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ORIGINAL ARTICLE

Safety of aortic aneurysm repair 8 weeks after percutaneous coronary intervention for coronary artery disease: a cohort study

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Abstract

Guidelines advice against dual antiplatelet therapy (DAPT) discontinuation less than 12 months after percutaneous coronary intervention with drug-eluting stents (DES-PCI). However, any delay of necessary surgery in patients with descending thoracic (DTA) or abdominal aortic aneurysm (AAA), treated by DES-PCI, increases the risk of aneurysm rupture/dissection. We evaluated the safety of 8-week waiting time between DES-PCI and endovascular aortic repair (EVAR). 1152 consecutive patients with coronary artery disease (CAD) needing elective DTA or AAA repair were enrolled and divided into two groups. Group A included 830 patients treated by DES-PCI for significant CAD who underwent surgery 8 weeks after implantation. Group B included 322 patients treated by DES-PCI at least 6 months before with no residual significant CAD and treated by elective EVAR. Groups were compared according to a composite of death, myocardial infarction, stent thrombosis, cerebrovascular events and bleeding. No aneurysm rupture/dissection occurred while waiting for surgery. Hospital averse events occurred in 6.2% (52/830) group A patients versus 6.5% (21/322) group B patients ($p=0.8$). Mortality was 0.7% (6/830) in group A and 0.9% (3/322) in group B ($p=0.7$). Multivariate predictors of events were triple vessel DES-PCI ($p<0.001$), >3 stents implanted ($p<0.001$), early-generation stents ($p<0.001$), diabetes insulin requiring ($p=0.01$), stent diameter < 3.0 mm ($p=0.009$) and total stented length > 30 mm ($p=0.02$). Eight weeks of waiting after DES-PCI in addition to an adequate management of DAPT were safe in terms of cardiac morbidity and bleeding complications. No aneurysm rupture occurred in the interval before surgery.

Keywords Percutaneous coronary intervention · Aortic aneurysm · Antiplatelet therapy · Cardiac risk

Introduction

Coronary artery disease (CAD) may be present in 40–55% of patients with descending thoracic aorta (DTA), abdominal aortic aneurysm (AAA) or thoracoabdominal aortic aneurysm (TAAA) scheduled for repair [1, 2]. The management of these patients raises several relevant clinical and ethical dilemmas. The best approach to CAD is the first challenge as cardiac ischemic events account for 60–70% perioperative mortality and are responsible for 40–70% of all late deaths [3, 4]. Many authors suggested that the preliminary treatment of CAD by percutaneous coronary intervention (PCI) improves early and mid-term outcomes [5]. However, PCI involves the necessity of dual antiplatelet therapy (DAPT) with aspirin and P2Y12 receptor antagonists for a determinate period thus increasing the risk of aneurysm rupture or dissection while waiting for surgery.

Guidelines from the ACC/AHA advice against suspension of P2Y12 inhibitors before 12 months from drug-eluting stent (DES) implantation (class I–level of evidence: B) due to increased risks of stent thrombosis, myocardial infarction and death [6, 7]. Consequently, major elective noncardiac surgery should be postponed for at least 12 months after DES implantation (Class I—level of evidence: B) [8, 9]. However, as elective AA repair is a time-sensitive surgery, any delay in necessary surgery could increase the risk of aneurysm rupture or dissection but a too short duration of

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DAPT could increase the possibility of cardiac ischemic events. The reduction to 6 months of P2Y12 inhibitor therapy may be possible only in selected patients with low ischemic risk. Nonetheless, this indication was given at IIb class with level of evidence B, reflecting the limited and conflicting evidences at that time [10]. To overcome these limitations, 2014 and 2017 guidelines suggested an alternative strategy of balloon angioplasty or use of bare-metal stent (BMS) in case of time-sensitive noncardiac surgery [6, 8]. However, either balloon angioplasty or BMS implant is inadequate for the optimal treatment of CAD since the most recent update on DAPT in CAD gives the implant of DES as the preferred treatment option (Class I—level of evidence: A) [10]. Indeed, at present, the best balance between the risk of rupture/dissection in the interim between PCI and AA repair versus the perioperative risk of stent thromboses/ischemia inherent to the premature DAPT discontinuation remains far to be defined.

