

Original Investigation

Coronary Catheterization and Percutaneous Coronary Intervention in China

10-Year Results From the China PEACE-Retrospective CathPCI Study

Xin Zheng, MD, PhD; Jeptha P. Curtis, MD; Shuang Hu, PhD; Yongfei Wang, MS; Yuejin Yang, MD, PhD; Frederick A. Masoudi, MD, MSPH; John A. Spertus, MD, MPH; Xi Li, MD, PhD; Jing Li, MD, PhD; Kumar Dharmarajan, MD, MBA; Nicholas S. Downing, MD; Harlan M. Krumholz, MD, SM; Lixin Jiang, MD, PhD; for the China PEACE Collaborative Group

IMPORTANCE The use of coronary catheterization and percutaneous coronary intervention (PCI) is increasing in China, but, to date, there are no nationally representative assessments of the quality of care and outcomes in patients undergoing these procedures.

OBJECTIVE To assess the quality of care and outcomes of patients undergoing coronary catheterization and PCI in China.

DESIGN, SETTING, AND PARTICIPANTS In a clinical observational study (China PEACE [Patient-Centered Evaluative Assessment of Cardiac Events]-Retrospective CathPCI Study), we used a 2-stage, random sampling strategy to create a nationally representative sample of 11 241 patients undergoing coronary catheterization and PCI at 55 urban Chinese hospitals in calendar years 2001, 2006, and 2011. Data analysis was performed from July 11, 2014, to November 20, 2015.

MAIN OUTCOMES AND MEASURES Patient characteristics, treatment patterns, quality of care, and outcomes associated with these procedures and changes over time.

RESULTS Of the 11 241 patients included in the study, the samples included, for 2001, 285 women (weighted percentage, 28.6%); for 2006, 826 women (weighted percentage, 32.2%), and for 2011, 2588 women (weighted percentage, 35.7%). Mean (SD) ages were 58 (8), 60 (11), and 61 (11) years, respectively. Between 2001 and 2011, estimated national rates of hospitalizations for coronary catheterization increased from 26 570 to 452 784 and for PCI, from 9678 to 208 954 (17-fold and 21-fold), respectively. More than half of stable patients undergoing coronary catheterization had nonobstructive coronary artery disease; this amount did not change significantly over time (2001: 60.3% [95% CI, 56.1%-64.5%]; 2011: 57.5% [95% CI, 55.8%-59.3%], $P = .05$ for trend). The proportion of PCI procedures performed via radial approach increased from 3.5% (95% CI, 1.7%-5.3%) in 2001 to 79.0% (95% CI, 77.7%-80.3%) in 2011 ($P < .001$ for trend). The use of drug-eluting stents (DESs) increased from 18.0% (95% CI, 14.2%-21.7%) in 2001 to 97.3% (95% CI, 96.9%-97.7%) in 2011 ($P < .001$ for trend) largely owing to increased use of domestic DESs. The median length of stay decreased from 14 days (interquartile range [IQR], 9-20) in 2001 to 10 days (IQR, 7-14) in 2011 ($P < .001$ for trend). In-hospital mortality did not change significantly, but both adjusted risk of any bleeding (odds ratio [OR], 0.53 [95% CI, 0.36-0.79], $P < .001$ for trend) and access bleeding (OR, 0.23 [95% CI, 0.12-0.43], $P < .001$) were decreased between 2001 and 2011. The medical records lacked documentation needed to calculate commonly used process metrics including door to balloon times for primary PCI and the prescription of evidence-based medications at discharge.

CONCLUSIONS AND RELEVANCE Although the use of catheterization and PCI in China has increased dramatically, we identified critical quality and documentation gaps that represent opportunities to improve care. Our findings can serve as a foundation to guide future quality improvement initiatives in China.

JAMA Intern Med. 2016;176(4):512-521. doi:10.1001/jamainternmed.2016.0166
Published online March 14, 2016.

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Research

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Abstract

Importance- The use of coronary catheterization and percutaneous coronary intervention (PCI) is increasing in China, but, to date, there are no nationally representative assessments of the quality of care and outcomes in patients undergoing these procedures.

