



Multivessel vs. culprit vessel-only percutaneous coronary intervention in ST-segment elevation myocardial infarction with and without cardiogenic shock

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Frontiers in Cardiovascular Medicine

Introduction

- patients with ST-segment elevation myocardial infarction (STEMI) with or without cardiogenic shock, **early revascularization**—mainly percutaneous coronary intervention (PCI) on the culprit vessel—is **the most effective** therapeutic strategy to **reduce both short- and long-term mortality**
- over half of patients with **hemodynamically stable STEMI** have **at least 1 other** obstructive lesion in non-culprit vessels
- STEMI with cardiogenic shock, up to **80% of patients** present with **multivessel coronary artery disease**
- COMPLETE trials comparing multivessel vs. culprit-only PCI have reported **improved clinical outcomes** including decreased cardiac mortality, myocardial reinfarction, and revascularization

Introduction

- the optimal time to treat non-culprit lesions is not known
- multivessel PCI: cardiogenic shock patients were excluded from these studies
- CULPRIT-SHOCK trial: acute MI complicated by cardiogenic shock suggested that immediate treatment of non-culprit lesions during primary PCI was harmful
- impact of multivessel PCI for STEMI with and without cardiogenic shock on in-hospital outcomes are limited and inconsistent
- The most recent practice trends of multiple PCI are unknown

Materials and methods: Data source, Study population

- Data: National Inpatient Sample (NIS) database
- from October 2015 through 2019
- ICD-10-CM diagnosis codes I21.0x, I21.1x, I21.2x, and I21.3
- Exclusion:
 - patients who did not undergo PCI;
 - missing information on the number of treated vessels in procedure codes
 - age at admission <18 years;
 - missing data on in-hospital mortality

Materials and methods: outcome measures

- Primary outcome: in-hospital all-cause mortality
- Secondary outcome: major adverse cardiac or cerebrovascular events (MACCE)
 - all-cause mortality,
 - cardiac complications (hemopericardium and cardiac tamponade necessitating pericardiocentesis),
 - stroke

Materials and methods: Statistical analyses

- Continuous variables: mean +/- SD or median [interquartile range (IQR)] as appropriate
- Categorical variables: numbers and percentages
- Multivariable logistic regression models: evaluate the association between in-hospital mortality, presented as odds ratios (OR) with 95% confidence interval (CI),
- variables included: multivessel PCI, age, sex, race, expected payer, hospital bed size, location and teaching status, atrial fibrillation,...

Materials and methods: Statistical analyses

- Differences between categorical variables: evaluated with the chi-squared test
- differences between continuous variables: assessed with the Student's t-test or Mann–Whitney U test as appropriate;
- the corresponding ORs and 95% CIs are presented as forest plots.
- The Breslow–Day test was used to analyze the interaction between subgroups.
- Considering the large sample size, a 2-sided P-value <0.01 was considered statistically significant.
- SAS 9.4 was used for all analyses

Results:

- 912,540 hospitalizations with a diagnosis of STEMI
- October 2015 to October 2019 from the NIS database
- Exclusion:
 - did not undergo PCI; (283,645)
 - missing information on the number of treated vessels (n = 3,280)
 - age at admission <18 years; (n = 440)
 - missing data on in-hospital mortality (n = 3,300)
- final analysis: 624,605 STEMI hospitalizations,
 - 546,305 (87.5%) without cardiogenic shock
 - 78,300 (12.5%) with cardiogenic shock

Results:

- In the cohort without cardiogenic shock,
 - 460,315 (84.3%) hospitalizations: underwent culprit-only PCI
 - 85,990 (15.7%): underwent multivessel PCI
- In the cohort with cardiogenic shock,
 - 60,695 (77.9%) hospitalizations: underwent culprit-only PCI
 - 17,335 (22.1%): underwent multivessel PCI

Results:

- Multivessel PCI in overall STEMI hospitalizations declined from 21.8% in 2015 to 14.6% in 2019 ($P_{\text{trend}} < 0.001$)