To evaluate the safety of further reduction of this waiting time in balance with ischemic or rupture/dissection risk, this retrospective study reports the experience of a large series of consecutive patients needing DTA or AAA elective repair who were serially screened for CAD by preoperative coronary computed tomography angiography (CCTA) or conventional coronary angiography. Patients with severe CAD were treated preliminarily by DES-PCI and underwent aneurysm repair 8 weeks later. Early and 12-month outcome was compared to that of a consecutive series of contemporary patients who underwent AA repair at least 6 months after previous DES-PCI.

Methods

Patients and preoperative cardiac evaluation

From January 2005 to December 2018, 2888 consecutive patients referred for elective AA repair. Preliminary exclusion criteria were as follows: autoimmune diseases (systemic lupus erythematosus, rheumatoid arthritis, scleroderma, Sjögren's syndrome or psoriatic arthritis), connective tissue disorders (Marfan syndrome, Ehlers–Danlos syndrome, Loeys–Dietz syndrome), ascending aorta and/or aortic and/or mitral valve diseases needing surgical treatment, acute myocardial infarction (MI), acute aortic dissection or rupture. To avoid misleading interference due to different surgical risk and clinical outcome, further exclusion criterion was need for open surgical treatment of aneurysm (DTA, TAAA, AAA). According with our consolidated policy, all patients who meet inclusion criteria underwent preliminary CCTA or conventional coronary angiography independently of the reported history or symptoms of CAD or their Revised Cardiac Risk Index (RCRI) for preoperative risk score [11]. When CCTA was not possible, not exhaustive, qualitatively inadequate or positive, patients were referred for invasive coronary angiography. Based on coronary angiography results, further exclusion criteria were the absence of significant coronary artery lesions ($\leq 70\%$) or DES-PCI performed less than 6 months before with no residual significant coronary lesions. Patient treated by isolated balloon coronary angioplasty, implant of BMS or needing for coronary artery bypass graft (CABG) surgery due to severe left main or significant multi-vessel coronary disease were excluded as well. Patients who required complex DES-PCI (long stents, three or more stents, overlapping, too small vessels, bifurcations, left main, last remaining vessel or recent acute coronary syndrome, history of stent thrombosis) were also excluded due to unacceptable risk of antiplatelet therapy suspension less than 12 months after PCI. At least, 1152 patients were enrolled and divided into 2 groups: group A included 830 patients (72%) with significant CAD suitable for DES-PCI according to the inclusion criteria; group B included 322 patients (28%) who have been treated by previous DES-PCI at least 6 months before with no residual significant coronary lesions (Group B—controls). Group A patients were preliminarily treated by DES-PCI and underwent DTA or AAA repair 8 weeks after stent implant. Group B patients underwent DTA or AAA repair soon after coronary angiography. Surgical treatment consisted in endovascular aneurysm repairs (EVAR) in the entire cohort. All patients had retrospectively calculated their DAPT and PRECISE-DAPT score that were analyzed according to the end-point of the study [12, 13]. The most pertinent clinical data and cardiac risk factors of patients enrolled are summarized in Table 1.

Follow-up information was obtained in dedicated institutional outpatient clinics or by telephone. Data included death, myocardial infarction (MI), stent thrombosis, cerebrovascular events and bleeding.

The study complies with the declaration of Helsinki. Ethical committee approval was gained from the Institutional Research Ethics Committee of the University of Naples Federico II. Given the retrospective nature of the study, the need for individual patient consent was waived but all patients had preliminarily granted written permission for the use of their medical records for research purposes and provided written informed consent to be treated according with our clinical protocol at the time of EVAR repair.

Study end-points and definitions

End-point was clinical outcome evaluated as hospital and 12-month adverse events. Adverse events were a composite of death, MI, stent thrombosis (definite or probable), cerebrovascular events and bleeding.