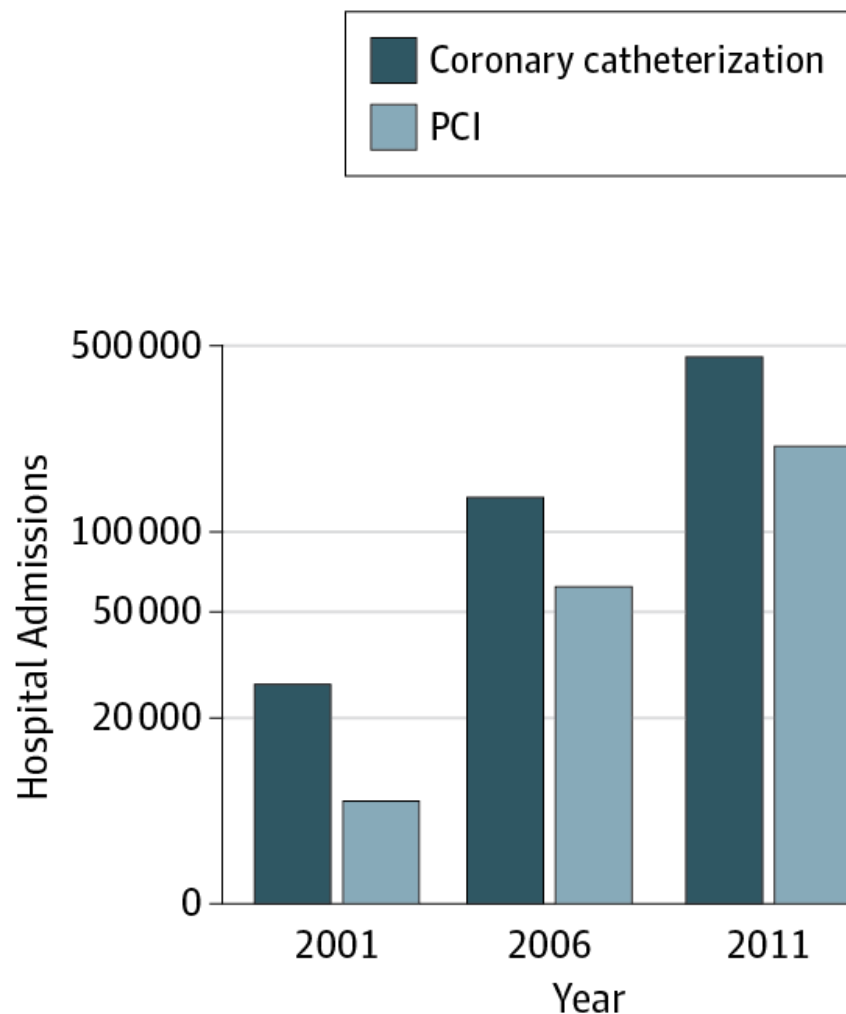
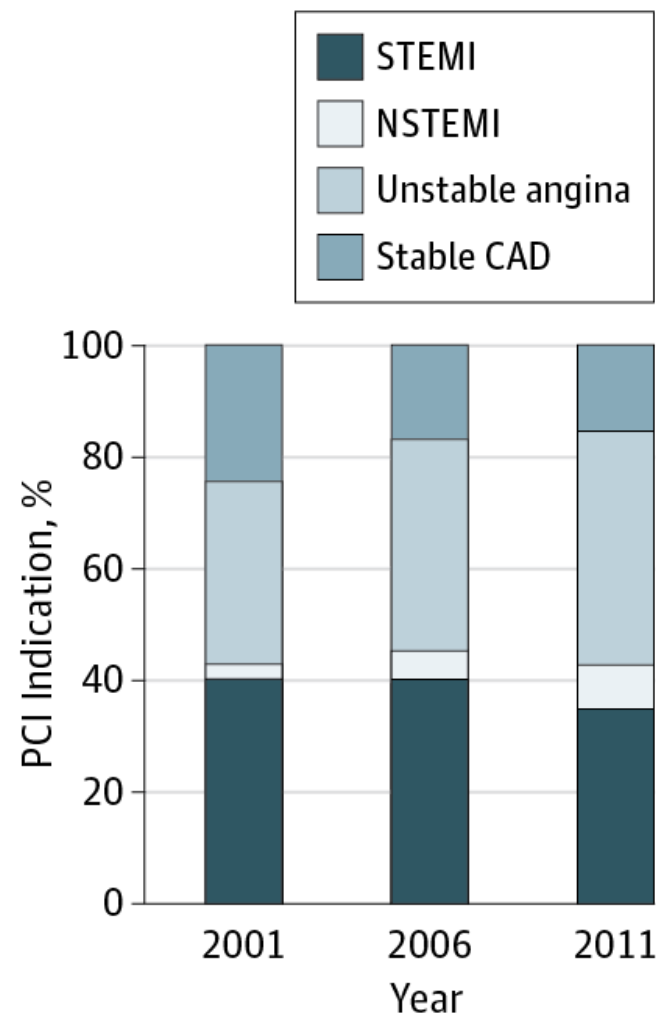
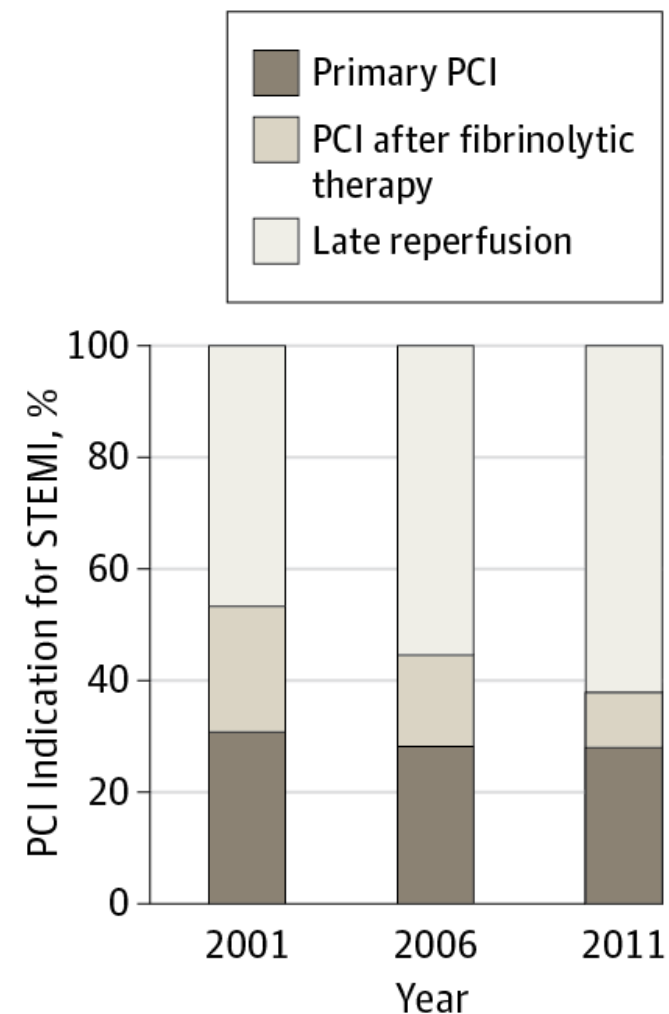
Objective- To assess the quality of care and outcomes of patients undergoing coronary catheterization and PCI in China.