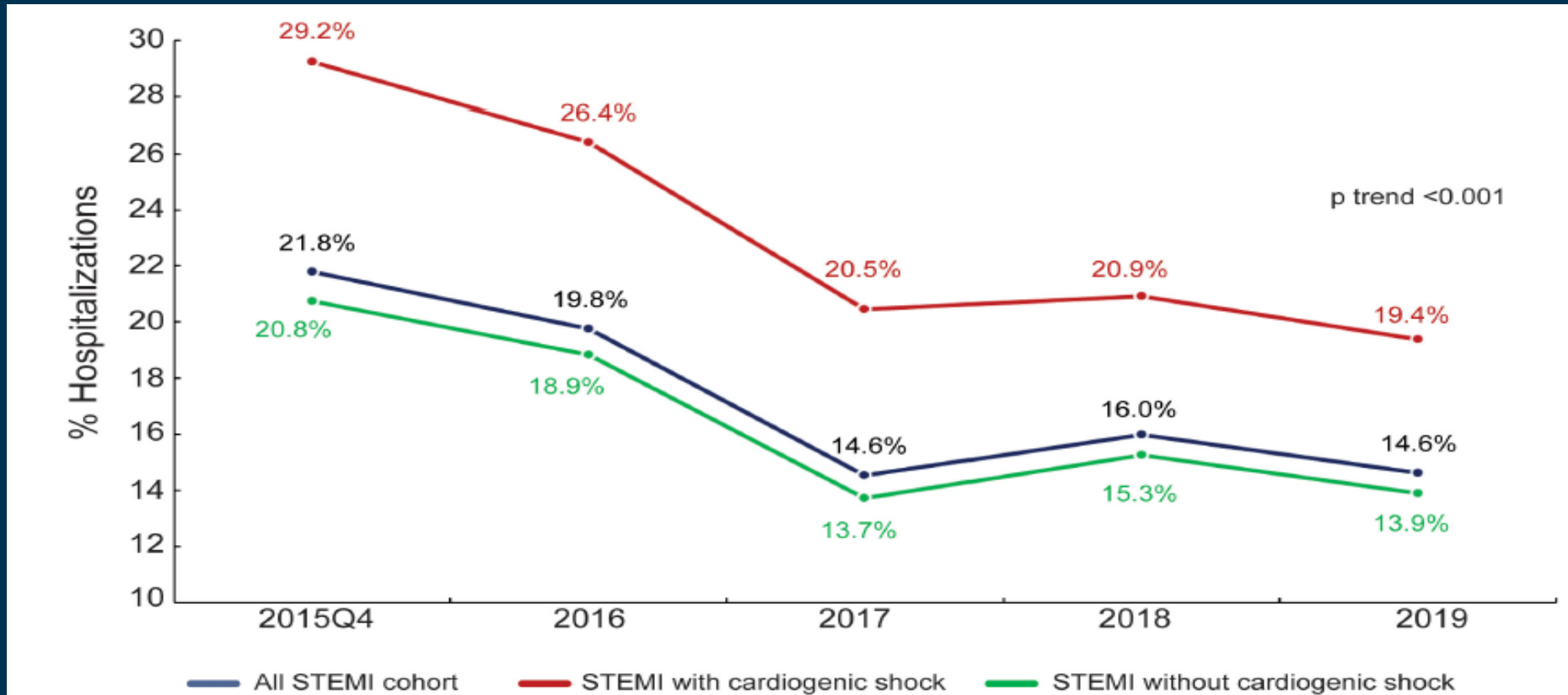


FIGURE 1

Trend of multivessel PCI performance during the study period. Percentage of overall STEMI hospitalizations, STEMI hospitalizations with cardiogenic shock, and STEMI hospitalizations without cardiogenic shock in which multivessel PCI was performed.

TABLE 1 Baseline characteristics in overall STEMI hospitalizations.

Variables	Culprit-only PCI N = 521,280	Multivessel PCI N = 103,325	P-value
Age	62.5 ± 12.6	63.5 ± 12.2	<0.001
Female	151,435 (29.1)	27,900 (27.0)	<0.001
Anterior STEMI	192,065 (36.8)	36,605 (35.4)	<0.001
Inferior STEMI	258,035 (49.5)	49,885 (48.3)	<0.001
Unspecified STEMI	79,105 (15.2)	19,990 (19.4)	<0.001
Race			<0.001
White	380,205 (76.3)	75,885 (77.1)	
Black	43,000 (8.6)	7,000 (7.1)	
Hispanic	41,185 (8.3)	8,180 (8.3)	
Asian/pacific islander	13,685 (2.8)	3,185 (3.2)	
Native American	2,635 (0.5)	565 (0.6)	
Other races	17,450 (3.5)	3,565 (3.6)	
Hypertension	373,945 (71.7)	76,560 (74.1)	<0.001
Diabetics	161,150 (30.9)	35,600 (34.5)	<0.001
History of smoke	140,915 (27.0)	27,970 (27.1)	0.805
Obesity	92,200 (17.7)	17,625 (17.1)	<0.001
Prior MI	62,685 (12.0)	12,370 (12.0)	0.630
Prior PCI	67,750 (13.0)	14,065 (13.6)	0.022
Prior CABG	18,770 (3.6)	4,330 (4.2)	<0.001
Prior stroke	24,305 (4.7)	5,090 (4.9)	<0.001
Peripheral arterial disease	37,245 (7.1)	8,475 (8.2)	<0.001
Chronic lung disease	73,755 (14.2)	13,870 (13.4)	<0.001
Hypothyroidism	43,240 (8.3)	8,480 (8.2)	0.675

Family history of CAD	81,195 (15.6)	16,265 (15.7)	0.549
Hospital size (number of beds)			<0.001
Small	79,735 (15.2)	14,995 (14.5)	
Medium	157,860 (30.3)	30,405 (29.4)	
Large	283,985 (54.5)	57,925 (56.1)	
Hospital location/teaching status			0.003
Rural hospital	31,220 (6.0)	6,405 (6.2)	
Urban non-teaching	119,000 (22.8)	23,870 (23.1)	
Urban teaching	310,060 (71.2)	73,050 (70.7)	
Payer			<0.001
Medicare	220,170 (42.3)	46,135 (44.7)	
Medicaid	56,500 (10.9)	10,590 (10.3)	
Private	185,740 (35.7)	35,585 (34.5)	
Self-pay	37,455 (7.2)	6,810 (6.6)	
No charge	3,140 (0.6)	565 (0.6)	
Other	17,295 (3.3)	3,445 (3.3)	
Systemic thrombolysis	10,905 (2.1)	2,500 (2.4)	<0.001
Thrombectomy	76,475 (14.7)	14,060 (13.6)	<0.001
MCS	44,370 (8.5)	15,145 (14.7)	<0.001
Cardiogenic shock	60,965 (11.7)	17,335 (16.8)	<0.001
Cost of care, U.S. \$	25,830 ± 22,514	35,980 ± 36,358	<0.001
Length of hospital stay	2 (2, 4)	3 (2, 5)	<0.001

