 ± 1.1, $p < 0.0001$) than the patients who received CABG without prior PCI [5]. Velicki et al. also found that the patients with prior PCI had significantly fewer distal coronary anastomoses (2.35 ± 0.81 versus 2.53 ± 0.78, $p = 0.016$) [12]. Drug-eluting stents are well known to cause endothelium dysfunction in both the vessels over the stents and downstream [17,18]. Thus chronic inflammatory reactions after PCI and subsequent endothelial dysfunction could interfere not only with the stented area but also the native coronary arteries and surrounding myocardium distal to the stent placement. This could not only decrease the possible locations for anastomoses but also affect the bypass graft patency [8,19,20].

Bonaros et al. reviewed 2728 patients in their institute [21], and found that the discriminatory power of the logistic EuroSCORE was lower in the patients with prior PCI (AUC = 0.552, confidence interval (CI) = 0.301–0.765) compared to the patients with no history of previous PCI (AUC = 0.875, CI = 0.806–0.934). The discriminatory power of the STS score for mortality was also lower in their study in the patients with prior PCI (AUC = 0.553, CI = 0.398–0.669) compared to those with no history of previous PCI (AUC = 0.914, CI = 0.860–0.967). In the current study, the discriminatory power of the STS score was better in both the prior stenting group and no stenting group (AUC = 0.876 versus 0.885) than EuroSCORE (AUC = 0.853 versus 0.847). The STS score predicted mortality rate significantly better than EuroSCORE in no stenting group ($p = 0.0024$).

This study has several limitations. This is a consecutive, observational, single center study, and the number of patients enrolled and the follow-up durations are both limited. Another apparent limitation is high in-hospital mortality. Our patients were at high risk, with heavy risk burden. (1) A large proportion of our patients had advanced comorbidities such as 13% who were receiving hemodialysis before CABG. Hemodialysis is a known risk factor for any kind of surgery, and Taiwan has the highest incidence of treated ESRD worldwide [22]. Preoperative renal dysfunction significantly increases the risk in CABG. Severe renal dysfunction (GFR < 30 ml/min per 1.73 m^2) or dialysis has been reported to increase the risk of operative mortality by more than 6 folds [23]. (2) Twenty-eight percent of our cases received emergency CABG, 13% of our cases required IABP before CABG, and 2.5% of our cases were placed on ECMO and received salvage CABG. Tomas et al. reported hospital mortality rates for emergency and salvage CABG of 13% and 41%, respectively [24]. In addition, Acharya et al. reported an operative mortality rate of 37.2% in CABG patients requiring preoperative mechanical circulatory support. When undergoing CABG as a salvage procedure, the mortality rate increased to 53.3% [25]. (3) Hepatitis and liver cirrhosis are “national diseases” in Taiwan, and it is common to encounter patients with liver cirrhosis, even though we did not have actual records or Child-Pugh scores in our database. Raja et al. reported that cirrhosis was independently associated with increased mortality (adjusted odds ratio 6.9) in CABG patient [26]. The impact of cirrhosis is not considered in the STS, and therefore the real mortality rate of such patients should be higher than the STS PROM.

In conclusion, prior coronary stenting did not increase the risk of in-hospital mortality in patients subsequently undergoing CABG. However, our patients had a high surgical risk, and thus the adverse effect of prior stenting may have been blunted. The quality of CABG was not identical between the two groups, and the patients with prior stenting received significantly less graft anastomosis. For this reason, a heart team responsible for revascularization can never be emphasized too much.

Conflicts of interest

The authors declare that they have no competing interests.

REFERENCES

[1] Epstein AJ, Polsky D, Yang F, Yang L, Groeneveld PW. Coronary revascularization trends in the United States, 2001–2008. JAMA 2011;305:1769–76.

[2] Hoffman SN, TenBrook JA, Wolf MP, Pauker SG, Salem DN, Wong JB. A meta-analysis of randomized controlled trials comparing coronary artery bypass graft with percutaneous transluminal coronary angioplasty: one- to eight-year outcomes. J Am Coll Cardiol 2003;41:1293–304.

[3] Mercado N, Wijns W, Serruys PW, Sigwart U, Flather MD, Stables RH, et al. One-year outcomes of coronary artery bypass graft surgery versus percutaneous coronary intervention with multiple stenting for multisystem disease: a meta-analysis of individual patient data from randomized clinical trials. J Thorac Cardiovasc Surg 2005;130:512–9.

[4] Hassan A, Buth KJ, Baskett RJF, Ali IS, Maitland A, Sullivan JAP, et al. The association between prior percutaneous coronary intervention and short-term outcomes after coronary artery bypass grafting. Am Heart J 2005;150:1026–31.

[5] Chocron S, Baillot R, Rouleau JL, Warnica WJ, Block P, Johnstone D, et al. Impact of previous percutaneous transluminal coronary angioplasty and/or stenting revascularization on outcomes after surgical revascularization: insights from the imagine study. Eur Heart J 2008;29:673–9.

[6] Massoudy P, Thielmann M, Lehmann N, Marr A, Kleikamp G, Maleszka A, et al. Impact of prior percutaneous coronary intervention on the outcome of coronary artery bypass surgery: a multicenter analysis. J Thorac Cardiovasc Surg 2009;137:840–5.