Design, Setting, and Participants- In a clinical observational study (China PEACE [Patient-Centered Evaluative Assessment of Cardiac Events]–Retrospective CathPCI Study), we used a 2-stage, random sampling strategy to create a nationally representative sample of 11 241 patients undergoing coronary catheterization and PCI at 55 urban Chinese hospitals in calendar years 2001, 2006, and 2011. Data analysis was performed from July 11, 2014, to November 20, 2015.

Main Outcomes and Measures- Patient characteristics, treatment patterns, quality of care, and outcomes associated with these procedures and changes over time.

Results- Of the 11 241 patients included in the study, the samples included, for 2001, 285 women (weighted percentage, 28.6%); for 2006, 826 women (weighted percentage, 32.2%), and for 2011, 2588 women (weighted percentage, 35.7%). Mean (SD) ages were 58 (8), 60 (11), and 61 (11) years, respectively. Between 2001 and 2011, estimated national rates of hospitalizations for coronary catheterization increased from 26 570 to 452 784 and for PCI, from 9678 to 208 954 (17-fold and 21-fold), respectively. More than half of stable patients undergoing coronary catheterization had non-obstructive coronary artery disease; this amount did not change significantly over time (2001: 60.3% [95% CI, 56.1%-64.5%]; 2011: 57.5% [95% CI, 55.8%-59.3%], $P = .05$ for trend). The proportion of PCI procedures performed via radial approach increased from 3.5% (95% CI, 1.7%-5.3%) in 2001 to 79.0% (95% CI, 77.7%-80.3%) in 2011 ($P < .001$ for trend). The use of drug-eluting stents (DESs) increased from 18.0% (95% CI, 14.2%-21.7%) in 2001 to 97.3% (95% CI, 96.9%-97.7%) in 2011 ($P < .001$ for trend) largely owing to increased use of domestic DESs. The median length of stay decreased from 14 days (interquartile range [IQR], 9-20) in 2001 to 10 days (IQR, 7-14) in 2011 ($P < .001$ for trend). In-hospital mortality did not change significantly, but both adjusted risk of any bleeding (odds ratio [OR], 0.53 [95% CI, 0.36-0.79], $P < .001$ for trend) and access bleeding (OR, 0.23 [95% CI, 0.12-0.43], $P < .001$) were decreased between 2001 and 2011. The medical records lacked documentation needed to calculate commonly used process metrics including door to balloon times for primary PCI and the prescription of evidence-based medications at discharge.