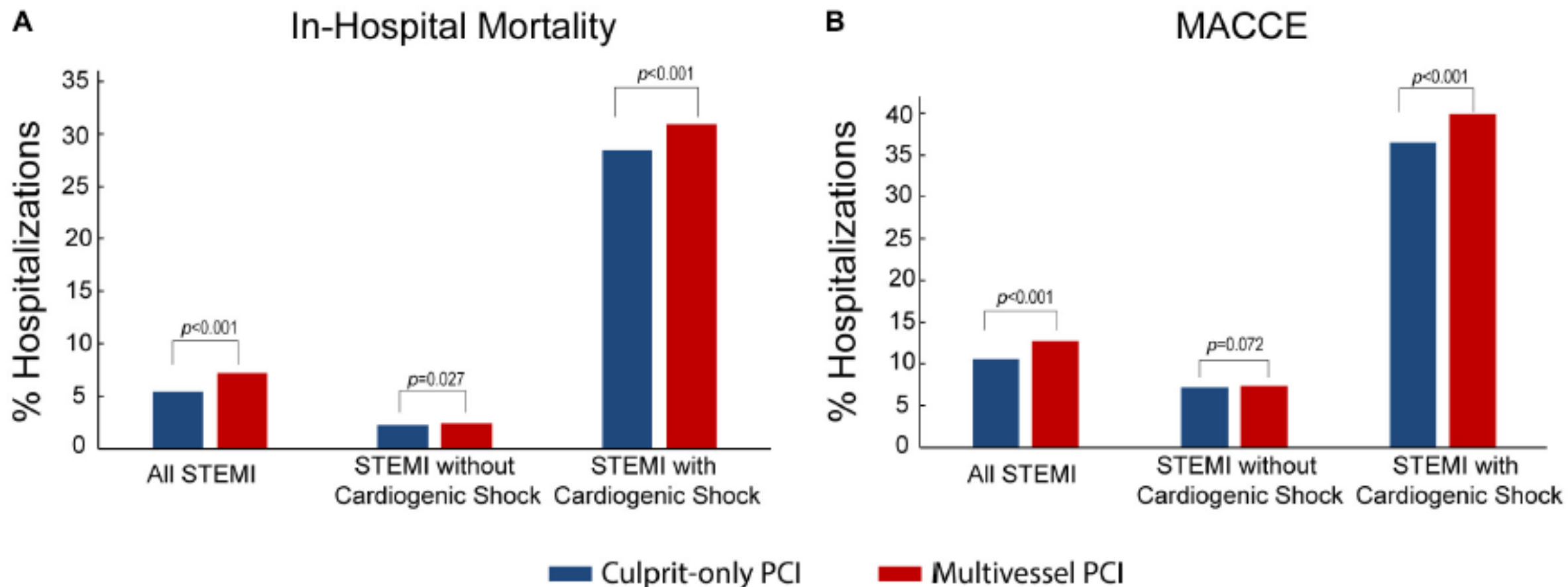
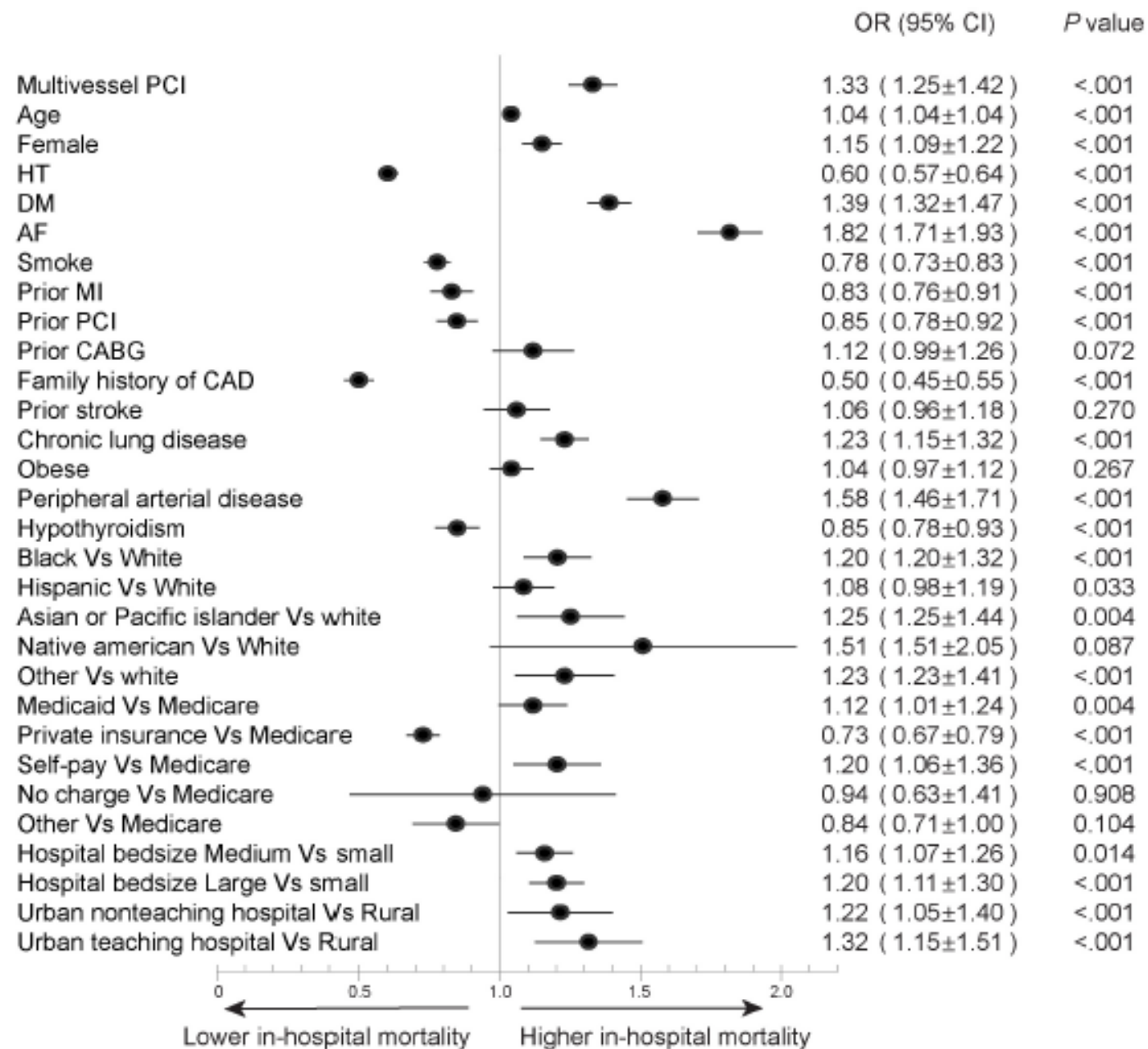