Hospital adverse events were events occurred within 30 days or at any time after operation if the patient did not

Table 1 Preoperative patient demographics and clinical data

Variable	Group A ($n=830$)	Group B ($n=322$)	p
Age (years)			
Mean	73.8 ± 4.2	72.7 ± 5.1	0.2
Median (IQR range)	74 (56–86)	74 (55–90)	0.2
Female sex	250 (30.1%)	94 (29.2%)	0.7
Hypertension	705 (84.9%)	44 (14.2%)	< 0.001
Hypercholesterolemia	483 (58.2%)	102 (31.7%)	< 0.001
Diabetes mellitus	292 (35.2%)	113 (35.1%)	0.9
Insulin requiring	58 (7%)	30 (9.3%)	0.003
Smoking status			
Previous smoker	188 (22.6%)	130 (40.3%)	< 0.001
Current smoker	290 (34.9%)	22 (6.8%)	< 0.001
Ejection fraction			
Mean	50 ± 7	50 ± 9	0.07
Median (IQR)	50 (40–55)	48 (40–55)	0.07
Family history of CAD	237 (28.5%)	96 (29.8%)	0.5
Thoracic aneurysm	232 (27.9%)	87 (27%)	0.8
Abdominal aneurysm	598 (72.1%)	235 (73%)	0.7
Aneurysm diameter (mm)			
Mean	63 ± 5	63 ± 4	1
Median (IQR)	63 (55–89)	61 (54–93)	0.09
Antiplatelet therapy (day)			
ASA100 mg + clopidogrel l75 mg	581 (70%)	74 (22.9%)	< 0.001
ASA100 mg + ticagrelor 250 mg	249 (30%)	37 (11.5%)	< 0.001
ASA 100 mg		211 (65.6%)	
RCRI score	2.1 ± 0.5	2.1 ± 0.6	1
DAPT score	2.2 ± 0.5	2. 1 ± 0.5	1
PRECISE-DAPT score	20.2 ± 4.6	19.8 ± 5.6	0.4

Data reported as n (%), mean ± SD, or median (interquartile range)

CAD coronary artery disease, *DAPT* dual antiplatelet therapy, *RCRI* Revised Cardiac Risk Index

leave the hospital. Time point for follow-up was fixed at 12 postoperative months in all patients to avoid bias due to the different duration of follow-up. According with Clinical End-Points in Coronary Stent Trials, we assumed that adverse outcomes within 30 days of implantation were temporally related to the procedure. Events within 12 months represented an interaction between the device and the disease. Later adverse events were more likely related to new disease activity [14].

The number of significant coronary lesions were the total number of stenosis > 70% in all coronary arteries. Acute MI was diagnosed when the criteria indicated by the 2018 Joint ESC/American College of Cardiology (ACC)/American Heart Association (AHA)/World Heart Federation (WHF) Task Force were fulfilled [15]. Death and stent thrombosis were assessed on the recommendations of the Clinical End-Points in Coronary stent trials [14]. Bleeding was defined and graded according to Bleeding Academic Research Consortium [16]. Cerebrovascular accident was any new episode of stroke or transient ischemic attack confirmed by computed tomography or magnetic resonance imaging. Need for new cardiac revascularization procedure was any new surgical or percutaneous revascularization procedure. Need for new cardiac revascularization procedure was not included in the composite end-points because it was merged in MI, given our policy of subjecting to coronary angiography all patients who developed postoperative MI.

Antiplatelet therapy

In group A, all patients were assuming DAPT. In group B, 114 (35.4%) were assuming DAPT and 208 (64.6%) aspirin alone 100 mg/die. DAPT consisted of clopidogrel 75 mg/day or ticagrelor 90–60 mg twice/day + aspirin 100 mg/day in both groups. Irrespectively of group, clopidogrel or ticagrelor were discontinued 5 days before the planned surgery, aspirin continued throughout the perioperative period. All patients after P2Y12 inhibitor discontinuation underwent bridging strategy with the administration of tirofiban (0.4 mcg/kg/min for 30 min, followed by continuous infusion

