Supplementary

SuppTab1. Distribution of patients' demographic and medical history variables in Euro-CTO cohort and their association with the failure of PCI estimated with univariate logistic regression analyses.

	Overall Total N = 14882	Success Total N = 12526 (84.2 %)	Failure Total N = 2356 (15.8 %)	Univariate analyses	
Demographics and Medical History Characteristics					
	Total N	N (%)	N (%)	OR (95 % CI)	P[a]
Gender					
Female	2230	1896 (85.0)	334 (15.0)	1.00	
Male	12634	10616 (84.0)	2018 (16.0)	1.08 (0.95 – 1.22)	0.24
Missing	18	14 (77.8)	4 (22.2)		
Smoker					
No	6302	5243 (83.2)	1059 (16.8)	1.00	0.06
Ex-smoker	3370	2850 (84.6)	520 (15.4)	0.90 (0.81 – 1.01)	
Current smoker	4005	3382 (84.4)	623 (15.6)	0.91 (0.82 – 1.02)	
Missing	1205	1051 (87.2)	154 (12.8)	-	
BMI (kg/m^2)[b]					
0-	3194	2713 (84.9)	481 (15.1)	1.00	0.75
25-	3568	3006 (84.2)	562 (15.8)	1.05 (0.92 – 1.20)	
27.5-	3267	2794 (85.5)	473 (14.5)	0.95 (0.83 – 1.10)	
30-	2905	2465 (84.9)	440 (15.1)	1.01 (0.87 – 1.16)	
35-	1033	859 (83.2)	174 (16.8)	1.14 (0.95 – 1.38)	
Missing	915	689 (75.3)	226 (24.7)	-	
As continuous				1.03 (0.97 – 1.08)	0.33
Median	27.7	27.6	27.4		
(IQR)	(25.3 – 30.5)	(25.3 – 30.5)	(25.3 – 30.7)		
Family history of CD[c]					
No	10222	8568 (83.8)	1654 (16.2)	1.00	
Yes	4659	3957 (84.9)	702 (15.1)	0.92 (0.83 – 1.01)	0.09
Missing	1	1 (100)	0 (0)	-	
Hypertension					
No	3598	3045 (84.6)	553 (15.4)	1.00	
Yes	10856	9169 (84.5)	1687 (15.5)	1.01 (0.91 – 1.12)	0.81
Missing	428	312 (72.9)	116 (27.1)	-	-
Dyslipidaemia					
No	3754	3096 (82.5)	658 (17.5)	1.00	
Yes	11127	9429 (84.7)	1698 (15.3)	0.85 (0.77 – 0.94)	0.001
Missing	1	1 (100)	0 (0)	-	
Diabetes					
No	8620	7220 (83.8)	1400 (16.2)	1.00	0.26
NID	2049	1728 (84.3)	321 (15.7)	0.96 (0.84 – 1.09)	
ID	2158	1773 (82.2)	385 (17.8)	1.12 (0.99 – 1.27)	
Missing	2055	1805 (87.8)	250 (12.2)	-	
Peripheral disease					
No	13105	11138 (85.0)	1967 (15.0)	1.00	
Yes	1349	1076 (79.8)	273 (20.2)	1.44 (1.25 – 1.65)	<0.001
Missing	428	312 (72.9)	116 (27.1)	-	

Demographics and Medical History Characteristics				
	Overall **Total** **N = 14882**	**Success** **Total N = 12526** **(84.2 %)**	**Failure** **Total N = 2356** **(15.8 %)**	**Univariate analyses**
	Total N	**N (%)**	**N (%)**	**OR (95 % CI)**	**P[a]**
Prior stroke					
No	14071	11912 (84.7)	2159 (15.3)	1.00	0.002
Yes	383	302 (78.9)	81 (21.1)	1.48 (1.15 -1.90)	
Missing	428	312 72.9)	116 (27.1)	-	
Angina pectoris					
No	1808	1461 (80.8)	347 (19.2)	1.00	<0.001
Stable	11783	9961 (84.5)	1822 (15.5)	0.77 (0.68 – 0.87)	
Unstable	1212	1033 (85.2)	179 (14.8)	0.73 (0.60 – 0.89)	
Missing	79	71 (89.9)	8 (10.1)	-	
Previous MI[d]					
No	7817	6584 (84.2)	1233 (15.8)	1.00	0.13
Non-STE[e]	3127	2580 (82.5)	547 (17.5)	1.13 (1.01 – 1.26)	
STE	2508	2098 (83.7)	410 (16.3)	1.04 (0.92 – 1.18)	
CABG territory[f]					
No	13553	11491 (84.8)	2062 (15.2)	1.00	
Yes	1305	1014 (77.7)	291 (22.3)	1.60 (1.39 – 1.84)	<0.001
Missing	24	21 (87.5)	3 (12.5)	-	
PCI					
No	7491	6379 (85.2)	1112 (14.8)	1.00	0.001
Yes	7368	6126 (83.1)	1242 (16.9)	1.16 (1.06 – 1.27)	
Missing	23	21 (91.3)	2 (8.7)	-	
PCI territory[g]					
No	12209	10343 (84.7)	1866 (15.3)	1.00	
Yes	2222	1851 (83.3)	371 (16.7)	1.11 (0.98 – 1.26)	0.09
Missing	451	332 (73.6)	119 (26.4)	-	
Previous attempts					
No	11230	9507 (84.7)	1723 (15.3)	1.00	
Yes	3608	2984 (82.7)	624 (17.3)	1.15 (1.04 – 1.28)	0.005
Missing	44	35 (79.5)	9 (20.5)	-	