Conclusions and Relevance- Although the use of catheterization and PCI in China has increased dramatically, we identified critical quality and documentation gaps that represent opportunities to improve care. Our findings can serve as a foundation to guide future quality improvement initiatives in China.

A Coronary artery catheterization and PCI**B** Stable CAD, NSTEMI, and STEMI**C** Primary PCI, PCI after fibrinolytic therapy, and late reperfusion**Figure 1.** Trends in Hospital Admissions and Percutaneous Coronary Intervention (PCI) Indication

A, Hospital admissions for coronary artery catheterization and PCI ($P < .001$). B, Proportion of PCI procedures for stable coronary artery disease (CAD) ($P < .001$), unstable angina ($P < .001$), ST-segment elevation myocardial infarction (STEMI) ($P < .001$), and non-STEMI (NSTEMI) ($P < .001$) among all the PCI procedures. C, Trends in the proportion of primary PCI ($P = .51$), PCI after fibrinolytic therapy ($P < .001$), and late reperfusion for patients who did not receive fibrinolytic therapy or primary PCI during the same admission ($P < .001$) among all the PCI procedures for patients with STEMI.

Table 1. Demographic, Clinical, Angiographic Characteristics of Patients Undergoing Catheterization (With or Without PCI)

Characteristic	2001 (n = 10 00)		2006 (n = 2755)		2011 (n = 7486)		P Value for Trend
	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	
Demographics							
Female	285	28.6 (25.8-31.4)	826	32.2 (30.5-34.0)	2588	35.7 (34.6-36.7)	<.001
Age, y							
Median (IQR)	59 (49-66)		61 (52-69)		61 (54-70)		<.001
Mean (SD)	58 (8)		60 (11)		61 (11)		<.001
<60	509	51.1 (48.0-54.2)	1244	47.6 (45.7-49.4)	3263	43.5 (42.3-44.6)	<.001
60-69	329	32.1 (29.2-35.0)	832	29.8 (28.1-31.6)	2279	31.7 (30.6-32.7)	.51
70-79	157	15.9 (13.6-18.2)	620	20.2 (18.7-21.7)	1692	21.4 (20.5-22.3)	<.001
≥80	5	0.8 (0.2-1.3)	59	2.4 (1.8-3.0)	252	3.5 (3.0-3.9)	<.001
Comorbidities							
Hypertension	528	54.0 (50.9-57.1)	1528	57.6 (55.8-59.5)	4502	59.4 (58.3-60.5)	.001
Dyslipidemia	576	55.5 (52.4-58.5)	1736	65.6 (63.9-67.4)	5015	66.7 (65.7-67.8)	<.001
Diabetes mellitus	161	16.8 (14.5-19.1)	567	20.4 (18.9-21.9)	1702	22.7 (21.8-23.7)	<.001
Current smoking	296	31.1 (28.2-33.9)	817	30.5 (28.8-32.2)	2207	30.3 (29.3-31.4)	.64
Prior MI	240	25.4 (22.7-28.1)	630	22.8 (21.2-24.4)	1509	19.6 (18.7-20.5)	<.001
Prior PCI	32	3.3 (2.2-4.4)	159	6.2 (5.3-7.1)	696	10.1 (9.4-10.8)	<.001
Prior CABG	8	1.0 (0.4-1.7)	11	0.4 (0.2-0.7)	30	0.5 (0.3-0.6)	.10
Prior stroke	56	6.9 (5.3-8.4)	157	6.0 (5.1-6.9)	491	6.5 (5.9-7.1)	.93