at 0.1 mcg/kg/min. If creatinine clearance > 30 mL/min; 0.2 mcg/kg/min for 30 min, followed by continuous infusion of 0.05 mcg/kg/min if creatinine clearance < 30 mL/min). Tirofiban was interrupted 4/6 h prior to surgery. The optimal time to start administration of tirofiban after P2Y12 inhibitor suspension was driven by means of the VerifyNow P2Y12 test (Accumetrics, San Diego, California, USA) in both groups. Tirofiban was started when the level of platelet inhibition was of about 75% of baseline function. Percentage of platelet inhibition was the percent of P2Y12 Reaction Unit change from baseline value (BASE value). Given that we had not a baseline value for our patient, already on P2Y12 inhibitor treatment, baseline value was derived from reference ranges. Patients had clopidogrel or ticagrelor resumed within 6 h from the procedure or as soon as possible related to patient blood loss.

Surgical procedures

EVAR was the approach of choice in all our patients whenever not contraindicated by difficult vascular accesses, unreliable landing zone or evidence of TAAA. Local anesthesia was usually preferred in patients undergoing EVAR. Heparin (100 IU/kg) was administered with subsequent boluses given to maintain an activated clotting time > 250 s. In DTA patients, a Medtronic Talent Stent Graft was always employed (Medtronic, Santa Rosa, CA, USA). In patients needing abdominal aorta repair, Endurant or Talent Stent Graft (Medtronic, Santa Rosa, CA, USA), Anaconda (Vascutek, Renfrewshire, Scotland, UK) or E-vita (Jotec, Hechingen, Germany) was used. Patients stayed in the intensive care unit for 12–24 h after the procedure and were monitored for myocardial ischemia with serial electrocardiography, serum cardiac enzyme analysis and echocardiography.

Statistical analysis

Sample size calculation was calculated to support the statistical powerful of results. It was based on the following assumptions: risk of adverse events of 20% in patients with CAD who undergo AA repair, cumulative early and mid-term incidences of the adverse events of about 10% in both groups (estimated difference 0%), margin of non inferiority of +2% (relative +20%), power of 80% and one-sided α-level of 0.05. Thus, a total sample of 988 patients were required taking into account a 99% complete follow-up at 12 months. Sample size was calculated by Sample Size Calculator by Raosoft (www.raosoft.com/samplesize.html).

Continuous variables were expressed as means ± standard or median (25th, 75th percentiles) and categorical data as proportions. The normal distribution of the continuous values was tested by means of the Anderson–Darling test. A p value > 0.05 was considered indicative of normal distribution. Comparison between continuous variables was made by means of Student's t test for normally distributed values. The Mann–Whitney U test was used for variables not normally distributed. Categorical variables were analyzed with the χ^2 test or Fisher's exact test, when required. Differences resulting in a p value < 0.05 were considered significant. The primary end-point was also assessed in pre-specified subgroups defined by several clinical and PCI-related characteristics drawn from Table 1 by calculating the odds ratio (OR) with 95% confidence intervals (CI). Based on univariate analysis, variable with a p value < 0.05 was entered into a multivariate logistic model. To assess the effect of DAPT score on ischemic events and precise DAPT score on bleeding, we developed a first model with DAPT and PRECISE-DAPT entered as a dichotomous variable (DAPT score ≥ 2 vs < 2; PRECISE-DAPT score ≥ 25 vs < 25) and then a second model with values entered as continuous variables. We compared ischemic and bleeding event rates in high-score patients versus low-score patients, and by each level of score by calculating odds ratios (OR) using Cox regression. We separately performed the analyses for patients with and without ischemic or bleeding events according to type of DES implanted. Data were analyzed by SPSS version 15 for Windows (SPSS, Inc., Chicago, IL, USA).