[a]P values for the binary variables correspond to the Wald-test, otherwise to the trend test. [b]BMI – body mass index; [c]CD – coronary disease; [d]MI – myocardial infarction; [e]STE MI– ST-segment elevation myocardial infarction (classic heart attack); [f]CABG territory of CTO whether it had been treated by CABG previously; [g]PCI territory of CTO – whether it had been treated by PCI previously.

Supp.Table 1 *continued*

SuppTab2. Baseline measurements in Euro-CTO cohort and their association with the failure of PCI estimated with univariate logistic regression analyses.

	Baseline measurements				
	Overall Total N = 14882	Success Total N = 12526 (84.2 %)	Failure Total N = 2356 (15.8 %)	Univariate analyses	
	N	N (%)	N (%)	OR (95 % CI)	P[a]
ECG[b]					
Normal	10284	8808 (85.6)	1476 (14.4)	1.00	<0.001
Non Q-Wave	687	548 (79.8)	139 (20.2)	1.51 (1.25 – 1.84)	
Q-Wave	832	687 (82.6)	145 (17.4)	1.26 (1.04 – 1.52)	
Questionable	2285	1857 (81.3)	428 (18.7)	1.38 (1.22 – 1.55)	
Missing	794	626 (78.8)	168 (21.2)	-	
LV global EF[c] (%)					
≥ 50	10310	8805 (85.4)	1505 (14.6)	1.00	<0.001
≥ 35 & < 50	3138	2582 (82.3)	556 (17.7)	1.26 (1.13 – 1.40)	
< 35	888	747 (84.1)	141 (15.9)	1.10 (0.91 – 1.33)	
Missing	546	392 (71.8)	154 (28.2)	-	
Wall motion[d]					
Normal	7147	6211 (86.9)	936 (13.1)	1.00	<0.001
Hypokinetic	5676	4751 (83.7)	925 (16.3)	1.29 (1.17 – 1.43)	
Akinetic	746	599 (80.3)	147 (19.7)	1.63 (1.34 – 1.98)	
Diskinetic	148	124 (83.8)	24 (16.2)	1.28 (0.83 – 2.00)	
Missing	1165	841 (72.2)	324 (27.8)	-	
Viable myocardium					
No	6376	5277 (82.8)	1099 (17.2)	1.00	
Yes	8483	7228 (85.2)	1255 (14.8)	0.83 (0.76 – 0.91)	<0.001
Missing	23	21 (91.3)	2 (8.7)	-	
N[c] of diseased vessel					
1	5870	4960 (84.5)	910 (15.5)	1.00	0.17
2	4546	3864 (85.0)	682 (15.0)	0.96 (0.86 – 1.07)	
3 -	4227	3522 (83.3)	705 (16.7)	1.09 (0.98 – 1.21)	
Missing	239	180 (75.3)	59 (24.7)	-	

[a]P values for the binary variables correspond to the Wald test, otherwise to the trend test. [b]ECG – ECG CTO related lesion, [c]LV global EF – Left ventricular ejection fraction, [d]Wall motion - segmental regional wall motion CTO-related lesion, [c]N – number.

SuppTab3. Distribution of lesion characteristics in Euro-CTO cohort and their association with the failure of PCI of CTO estimated with univariate logistic regression analyses.