Table 1. Continued

Characteristic	2001 (n = 10 00)		2006 (n = 2755)		2011 (n = 7486)		P Value for Trend
	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	
Presentations at admission							
eGFR, mL/min/1.73 m ² , median (IQR)	78.5 (65.2-92.9)		83.5 (67.7-99.4)		90.3 (74.7-107.1)		<.001
<60	135	13.6 (11.5-15.8)	380	13.0 (11.8-14.3)	707	9.1 (8.5-9.8)	<.001
≥60	637	65.0 (62.1-68.0)	2038	75.4 (73.8-77.0)	6231	82.9 (82.0-83.7)	<.001
Unmeasured	228	21.3 (18.8-23.9)	337	11.5 (10.4-12.7)	548	8.0 (7.4-8.6)	<.001
Heart failure at admission	44	3.9 (2.7-5.1)	123	4.7 (3.9-5.5)	295	3.5 (3.1-3.9)	.05
Cardiogenic shock at admission	5	0.3 (0.0-0.6)	19	0.5 (0.2-0.8)	45	0.6 (0.4-0.7)	.28
Cardiac arrest at admission	0	0.0 (0.0-0.0)	1	0.0 (0.0-0.1)	2	0.0 (0.0-0.0)	.84
Extent of CAD							
Nonobstructive CAD, <50%	345	36.0 (33.0-38.9)	747	30.4 (28.7-32.1)	2022	28.4 (27.4-29.4)	<.001
1-Vessel disease	271	25.1 (22.4-27.8)	676	22.9 (21.3-24.4)	1866	24.7 (23.7-25.6)	.46
2-Vessel disease	225	22.1 (19.6-24.7)	739	26.0 (24.4-27.6)	1967	26.1 (25.1-27.1)	.03
3-Vessel disease	153	16.5(14.2-18.8)	586	20.5(19.0-22.0)	1621	20.7(19.8-21.6)	.01
Left main disease	20	2.2 (1.3-3.2)	131	4.4 (3.6-5.2)	399	6.2 (5.6-6.7)	<.001

Table 1. Continued

Characteristic	2001 (n = 10 00)		2006 (n = 2755)		2011 (n = 7486)		P Value for Trend
	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	No.	Weighted % (95% CI)	
Diagnostic catheterization process metrics							
Incidence of nonobstructive CAD ^a	300/522	60.3 (56.1-64.5)	637/1129	61.2 (58.4-64.1)	1638/2967	57.5 (55.8-59.3)	.05
Discharge diagnosis							
STEMI	219	20.4 (17.9-22.9)	735	23.0 (21.5-24.6)	1606	18.9 (18.0-19.8)	.001
NSTEMI	19	1.7 (0.9-2.5)	109	3.8 (3.1-4.5)	409	4.9 (4.4-5.4)	<.001
Unstable angina	240	26.4 (23.7-29.1)	779	31.3 (29.6-33.1)	2498	36.3 (35.2-37.3)	<.001
Stable CAD	358	33.7 (30.8-36.7)	785	27.8 (26.1-29.5)	2066	27.0 (26.0-28.0)	<.001
Non-CAD	164	17.7 (15.4-20.1)	344	13.8 (12.6-15.1)	899	12.7 (11.9-13.4)	<.001

Abbreviations: CABG, coronary artery bypass graft; CAD, coronary artery disease; eGFR, estimated glomerular filtration rate; IQR, interquartile range; MI, myocardial infarction; NSTEMI, non-ST-segment elevation MI;

PCI, percutaneous coronary intervention; STEMI, ST-segment elevation MI.

^a Among the patients without acute coronary syndrome.