Results

Patient population

Of 2761 consecutive patients referred for elective DTA, AAA or TAAA repair, 1152 (41.7%) met inclusion criteria. Of these, 830 (72%) patients were treated by PCI for significant CAD (enrolled in group A) and 322 (28%) not needing for further coronary treatment although they were previously treated by DES-PCI at least 6 months before (enrolled in group B). As reported in Table 1, group A patients had a worse risk profile as compared with group B. Mean RCRI score was 2.1 ± 0.5 in group A and 2.1 ± 0.6 in group B ($p = 1$). By Pearson's correlation, only a weak correlation between preoperative RCRI score and actual presence of significant CAD at coronary angiography was registered in group A patients ($r = 0.23$). Mean DAPT score was 2.2 ± 0.5 in group A and 2.1 ± 0.5 in group B ($p = 1$). Mean PRECISE-DAPT score was 20.2 ± 4.6 in group A and 19.8 ± 5.6 in group B ($p = 0.2$). A total of 1176 coronary arteries were treated by 1358 DES within group A. Single-vessel PCI was performed in 535 patients (64.5), double in 244 (29.4%), triple in 51 (6.1%). A total of 467 coronary arteries had been previously treated by 5 589 DES within group B. Single-vessel PCI was performed in 201 patients (62.4%), double in 97

(30.1%), triple in 24 (7.5%). Distribution of target vessels for PCI and stent type for both groups are detailed in Table 2.

The mean time between PCI and aneurysm repair was 8.2 ± 0.3 weeks (range 8–10) in group A and 16.4 ± 7.7 (range 6–56) months in group B. No aneurysm rupture occurred in the interim between DES-PCI and repair in group A.

Driven by VerifyNow P2Y12 test, patients treated by DAPT underwent aneurysm repair within 4.4 ± 0.2 days from P2Y12 inhibitors discontinuation (4.5 ± 0.2 group A vs 4.3 ± 0.3 group B, $p = 0.9$). Notably, immediately after drug suspension, 118 (13.8%) patients had P2Y12 inhibition ≤ 25% (mean 15.6 ± 7.4, range 0–25), equivalent to PRU ≤ 210. These patients were considered drug resistant or low responders and were operated on immediately without any bridging therapy.

Early outcome

Overall and detailed incidences of adverse events are depicted in Table 3. Adverse events occurred in 6.2% (52/830) group A patients and in 6.5% (21/322) group B patients ($p = 0.8$). Mortality was 0.7% (6/830) in group A and 0.9% (3/322) in group B ($p = 0.7$). Causes of death were as follows: two renal failure, one multiple organ failure (MOF), one intestinal infarction, four MI, and one stroke, Perioperative MI was registered in 3.2% (27/830) group A patient versus 3.4% (11/322) group B patients ($p = 0.8$). Adverse events were mainly related to DES-PCI procedure in both groups. Strong multivariate predictors of adverse events in both groups were triple vessel DES-PCI (OR 0.2, 95% CI 0.08–0.4; $p < 0.001$), > 3 stents implanted (OR 0.2, 95% CI 0.09–0.4; $p < 0.001$) and early-generation stents (OR 0.2, 95% CI 0.09–0.4; $p < 0.001$); moderate multivariate predictors were diabetes insulin requirement (OR 0.3, 95% CI 0.1–0.7; $p = 0.01$), stent diameter < 3.0 mm (OR 0.3, 95% CI 0.1–0.6; $p = 0.009$) and total stented length > 30 mm (OR 0.3, 95% CI 0.1–0.8; $p = 0.02$). DAPT score ≥ 2 was only weakly associated with ischemic events in group A (OR 0.4, 95% CI 1.2–3.4; $p = 0.04$) but was not in group B (OR 0.5, 95% CI 0.2–1.3; $p = 0.1$).

Notably, there were not differences in cumulative adverse events comparing patients treated for DTA with those treated by AAA within groups (group A: 18 vs 34, $p = 0.1$; group B: 11 vs 17, $p = 0.1$) or between groups (DTA: 18 vs 11, $p = 0.2$; AAA: 34 vs 17, $p = 0.1$).