Lesion Characteristics					
	Overall	**Success**	**Failure**		
	Total	**Total N = 12526**	**Total N = 2356**		
	N = 14882	**(84.2 %)**	**(15.8 %)**	**Univariate analyses**	
	Total N	**N (%)**	**N (%)**	**OR (95 % CI)**	**P[a]**
CTO artery					
LAD	3795	3280 (86.4)	515 (13.6)	1.00	<0.001
LCX	2167	1855 (85.6)	312 (14.4)	1.07 (0.92 – 1.25)	
RCA	7814	6496 (83.1)	1318 (16.9)	1.29 (1.16 – 1.44)	
Other[a]	1083	886 (81.8)	197 (18.2)	1.42 (1.18 – 1.70)	
Missing	23	9 (39.1)	14 (60.9)	-	
CTO location					
Distal	1019	861 (84.5)	158 (15.5)	1.00	0.18
Mid	5790	4953 (85.5)	837 (14.5)	0.92 (0.77 – 1.11)	
Ostial	1546	1241 (80.3)	305 (19.7)	1.34 (1.08 – 1.65)	
Proximal	6162	5206 (84.5)	956 (15.5)	1.00 (0.83 – 1.20)	
Missing	365	265 (72.6)	100 (27.4)	-	
In stent CTO					
No	13763	11555 (84.0)	2208 (16.0)	1.00	
Yes	1116	971 (87.0)	145 (13.0)	0.78 (0.65 – 0.94)	0.007
Missing	3	0 (0)	3 (100)	-	
Occlusion duration[b]					
Likely	6884	5835 (84.8)	1049 (15.2)	1.00	0.98
Certain	3059	2615 (85.5)	444 (14.5)	0.94 (0.84 – 1.07)	
Undetermined	4087	3459 (84.6)	628 (15.4)	1.01 (0.91 – 1.12)	
Missing	852	617 (72.4)	235 (27.6)	-	
Collaterals filling					
None	1073	852 (79.4)	221 (20.6)	1.00	
Distal	2175	1780 (81.8)	395 (18.2)	0.86 (0.71 – 1.03)	0.10
Ipsilateral	2095	1872 (89.4)	223 (10.6)	0.46 (0.37 – 0.56)	<0.001
Retrograde	5569	4697 (84.3)	872 (15.7)	0.72 (0.61 – 0.84)	<0.001
Ips./retrogr.	3724	3193 (85.7)	531 (14.3)	0.64 (0.54 – 0.76)	<0.001
Missing	246	132 (53.7)	114 (46.3)	-	
Collateral circulation					
CC0	2150	1825 (84.9)	325 (15.1)	1.00	
CC1	4943	4277 (86.5)	666 (13.5)	0.87 (0.76 – 1.01)	0.07
CC2	6695	5611 (83.8)	1084 (16.2)	1.08 (0.95 – 1.24)	0.24
Missing	1094	813 (74.3)	281 (25.7)	-	
Distal opacification					
Not visible	1136	896 (78.9)	240 (21.1)	1.00	<0.001
Faint	6056	5098 (84.2)	958 (15.8)	0.70 (0.60 – 0.82)	
Good	6637	5750 (86.6)	887 (13.4)	0.58 (0.49 – 0.68)	
Missing	1053	782 (74.3	271 (25.7)	-	
Vessel diameter (mm)					
0-	5489	4737 (86.3)	752 (13.7)	1.00	
3-	8246	7033 (85.3)	1213 (14.7)	1.09 (0.98 – 1.20)	0.10
Missing	1147	756 (65.9)	391 (34.1)	-	
as continuous				1.01 (0.90 – 1.13)	0.84
Median	3.0 (2.5 –				
(IQR)	3.0)	3.0 (2.5 – 3.0)	3.0 (2.5 – 3.0)		

Lesion Characteristics				
Overall	**Success**	**Failure**		
Total	**Total N = 12526**	**Total N = 2356**		
N = 14882	**(84.2 %)**	**(15.8 %)**	**Univariate analyses**	
Total N	**N (%)**	**N (%)**	**OR (95 % CI)**	**Pa**

[a]P values corresponding to trend tests across groups.[a]CTO artery – other: LMT, SB, BP-venous, BP-arterial; [b]Occlusion duration characteristics implies whether the artery has been occluded for a long period of time confirmed clinically or angiographically;

SuppTab3. *continued*

SuppTab4 Regression coefficients of EuroCTO CASTLE model with age as continuous variable.

Factor	OR (95 %CI)	P-value
EuroCTO CASTLE model		
CABG		
No	1.00	
Yes	1.42 (1.26 - 1.61)	<0.0001[a]
Tortuosity		
Straight/Slight	1.00	<0.001
Moderate	1.15 (1.02 - 1.28)	
Severe/Unseen	2.28 (2.00 - 2.60)	
Calcification		
No/mild	1.00	<0.001
Moderate	1.15 (1.03 - 1.29)	
Severe	2.18 (1.92 - 2.47)	
Stump		
Tapered	1.00	<0.001
Blunt	1.64 (1.47 - 1.84)	
No	2.73 (2.38 - 3.13)	
CTO length		
<20	1.00	<0.001
20-	1.43 (1.22 - 1.67)	
25-	1.49 (1.24 - 1.79)	
30-	1.60 (1.36 - 1.89)	
35-	1.78 (1.55 - 2.04)	
Age in 5 years increments	1.04 (1.02 - 1.06)	0.0008[a]

Multiple imputation = 20, number of observation = 14882, due to nonresponse the average relative variance increase, RVI = 0.064, and the largest fraction of missing information, FMI = 0.124. P-value corresponding to the [a]Wald-test otherwise to the trend test across groups.