FIGURE 2

In-hospital mortality and MACCE in multivessel PCI vs. culprit-only PCI. (A,B) Shown are percentages of in-hospital mortality (A) and MACCE (B) comparing multivessel PCI vs. culprit-only PCI in the overall STEMI cohort, STEMI without cardiogenic shock cohort, and STEMI with cardiogenic shock cohort.



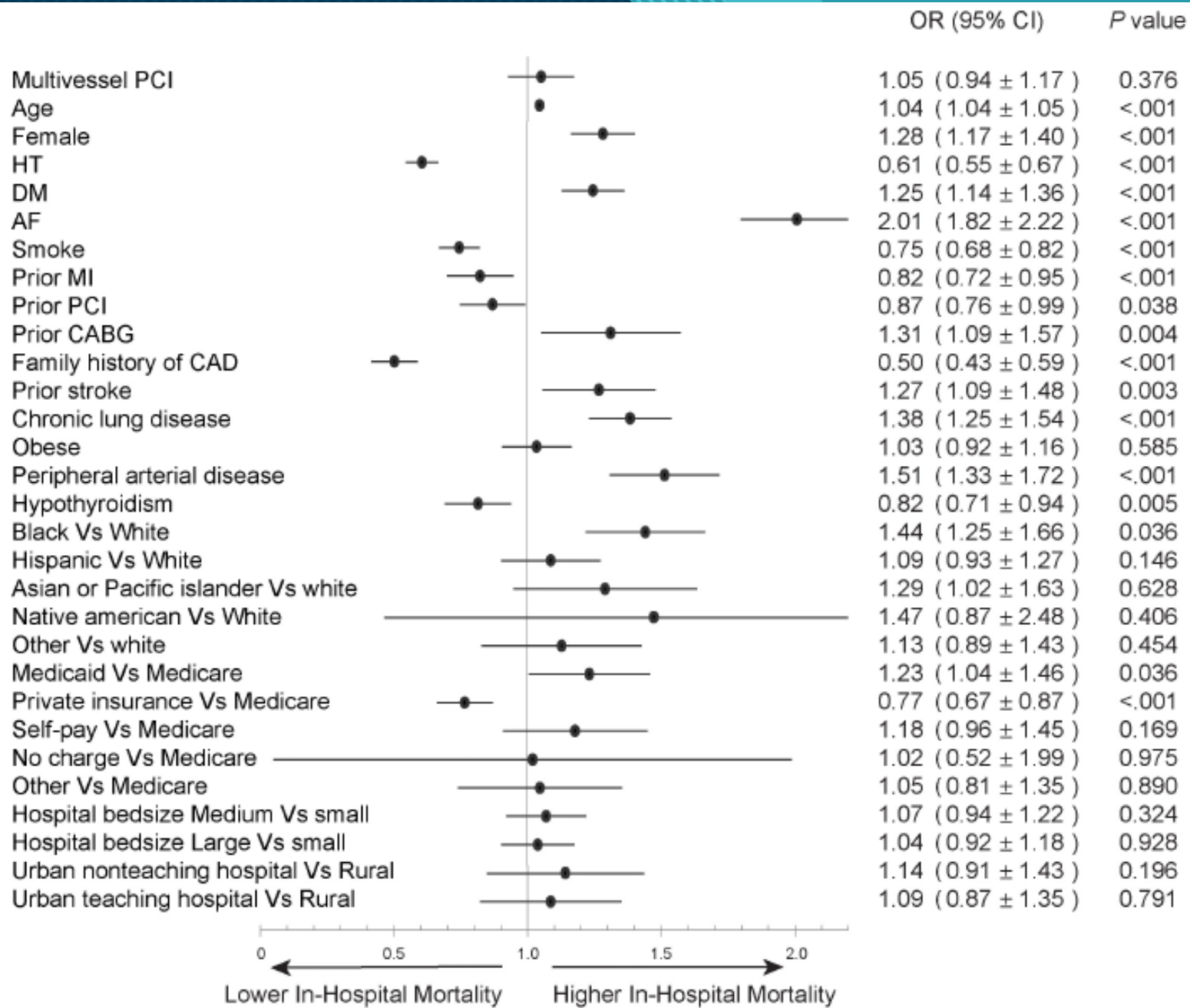
Results:

- The increase in in-hospital mortality was observed in each calendar year during the study period
- Multivessel PCI: in-hospital mortality
 - 2-vessels and >2 vessels.
 - Higher rates of (9.6 vs. 6.8%, $P < 0.001$) and MACCE (15.8 vs. 12.3%, $P < 0.001$)

TABLE 2 Baseline characteristics in STEMI hospitalizations without cardiogenic shock.