Table 2 Distribution of target vessels for PCI and stent type

Variable	Group A ($n = 830$)	Group B ($n = 322$)	p
PCI procedure			
Single PCI	535 (64.5%)	201 (62.4%)	0.5
Double PCI	244 (29.4%)	97 (30.1%)	0.8
Triple PCI	51 (6.1%)	24 (7.5%)	0.4
PCI target vessels			
LAD	811 (68.9%)	303 (64.9%)	0.05
Circumflex	178 (15.2%)	72 (15.4%)	0.2
RCA	187 (15.9%)	75 (19.7%)	0.005
Stent implanted			
Total	1358	467	
Early-generation DES sirolimus	186 (13.7%)	70 (14.7%)	0.5
New generation DES everolimus	303 (22.3%)	102 (21.9%)	0.8
Zotarolimus	416 (30.6%)	130 (27.8%)	0.2
Sirolimus	453 (33.4%)	165 (35.6%)	0.4
> 3 DES implanted	124 (14.9%)	52 (16.1%)	0.6
Stent diameter, mm	3.1 ± 0.4	3.2 ± 0.5	< 0.001
< 3 mm	407 (29.9%)	141 (30.2%)	0.9
3.0–3.2 mm	570 (42%)	196 (42%)	0.9
> 3.2 mm	381 (28.1%)	130 (27.8%)	0.8
Total stented length mm	22 ± 1.4	22 ± 1.3	0.9
< 19.0 mm	272 (32.8%)	106 (32.9%)	1
19–22 mm	274 (33%)	109 (33.8%)	0.8
> 22 mm	284 (34.2%)	107 (33.3%)	0.7

Data reported as *n* (%), mean ± SD

PCI percutaneous coronary intervention, *LAD* left anterior descending, *RCA* right coronary artery, *DES* drug-eluting stent

Table 3 Hospital and 12-month adverse events

	Group A ($n=830$)	Group B ($n=322$)	p
Hospital			
Adverse events	52 (6.2%)	21 (6.5%)	0.8
Deaths	6 (0.7%)	3 (0.9%)	0.7
Acute MI	27 (3.2%)	11 (3.4%)	0.8
Stent thrombosis	20 (2.4%)	9 (2.8%)	0.8
Need for repeated procedure	16 (1.9%)	5 (1.5%)	0.6
Cerebrovascular events	11 (1.3%)	5 (1.5%)	0.8
Stroke	5 (0.6)	2 (0.6%)	0.9
TIA	6 (0.7)	3 (0.9%)	0.8
Bleeding BARC Type 3a	6 (0.7)	3 (0.9%)	0.8
Type 3b	5 (0.6)	1 (0.3%)	0.5
(Fatal bleeding) Type 5	–	–	
	Group ($n=824$)	Group ($n=319$)	
12-month follow-up			
Adverse events	11 (1.3%)	5 (1.5%)	0.8
Deaths	2 (0.2%)	1 (0.3%)	0.7
Acute MI	7 (0.8%)	3 (0.9%)	0.9
Stent thrombosis	5 (0.6%)	2 (0.6%)	0.9
Need for repeated procedure	5 (0.6%)	1 (0.3%)	0.5
Cerebrovascular events	3 (0.3%)	2 (0.6%)	0.5
Stroke	2 (0.2%)	1 (0.3%)	0.5
TIA	1 (0.1%)	1 (0.3%)	0.5
Bleeding BARC Type 3c	–	1 (0.3%)	–

Data reported as n (%), mean ± SD

BARC bleeding academic research consortium, *MI* myocardial infarction, *TIA* transient ischemic attack

Linear regression analysis of DAPT score as continuous variable confirmed a significant association with ischemic events in group A ($R^2=0.7$, $p=0.009$) but not in group B ($R^2=0.40$, $p=0.08$). Nonetheless, rates of ischemic events were lower at scores of 1 and 2 and increased significantly at levels of 3 or more. The relationship between score and ischemic risk was J-shaped with lower risks at scores of 1 and 2 and increased risk at levels of 3 or higher. PRECISE-DAPT score ≥ 25 was associated with bleeding events in both groups (group A: OR 0.2, 95% CI 0.06–0.9, $p=0.03$; group B: OR 0.1, 95% CI 0.02–0.5, $p=0.005$), linear regression analysis confirmed this significant association (group A: $R^2=0.7$, $p=0.008$; group B: $R^2=0.8$, $p<0.001$).