[7] Gomes WJ, Giannotti-Filho O, Paez RP, Hossne Jr NA, Catani R, Buffolo E. Coronary artery and myocardial inflammatory reaction induced by intracoronary stent. Ann Thorac Surg 2003;76:1528–32.

[8] Gomes WJ, Buffolo E. Coronary stenting and inflammation: implications for further surgical and medical treatment. Ann Thorac Surg 2006;81:1918–25.

[9] Fukui T, Tanaka S, Takanashi S. Previous coronary stents do not increase early and long-term adverse outcomes in patients undergoing off-pump coronary artery bypass grafting: a propensity-matched comparison. J Thorac Cardiovasc Surg 2014;148:1843–9.

[10] Sánchez E, Cid-Cumplido M, Moreno-Millán E, Tarhini IS, Khan I, Pineda T, et al. Previous percutaneous coronary intervention does not increase in-hospital mortality after

surgical revascularization: analysis of 63420 cases. Argent J Cardiol 2013;81:225–32.
[11] Mannacio V, Di Tommaso L, De Amicis V, Lucchetti V, Pepino P, Musumeci F, et al. Previous percutaneous coronary interventions increase mortality and morbidity after coronary surgery. Ann Thorac Surg 2012;93:1956–62.
[12] Velicki L, Cemerlic-Adjic N, Panic G, Jung R, Redzek A, Nicin S. CABG mortality is not influenced by prior PCI in low risk patients. J Card Surg 2013;28:353–8.
[13] Carnero-Alcázar M, Alswies A, Villagrán Medinilla E, Maroto LC, Silva Guisasola JA, Cobiella Carnicer J, et al. Mid-term outcomes after off-pump coronary surgery in patients with prior intracoronary stent. Eur J Cardiothorac Surg 2012;41:1295–303.
[14] Niclauss L, Colombier S, Prêtre R. Percutaneous coronary interventions prior to coronary artery bypass surgery. J Card Surg 2015;30:313–8.
[15] Mehta GS, LaPar DJ, Bhamidipati CM, Kern JA, Kron IL, Upchurch GR, et al. Previous percutaneous coronary intervention increases morbidity after coronary artery bypass grafting. Surgery 2012;152:5–11.
[16] Kirtane AJ, Stone GW. How to minimize stent thrombosis. Circulation 2011;124:1283–7.
[17] Lüscher TF, Steffel J, Eberli FR, Joner M, Nakazawa G, Tanner FC, et al. Drug-eluting stent and coronary thrombosis: biological mechanisms and clinical implications. Circulation 2007;115:1051–8.
[18] Nakazawa G, Otsuka F, Nakano M, Vorpahl M, Yazdani SK, Ladich E, et al. The pathology of neoatherosclerosis in human coronary implants bare-metal and drug-eluting stents. J Am Coll Cardiol 2011;57:1314–22.
[19] Barakate MS, Hemli JM, Hughes CF, Bannon PG, Horton MD. Coronary artery bypass grafting (CABG) after initially successful percutaneous transluminal coronary angioplasty (PTCA): a review of 17 years experience. Eur J Cardiothorac Surg 2003;23:179–86.
[20] Yap C-H, Yan BP, Akowuah E, Dinh DT, Smith JA, Shardey GC, et al. Does prior percutaneous coronary intervention adversely affect early and mid-term survival after coronary artery surgery? JACC Cardiovasc Interv 2009;2:758–64.
[21] Bonaros N, Vill D, Wiedemann D, Fischler K, Friedrich G, Pachinger O, et al. Major risk stratification models do not predict perioperative outcome after coronary artery bypass grafting in patients with previous percutaneous intervention. Eur J Cardiothorac Surg 2011;39:e164–9.
[22] United States Renal Data System. *2015 USRDS annual data report: Epidemiology of kidney disease in the United States*. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2015. [Internet]. usrds.org. Available from: http://www.usrds.org/2015/download/vol2_13_International_15.pdf [Accessed 16.04.16].
[23] Cooper WA, O'Brien SM, Thourani VH, Guyton RA, Bridges CR, Szczech LA, et al. Impact of renal dysfunction on outcomes of coronary artery bypass surgery: results from the Society of Thoracic Surgeons National Adult Cardiac Database. Circulation 2006;113:1063–70.
[24] Axelsson TA, Mennander A, Malmberg M, Gunn J, Jeppsson A, Gudbjartsson T. Is emergency and salvage coronary artery bypass grafting justified? The Nordic emergency/salvage coronary artery bypass grafting study. Eur J Cardiothorac Surg 2015:ezv388.
[25] Acharya D, Gulack BC, Loyaga-Rendon RY, Davies JE, He X, Brennan JM, et al. Clinical characteristics and outcomes of patients with myocardial infarction and cardiogenic shock undergoing coronary artery bypass surgery: data from the Society of Thoracic Surgeons National Database. Ann Thorac Surg 2016;101:558–66.
[26] Gopaldas RR, Chu D, Cornwell LD, Dao TK, Lemaire SA, Coselli JS, et al. Cirrhosis as a moderator of outcomes in coronary artery bypass grafting and off-pump coronary artery bypass operations: a 12-year population-based study. Ann Thorac Surg 2013;96:1310–5.