Table 2. Procedure Characteristics of PCI

Characteristics	2001 (n = 419)		2006 (n = 1476)		2011 (n = 3961)		P Value for Trend
	Relative Frequency	Weighted % (95% CI)	Relative Frequency	Weighted % (95% CI)	Relative Frequency	Weighted % (95% CI)	
Vascular access							
Femoral	348/419	85.8 (82.5-89.2)	985/1476	60.3 (57.8-62.8)	857/3961	19.4 (18.2-20.6)	<.001
Radial	15/419	3.5 (1.7-5.3)	456/1476	37.4 (35.0-39.9)	3035/3961	79.0 (77.7-80.3)	<.001
Brachial	1/419	0.6 (0.0-1.3)	7/1476	0.4 (0.1-0.8)	37/3961	0.6 (0.3-0.8)	.75
Unrecorded	55/419	10.1 (7.2-13.0)	28/1476	1.8 (1.1-2.5)	32/3961	1.0 (0.7-1.4)	<.001
Hemostasis technique ^a							
Manual compression	289/348	84.0 (80.1-87.8)	815/985	84.0 (81.7-86.3)	610/857	73.1 (70.2-76.1)	<.001
Sealant	1/348	0.3 (0.0-0.8)	25/985	2.9 (1.9-4.0)	14/857	1.4 (0.6-2.2)	.65
Suture	6/348	0.9 (0.0-2.0)	37/985	2.5 (1.5-3.4)	42/857	4.2 (2.9-5.6)	.001
Other	0/348	0.0 (0.0-0.0)	1/985	0.1 (0.0-0.3)	2/857	0.3 (0.0-0.7)	.19
Unrecorded	52/348	14.8 (11.1-18.6)	107/985	10.5 (8.6-12.4)	189/857	21.0 (18.2-23.7)	<.001
No. of vessels treated during PCI							
1	295/419	71.0 (66.7-75.4)	1028/1476	69.8 (67.5-72.2)	2819/3961	70.4 (69.0-71.8)	.95
2	71/419	18.2 (14.5-21.9)	325/1476	24.2 (22.0-26.4)	821/3961	21.3 (20.0-22.6)	.82
3	5/419	1.3 (0.2-2.4)	59/1476	3.1 (2.2-4.0)	105/3961	2.7 (2.2-3.2)	.47
Multiple ^b	76/419	19.5 (15.7-23.3)	384/1476	27.3 (25.0-29.6)	926/3961	24.0 (22.7-25.3)	.96
Unrecorded	48/419	9.5 (6.7-12.3)	64/1476	2.9 (2.0-3.7)	216/3961	5.6 (4.9-6.3)	.82

Table 2. Continued

Characteristics	2001 (n = 419)		2006 (n = 1476)		2011 (n = 3961)		P Value for Trend
	Relative Frequency	Weighted % (95% CI)	Relative Frequency	Weighted % (95% CI)	Relative Frequency	Weighted % (95% CI)	
Lesion location ^c							
Left main	2/517	0.4 (0.0-1.0)	26/2089	1.3 (0.8-1.8)	83/5410	2.1 (1.7-2.5)	.001
Left anterior descending	256/517	47.7 (43.4-52.0)	1012/2089	47.5 (45.3-49.6)	2600/5410	47.7 (46.4-49)	.91
Circumflex	95/517	19.3 (15.9-22.7)	398/2089	20 (18.3-21.7)	1067/5410	20 (18.9-21.0)	.81
Ramus	4/517	1.0 (0.2-1.9)	12/2089	0.6 (0.3-1.0)	43/5410	0.9 (0.6-1.1)	.71
Right coronary artery	150/517	29.9 (26.0-33.9)	640/2089	30.7 (28.7-32.7)	1651/5410	30.2 (28.9-31.4)	.83
Bypass graft lesions	7/517	1.4 (0.4-2.4)	27/2089	1.1 (0.6-1.5)	58/5410	0.8 (0.6-1.0)	.10
Intracoronary devices used							
Aspiration catheters	0/419	0	3/1476	0.3 (0.0-0.6)	44/3961	1.7 (1.3-2.1)	<.001
Brachytherapy/cutting balloon/Rotablator	1/419	0.2 (0.0-0.7)	1/1476	0.0 (0.0-0.1)	7/3961	0.2 (0.1-0.4)	.34
FloWire/IVUS/pressure wire	1/419	0.2 (0.0-0.6)	10/1476	2.8 (2.0-3.7)	13/3961	0.8 (0.5-1.1)	.009
Thrombectomy device	3/419	0.4 (0.0-1.1)	1/1476	0.1 (0.0-0.2)	1/3961	0.1 (0.0-0.2)	.11
Stent	267/419	69.4 (65.0-73.8)	1291/1476	90.4 (88.9-91.9)	3445/3961	89.4 (88.5-90.4)	<.001
Stent type ^d							
DES	72/408	18.0 (14.2-21.7)	1942/2310	87.2 (85.9-88.6)	6229/6399	97.3 (96.9-97.7)	<.001
Domestic DES	2/72	1.6 (0.0-4.4)	1213/1942	52.5 (50.3-54.7)	4968/6229	74.8 (73.7-75.8)	<.001
BMS	226/408	54.7 (49.8-59.5)	271/2310	9.6 (8.4-10.8)	32/6399	0.8 (0.6-1.1)	<.001
Unrecorded	109/408	27.3 (22.9-31.6)	94/2310	3.1 (2.4-3.9)	131/6399	1.8 (1.4-2.1)	<.001
No. of stents/patient, mean (SD)	1.4 (0.7)		1.7 (0.9)		1.8 (0.9)		<.001
Ad hoc PCI	295/419	74.3 (70.1-78.5)	1237/1476	88.3 (86.7-90.0)	3422/3961	89.1 (88.1-90.0)	<.001