Need for repeat revascularization occurred in 1.9% (16/830) group A patients and in 1.5% (5/322) group B ($p=0.6$). Atrial fibrillation within 48 h after the AA repair occurred in 10.4% (87/830) group A patients and 12.1% (39/322) group B patients ($p=0.4$). Atrial fibrillation was successfully treated by amiodarone. Whenever possible, P2Y12 inhibitor treatment was resumed on first postoperative day. No fatal bleeding occurred in both groups.

Follow-up

Follow-up was 99.4% complete (1136/1143). Overall and detailed 12-month incidences of adverse events are depicted in Table 3. Adverse events occurred in 1.3% (11/824) group A patients and in 1.9% (6/319) group B patients ($p=0.8$). MI were mainly due to stent thrombosis in both groups. Repeated revascularization procedures were performed in five group A patients and one group B patients. Incidence of bleeding events rate was negligible at follow-up.

Discussion

The main findings of this retrospective study are as follows: (1) EVAR 8 weeks after DES implant compared with 6 months was not inferior with regard to net of deaths and composite of ischemic events or bleedings; (2) neither differences in cumulative adverse events were detected in patients treated for DTA or AAA within groups nor between groups; (3) neither ruptures nor aneurysm dissections were registered in the 8 weeks of waiting between DES-PCI and AA

repair; (4) the suggested cutoff < 2 for DAPT score had poor discrimination for ischemic risk in our cohort, (5) the occurrence of ischemic event in patients treated by last generation DES was negligible; (6) point-of-care platelet function test represented a useful tool to guide preoperative DAPT management.

The optimal management of DAPT following PCI has been subject to continuous updates and revisions that provided different and, sometimes, contradictory recommendations over the time. Nonetheless, all of these agree that DAPT should be continued for at least 12 months or more after DES implantation. A shorter 6-month period could be admitted only in selected patients. As a consequence, necessary surgery should be delayed for at least 12 or 6 months after PCI-DES implantation [6–10]. On the other hand, guidelines for the treatment of aortic aneurysms reported an overall incidence of 5.3% ruptures per year in patients with aneurysm diameter > 5.5 cm and of 8.3% per year in patients with diameter > 6 cm, meaning that, in our cohort of patients with a mean diameter of 6.3 ± 4 cm, we should expect the non-negligible number of 8–12 aneurysm ruptures per year [17]. Based on the significant risk of aneurysm rupture or dissection, we chose as far back as 2005 to reduce the waiting time between stenting PCI and EVAR to 8 weeks. By means of this policy, in addition to a strict control of blood pressure with a goal of ≤ 120/80 mm Hg, we did not experience any aneurysm rupture/dissection in the entire population of this study.

Indeed, the strategy of 8 weeks after DES-PCI challenged the original guidelines. However, increasing body of evidences from the literature and the introduction of new-generation DES led to frequent updates of guidelines on DAPT over the years. Recent update introduced a number of significant novelties. Among these, 6 months of DAPT is recommended in patients treated by DES-PCI for stable CAD irrespective of the stent type (class I—level of evidence: A); the use of the DAPT and the PRECISE-DAPT risk scores may be considered for definition of different DAPT durations (class IIb—level of evidence: A); DES is the preferred percutaneous treatment option for CAD (class I—level of evidence A); patients with DAPT safety concerns and stable CAD that had undergone DAPT for 1 month (class IIb—level of evidence: C) [10]. The possibility of reduced duration of DAPT after DES-PCI has been also analyzed by the ISAR-SAFE, ISAR-TRIPLE and PRODIGY trials, which did not evidence any significant difference in clinical outcome between 6 months and 12 months of therapy [18–20]. Girardi et al., in a series of 44 patients who underwent open repair of TA after suspension of clopidogrel 4.6 weeks from bare-metal stent PCI, did not register any cardiac ischemic event or bleeding complication. Moreover, the PARIS study showed that brief (< 14 days) interruption of clopidogrel (aspirin continued) in patients needing surgical procedures did not increase thrombotic risk [5, 21]. All these data, taken together in the present, provide support to our original choice of 8 weeks waiting after DES-PCI for AA repair. Our results evidenced no difference in adverse events after 8 weeks compared to 6 months of waiting time after DES-PCI. We also failed to detect any significant difference in perioperative bleeding events between the two treatment groups. This low rate of either ischemic or bleeding events in group A could be also ascribed to our strategy of individualized approach to P2Y12 inhibitor discontinuation based on routine use of a platelet function testing and bridging with intravenous glycoprotein inhibitors tirofiban at surgery time. This strategy, in addition to prompt resumption of P2Y12 inhibitors treatment on 1st or 2nd postoperative day, allowed a very short discontinuation of therapy that seems to be effective against stent thrombosis and bleeding complications. The routine use of a platelet function testing allowed also the identification of poor clopidogrel/ticagrelor responders who took advantage of rapid platelet function recovery and consequently shorter tirofiban administration time [22].