Variables	Culprit-only PCI N = 460,315	Multivessel PCI N = 85,990	P-value
Age	62.1 ± 12.5	63.0 ± 12.2	<0.001
Female	131,160 (28.5)	22,745 (26.5)	<0.001
Anterior STEMI	165,860 (36.0)	28,700 (33.4)	<0.001
Inferior STEMI	231,020 (50.2)	43,215 (50.3)	0.712
Unspecified STEMI	70,030 (15.2)	16,450 (19.1)	<0.001
Race			<0.001
White	336,805 (76.5)	63,570 (77.6)	
Black	38,285 (8.7)	5,905 (7.2)	
Hispanic	36,165 (8.2)	6,635 (8.1)	
Asian/pacific islander	11,630 (2.6)	2,445 (3.0)	
Native American	2,235 (0.5)	465 (0.6)	
Other races	15,030 (3.4)	2,920 (3.6)	
Hypertension	332,565 (72.3)	64,500 (75.0)	<0.001
Diabetics	140,250 (30.5)	28,620 (33.3)	<0.001
History of smoke	126,375 (27.5)	24,000 (27.9)	0.006
Obesity	82,300 (17.9)	14,770 (17.2)	<0.001
Prior MI	56,110 (12.2)	10,465 (12.2)	0.873
Prior PCI	60,940 (13.2)	11,970 (13.9)	<0.001
Prior CABG	16,610 (3.6)	3,755 (4.4)	<0.001
Prior stroke	21,265 (4.6)	4,170 (4.9)	0.003
Peripheral arterial disease	30,580 (6.6)	6,290 (7.3)	<0.001
Chronic lung disease	62,705 (13.6)	10,930 (12.7)	<0.001
Hypothyroidism	37,690 (8.2)	6,905 (8.0)	0.121

Family history of CAD	75,310 (16.4)	14,645 (17.3)	<0.001
Hospital size (number of beds)			<0.001
Small	71,040 (15.4)	12,705 (14.8)	
Medium	139,570 (30.3)	25,705 (29.9)	
Large	249,705 (54.3)	47,580 (55.3)	
Hospital location/teaching status			0.003
Rural hospital	28,060 (6.1)	5,530 (6.4)	
Urban non-teaching	105,650 (23.0)	20,220 (23.5)	
Urban teaching	326,605 (71.0)	60,240 (70.1)	
Payer			<0.001
Medicare	188,520 (41.0)	36,860 (43.0)	
Medicaid	50,275 (10.9)	8,665 (10.1)	
Private	168,430 (36.7)	31,000 (36.1)	
Self-pay	33,745 (7.3)	5,850 (6.8)	
No charge	2,850 (0.6)	510 (0.6)	
Other	15,665 (3.4)	2,940 (3.4)	
Systemic thrombolysis	9,280 (2.0)	2,075 (2.4)	<0.001
Thrombectomy	64,265 (14.0)	10,910 (12.7)	<0.001
MCS	13,455 (2.9)	4,230 (4.9)	<0.001
Cost of care, U.S. \$	22,990 ± 15,863	30,691 ± 25,804	<0.001
Length of hospital stay	2 (2, 3)	3 (2, 4)	<0.001



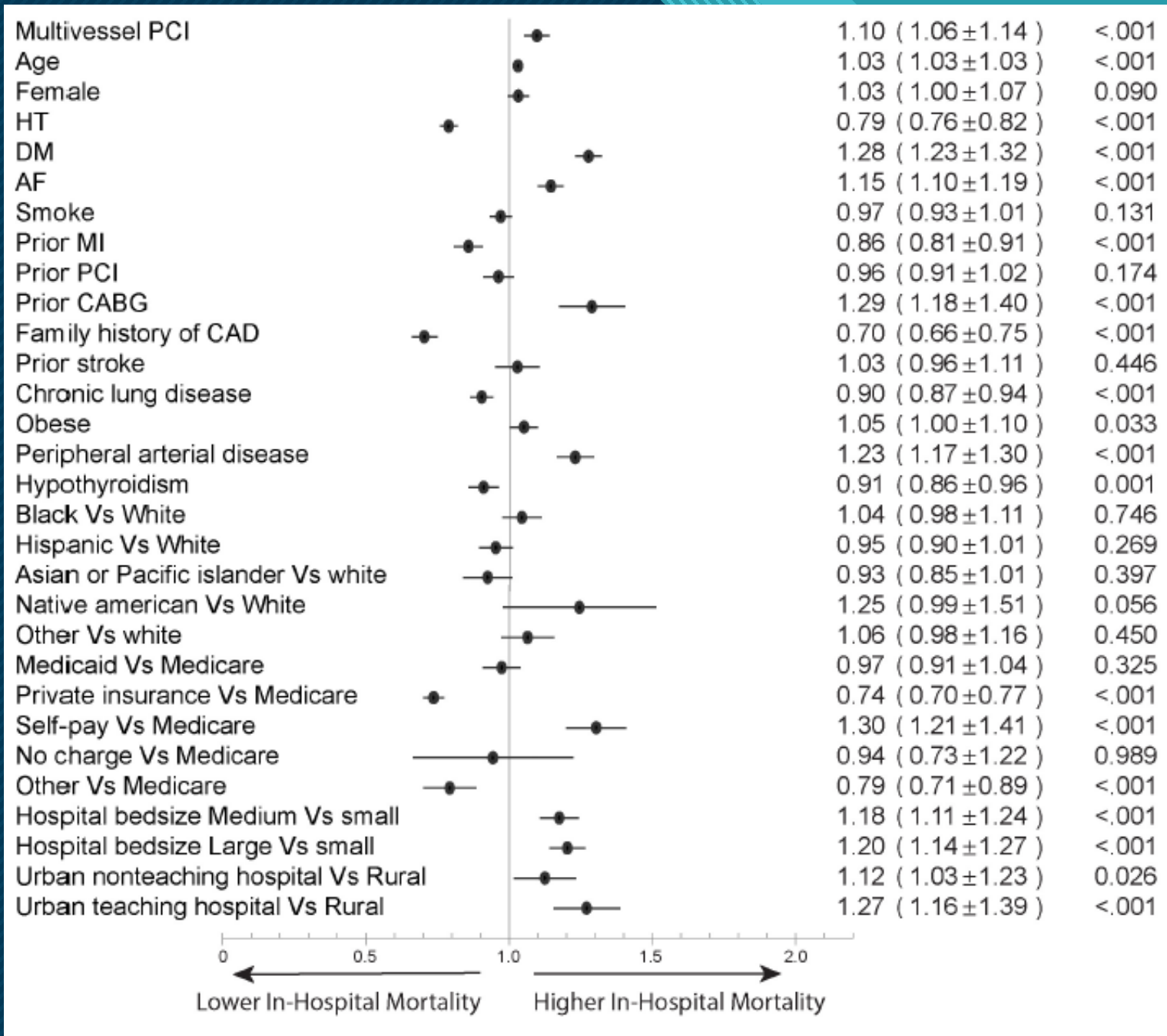
Results:

- in the STEMI without cardiogenic shock, multivessel PCI was not associated with an increased risk of in-hospital mortality (RR = 1.05; 95% CI:0.94–1.17)
- Comparison between 2-vessel and >2-vessel PCI,
- the 2-vessel procedure had in-hospital mortality (2.3 vs. 2.3%) and MACCE rate (7.2 vs. 7.1%) similar to culprit-only PCI;
- PCI involving >2 vessels was associated with worse in-hospital outcomes (in-hospital mortality, 3.3% and MACCE, 8.8%).
- >2-vessel PCI was associated with an increased risk of in-hospital death (OR = 1.45, 95% CI: 1.15–1.82)

TABLE 3 Baseline characteristics in STEMI hospitalizations with cardiogenic shock.

Variables	Culprit only PCI N = 60,965	Multiple vessels PCI N = 17,335	P-value
Age	65.9 ± 12.3	66.0 ± 11.9	0.871
Female	20,275 (33.3)	5,155 (29.8)	<0.001
Anterior STEMI	26,205 (43.0)	7,905 (45.6)	<0.001
Inferior STEMI	27,015 (44.3)	6,670 (38.5)	<0.001
Unspecified STEMI	9,075 (14.9)	3,540 (20.4)	<0.001
Race			<0.001
white	43,400 (74.8)	12,315 (74.9)	
black	4,715 (8.1)	1,095 (6.7)	
Hispanic	5,020 (8.7)	1,545 (9.4)	
Asian/pacific islander	2,055 (3.5)	740 (4.5)	
Native American	400 (0.7)	100 (0.6)	
Other races	2,420 (4.2)	645 (3.9)	
Hypertension	4,1380 (67.9)	12,060 (69.6)	<0.001
Diabetics	20,900 (34.3)	6,980 (40.3)	<0.001
History of smoke	14,540 (23.9)	3,970 (22.9)	0.010
Obesity	9,900 (16.2)	2,855 (16.5)	0.468
Prior MI	6,575 (10.8)	1,905 (11.0)	0.445
Prior PCI	6,810 (11.2)	2,095 (12.1)	<0.001
Prior CABG	2,160 (3.5)	575 (3.3)	0.153
Prior stroke	3,040 (5.0)	920 (5.3)	0.089
Peripheral arterial disease	6,665 (10.9)	2,185 (12.6)	<0.001
Chronic lung disease	11,050 (18.1)	2,940 (17.0)	<0.001
hypothyroidism	5,550 (9.1)	1,575 (9.1)	0.942

Family history of CAD	5,885 (9.7)	1,620 (9.4)	0.224
Hospital size (number of beds)			<0.001
Small	8,394 (13.8)	2,290 (13.2)	
Medium	18,290 (30.0)	4,700 (27.1)	
large	34,280 (56.2)	10,345 (59.7)	
Hospital location/teaching status			0.036
Rural hospital	3,160 (5.2)	875 (5.1)	
Urban non-teaching	13,350 (21.9)	3,650 (21.1)	
Urban teaching	44,455 (72.9)	12,810 (73.9)	
Payer			<0.001
Medicare	31,650 (52.0)	9,275 (53.6)	
Medicaid	6,225 (10.2)	1,925 (11.1)	
Private	17,310 (28.5)	4,585 (26.5)	
Self-pay	3,710 (6.1)	960 (5.6)	
No charge	290 (0.5)	55 (0.3)	
Other	1,630 (2.7)	505 (2.9)	
Systemic thrombolysis	1,625 (2.7)	425 (2.5)	0.120
Thrombectomy	12,210 (20.0)	3,150 (18.2)	<0.001
MCS	30,915 (50.7)	10,915 (63.0)	<0.001
Cost of care, U.S. \$	47,273 ± 97,822	62,225 ± 136,938	<0.001
Length of hospital stay	5 (2, 9)	5 (2, 10)	<0.001