SuppTab 5. Distribution of risk factors on the validation set before multiple imputations.

	Overall Total N = 5745	Success Total N = 5042 (87.8%)	Failure Total N = 703 (12.2%)	
	N	N (%)	N (%)	P-value[a]
CABG				
No	4980	4399 (88.3)	581 (11.7)	0.001
Yes	764	642 (84.0)	122 (16.0)	
Missing	1	1 (100)	0 (0)	
Age (years)				<0.001
<55	1096	986 (90.0)	110 (10.0)	
55-	909	818 (90.0)	91 (10.0)	
60-	986	876 (88.8)	110 (11.2)	
65-	966	831 (86.0)	135 (14.0)	
70-	809	678 (83.8)	131 (16.2)	
75-	628	542 (86.3)	86 (13.7)	
80-	346	308 (89.0)	38 (11.0)	
Missing	5	3 (60.0)	2 (40.0)	
As continuous				
Mean (SD)	64.2 (10.4)	64.0 (15.5)	65.6 (9.8)	
Tortuosity				<0.001
Straight/Slight	4394	3984 (90.7)	410 (9.3)	
Moderate	713	609 (85.4)	104 (14.6)	
Severe/Unseen	345	263 (76.2)	82 (23.8)	
Missing	293	186 (63.5)	107 (36.5)	
Calcification				<0.001
None/Mild	3019	2786 (92.3)	233 (7.7)	
Moderate	1590	1410 (88.7)	180 (11.3)	
Severe	924	717 (77.6)	207 (22.4)	
Missing	212	129 (60.8)	83 (39.2)	
Stump				<0.001
Tapered	2276	2139 (94.0)	137 (6.0)	
Blunt	2286	2018 (88.3)	268 (11.7)	
No	911	716 (78.6)	195 (21.4)	
Missing	272	169 (62.1)	103 (37.9)	
Length of CTO (mm)				<0.001
0-	1649	1565 (94.9)	84 (5.1)	
20-	914	829 (90.7)	85 (9.3)	
25-	731	653 (89.3)	78 (10.7)	
30-	779	667 (85.6)	112 (14.4)	
35-	1546	1292 (83.6)	254 (16.4)	
Missing	126	36 (28.6)	90 (71.4)	
As continuous				
Median (IQR)	25 (15 – 35)	25 (15 – 35)	30 (20 – 45)	

[a]P- value corresponding to trend test by the outcome of PCI, except for CABG for which chi-squared test was used. Missing value category was excluded for these tests.

SuppTab 6. Coefficients of the total risk scores obtained from the univariate logistic regression analysis on the derivation set and used for prediction of the probability of failure of PCI on the validation set.

	log OR	P	95 % CI (logOR)	Average RVI[a]	Largest FMI[b]
$\widehat{\beta_1}$, total score	0.5252	<0.001	0.48 to 0.57	0.03	0.06
$\widehat{\beta_0}$, intercept	-2.8217	<0.001	-2.93 to -2.71		

$$logit\ \pi_i = -2.8217 + 0.5252 \times Total\ score_i{}^c$$

$$Predictive\ probability\ of\ failure_i = \frac{1}{1 + e^{-\ logit(\pi_i)}}$$

[a]RVI – relative variance increase; [b]FMI – fraction of missing information; [c]Total score$_i$ – total score for i [th] patient

SuppTab 7. Observed risks and predicted risks computed by the EuroCTO CASTLE model on the imputed validation set

Risk groups		Risk scores	N of procedures	N of failures	Mean predicted risk (%)
1	Low	0 & 1	1947	103	8.3
2	Intermediate	2	2161	242	14.5
3	High	3	1121	205	22.3
4	Very high	4 - 6	516	153	35.5
		Total	5745	703	15.8

SuppTab 8. Observed risks and predicted risks without and with the adjustment for year of operation. Predicted risk were computed for each risk scores by the EuroCTO CASTLE model on the imputed validation set

Risk scores	N of procedures	N of failures	Mean predicted risk (%)	
			Unadjusted	Adjusted
0	488	10	5.6	4.1
1	1459	93	9.1	6.7
2	2161	242	14.5	10.9
3	1121	205	22.3	17.1
4	406	113	32.7	25.7
5	103	37	45.1	36.8
6	7	3	58.2	49.5
Total	5745	703	15.8	12.0