A further finding of this study was the more favorable safety profile of newer generation DES in terms of risk of ischemic events. A subgroup analysis of end-point according to stent generation showed that recent devices were significantly associated with lower rates of hospital and 12-month adverse events in general, and cardiac ischemic events in particular, when compared with early-generation stents. In this regard, the recent OPTIMIZE and RESET trials reported that 12-month DAPT duration was not better than 3 months of therapy in terms of ischemic events in patients who had new-generation DES implanted [23, 24]. Indeed, the recent introduction on the market of the newer generation of DES, with rapid re-endothelialization, can lead in the future to a significant further reduction of the waiting time after primary PCI for any successive necessary surgical procedure.

It was striking to note that in our population treated by EVAR there were not differences in patients treated for DTA or AAA with regard to adverse event either within or between groups. Interestingly, EVAR treatment of DTA provided excellent results with very low rate of adverse events as compared with open approach. Paradoxically, in our experience, endovascular treatment of DTA was less demanding than treatment of AAA.

Finally, it was interesting that the DAPT score at two cut-offs was not able to discriminate ischemic risk in our study. We assessed that only value ≥ 3 was significantly able to capture ischemic events. The event rate was very low at values from − 2 to 2 but became significantly elevated only in patients with scores of 3 or higher. Notably, ischemic events did not increase linearly with level of score. Conversely, PRECISE-DAPT was a good predictor of bleeding in patients at ≥ 25 score. However, these results must be

taken with caution due the possible bias due to the preliminary exclusion in this study of patients perceived at high risk of ischemic or bleeding events.

This study has some important limitations. First, the retrospective nature. However, it could be very difficult to collect similarly high number patients for a prospective study. Second, clopidogrel and ticagrelor were the only P2Y12 inhibitors investigated. Hence, our results may not be extended to patients treated with more potent P2Y12 inhibitors. Finally, although the large number of patients enrolled, some events of interest occurred at very low rate to provide a reliable identification of the inherent risk factors.

Conclusion

The results of the present study support an aggressive approach to treating CAD before DTA or AAA repair. Preoperative coronary angiography is safe and preventive PCI protects patients against cardiac ischemic events. Reduced waiting time of 8 weeks in the interim between DES-PCI and EVAR for non-deferrable DTA or AAA does not increase the risk of aneurysm rupture and is long enough to allow stent endothelialization. A judicious and meticulous perioperative management of DAPT could contribute to minimize either hospital or 12-month postoperative ischemic morbidity and bleeding complications.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All authors fully disclose ethical problems and all direct or indirect potential conflict of interest (financial or not financial) and any relationships, including any relationship of their family, with pharmaceutical companies, biomedical device manufacturers or other corporations whose products or services related to the subject matter of the article.

Informed consent All patients provided written informed conent to be treated according with our clinical protocol and provided written permission for use of their medical record for research purpose.

Research involving human participants and/or animals The research involved human participants. Given the retrospective nature of the study, the need for individual patient consent was waived but all patients had preliminarily granted permission for the use of their medical records for research purposes and provided written informed consent to be treated according to our protocol at the time of AA repair.

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