Results:

- STEMI with cardiogenic shock, multivessel PCI was associated with increased risk of in-hospital mortality (OR = 1.10; 95% CI: 1.06–1.14)
- In the subgroup analysis, the rate of in-hospital mortality for 2-vessel and >2-vessel procedures were 30.7 and 31.6%, respectively, and the rate of MACCE was 39.8 and 40.3%, respectively, with similar results observed across all subgroups

Discussion

- Five main findings:
- (1) The rate of multivessel PCI decreased during the study period, due to the declining rates of STEMI with and without cardiogenic shock.
- (2) In the overall STEMI cohort, **in-hospital mortality and rate of MACCE** for **multivessel PCI** were **significantly higher** than the rate of **culprit-only PCI**.

Discussion

- (3) In STEMI hospitalizations **without cardiogenic shock**, multivessel PCI **was not associated** with an **elevated risk of in-hospital mortality and MACCE rate**.
- (4) In STEMI hospitalizations **with cardiogenic shock**, multivessel PCI was associated with a **significantly increased risk of in-hospital mortality and MACCE rate**.
- (5) The **elevated risk** of **multivessel PCI** in the **overall STEMI** cohort was driven by the **higher portion of cardiogenic shock** hospitalizations

Discussion

- Multivessel disease is **associated with worse clinical outcomes** compared with single-vessel disease.
- The optimal strategy for **treatment of the non-culprit vessel** is **unclear**, as reflected in the discrepancies in treatment guidelines.
- The current evidence indicates diverse effects of multivessel PCI on clinical outcomes **depending** on the presence of **cardiogenic shock**.
- Except for the **CULPRIT-SHOCK** trial, randomized clinical trials have excluded patients with cardiogenic shock and have reported **favorable** outcomes of **multivessel PCI**, due to a reduction in repeated revascularizations

Discussion

- The COMPLETE trial showed that the benefit (MV-PCI) extended beyond repeated revascularizations, also reducing the rates of cardiac death and MI.
- The optimal timing of non-culprit vessel revascularization has not been adequately investigated.
- An analysis of 1,964 patients from 5 clinical trials that included multivessel PCI during the index hospitalization demonstrated a significant reduction in cardiovascular mortality in addition to repeated revascularizations.
- The present analysis of NIS data confirms the safety of non-culprit PCI during the index hospitalization for STEMI without cardiogenic shock.

Discussion

- During the study period, multivessel PCI was performed during the index hospitalization in only 15.7% of STEMI hospitalizations without cardiogenic shock.
- Thus, most patients with multivessel disease admitted with STEMI did not have their non-culprit vessel treated before discharge.
- Our data provide support for the treatment of non-culprit vessel coronary disease during the index hospitalization, considering the possible long-term benefit for complete revascularization

Discussion

- For STEMI without cardiogenic shock, **multivessel PCI** during **the index hospitalization** appears **safe and should be considered**, at least in selected hemodynamically stable myocardial infarction patients.
- In this analysis, 85.7% of multivessel procedures were performed **on two vessels**.
- **The 2-vessel** procedure is **safe** and does not incur excessive risks of in-hospital mortality and MACCE compared with culprit only PCI

Discussion

- Hospitalizations involving a >2-vessel procedure is still associated with a **significant increase** in in-hospital mortality and MACCE
- These results indicate that there is **a limit** to how many vessels can be **safely treated**.
- In cases involving >2 vessels, it is important to consider staged PCI VS. CABG because of the complexity of the coronary artery disease.

Discussion

- The results of the CULPRIT-SHOCK trial showed the detrimental effect of immediate multivessel PCI on cardiogenic shock complicated by MI at 30 days.
- In line with this finding, **multivessel PCI** was associated with increased risk of in-hospital mortality and MACCE in STEMI hospitalizations with **cardiogenic shock**

Discussion

- An explanation for the **differential impact of multivessel PCI** in hospitalizations **with vs. without** cardiogenic shock:
 - The **long procedure time** may cause more stress and expose patients to more hemodynamic instability;
 - **Injection of a large amount of contrast agent may further impair** the function of an **underperfused kidney** in the setting of cardiogenic shock

Discussion

- It has been suggested that **immediate multivessel PCI** is associated with a **higher short-term** but **lower long-term risk of death** than culprit lesion-only PCI.
- This is not supported by the **1-year outcome** from the **CULPRIT-SHOCK** trial that showed **no reduction** in the multivessel PCI group with a longer follow-up (between 30 days and 1 year)

Discussion

- In the CULPRIT-SHOCK trial, staged PCI of non-culprit lesions within 30 days was only performed **on 17.4% patients**
- Whether performing more stage PCIs can improve outcomes and if so, the optimal time to treat the non-culprit lesion **remain to be determined**. (similar to CCS)

Advantages:

- To our knowledge, this analysis represents the largest-sample study of the impact of **multivessel PCI** on **STEMI with cardiogenic shock**.
- The NIS database has been widely validated internally and externally in studies with adequate sampling
- Our results provide real-world evidence of the harmful effects of immediate multivessel PCI as reported in the **CULPRIT-SHOCK** trial

Advantages:

- Our analyses were robust and included subgroup analyses;
- Provides insight into the practice patterns and impact of multivessel PCI in the real world, confirming the findings of the CULPRIT-SHOCK trial.
- The declining trend of multivessel PCI performance in the setting of cardiogenic shock during the study period may reflect the influence of the CULPRIT-SHOCK trial on clinical practice

Study limitations

- Large inpatient cohorts such as the NIS are subject to coding and documentation errors.
- The administrative database lacked clinical details for individual hospitalization including angiographic and procedural details, biochemistry data, echocardiography, and medications as well as long-term follow-up data;
- The retrospective observational study design made the analysis liable to **selection bias**

❖ این مطالعه روی ۹۱۲،۵۴۰ بیمار انفارکتوس حاد قلبی از سال ۲۰۱۵ تا ۲۰۱۹ انجام شد. بیماران به دو گروه کلی culprit-only PCI (۵۲۱،۲۸۰) و MV PCI (۱۰۳،۳۲۵) تقسیم شدند. بیماران به مدت یکسال فالوآپ شده و مرگ و میر داخل بیمارستان و MACCE در دو گروه مقایسه شد. نتایج نشان داد که:

۱. بیمارانی که PCI چند رگ داشتند نسبت به only PCI مرگ و میر داخل بیمارستانی و MACCE بیشتری داشتند.
 ۲. بیماران PCI چند رگ و بدون شوک کاردیوژنیک مرگ و میر داخل بیمارستانی و MACCE شان با بیماران only PCI تفاوتی نداشت.
 ۳. در بیماران با PCI چند رگ و شوک کاردیوژنیک مرگ و میر داخل بیمارستانی بیشتر بود.
- نتیجه گیری:** انجام MVD PCI بر روی یک رگ دیگر در انفارکتوس بدون شوک کاردیوژنیک می تواند امن و سودمند باشد اما در صورت وجود شوک کاردیوژنیک مرگ و میر افزایش می یابد.

culprit-only PCI : فقط PCI اولیه بر روی رگ مسئول
MV PCI (MultiVessel) : PCI اولیه بر روی رگ مسئول و PCI همزمان در سایر عروق درگیر



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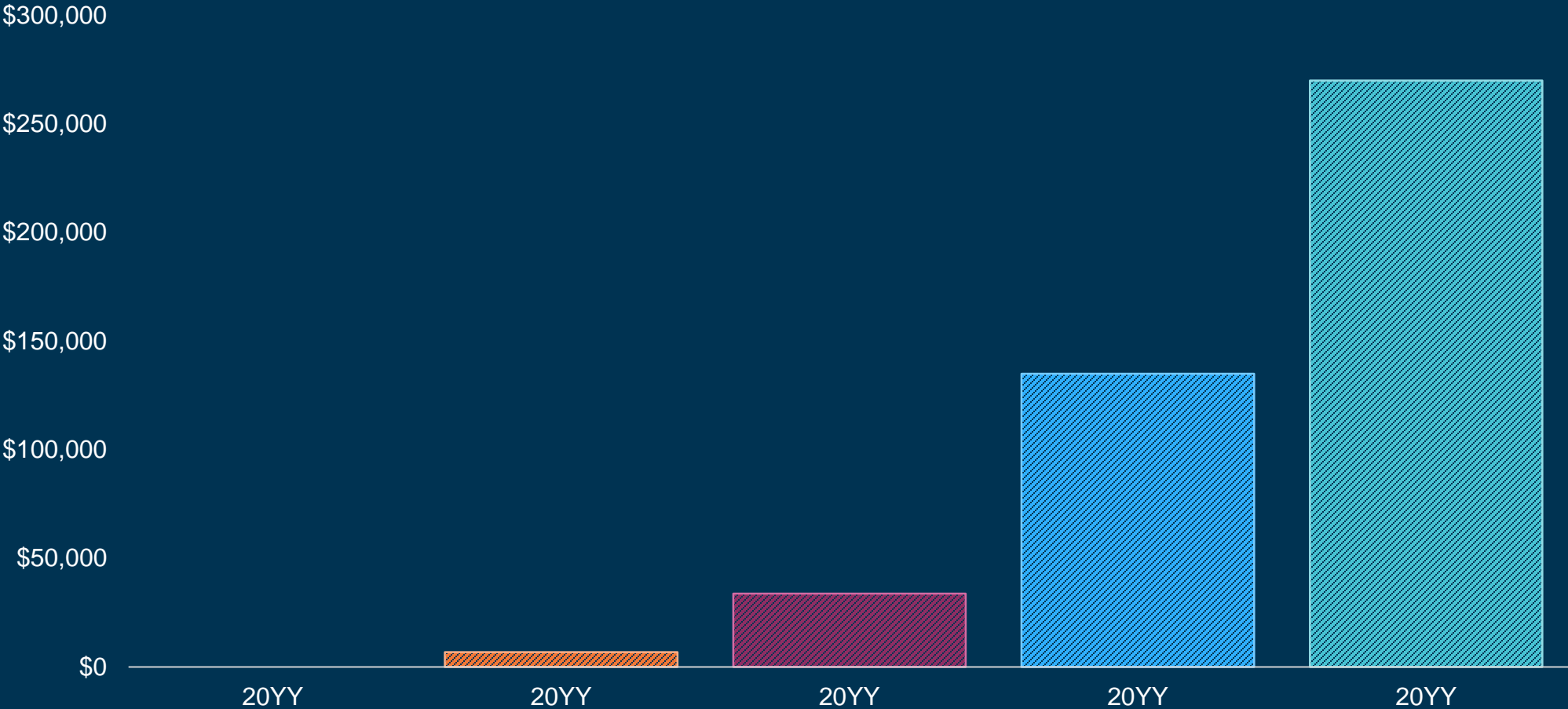
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