Abbreviations: BMS, bare metal stent; DES, drug-eluting stent; IVUS, intravascular ultrasonography; PCI, percutaneous coronary intervention.

^c Among 8016 lesions treated.

^d Among 9117 stents.

^a Among the patients with femoral access.

^b Combined data on 2- and 3-vessel treatment.

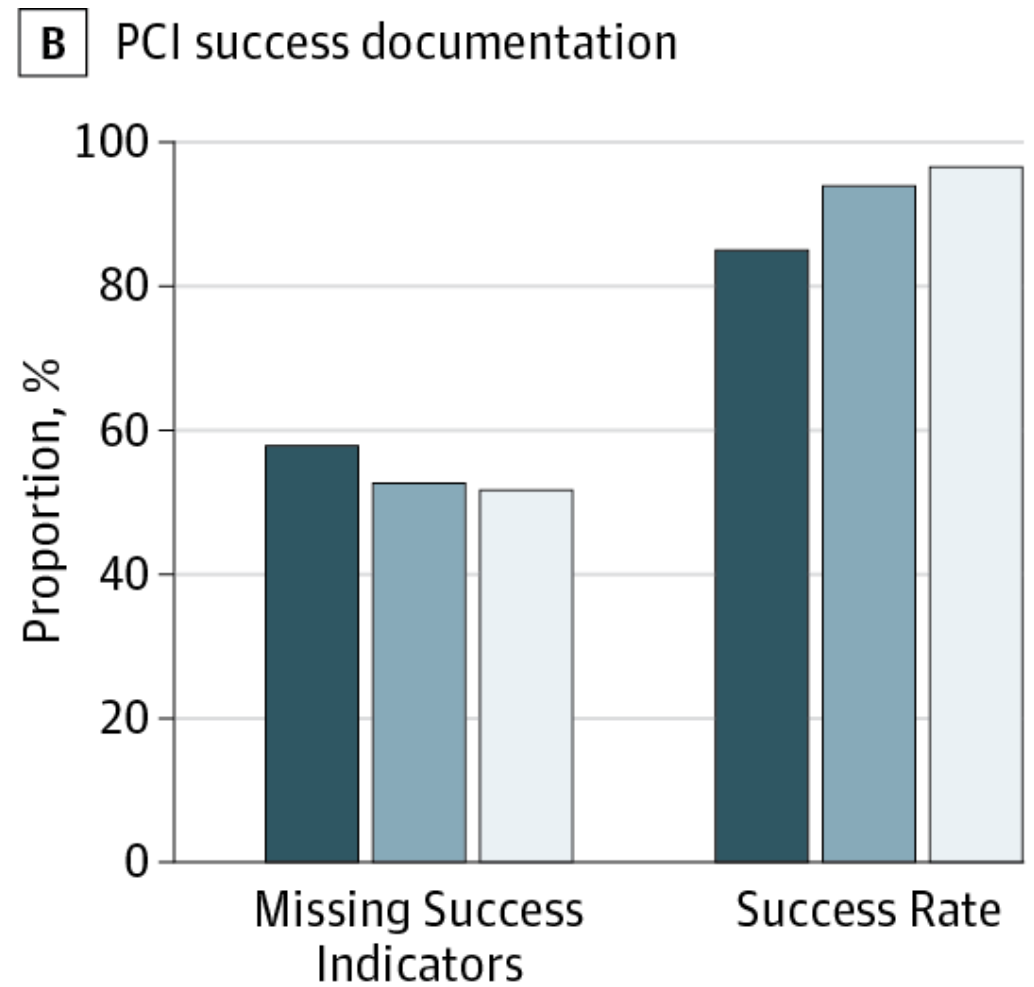
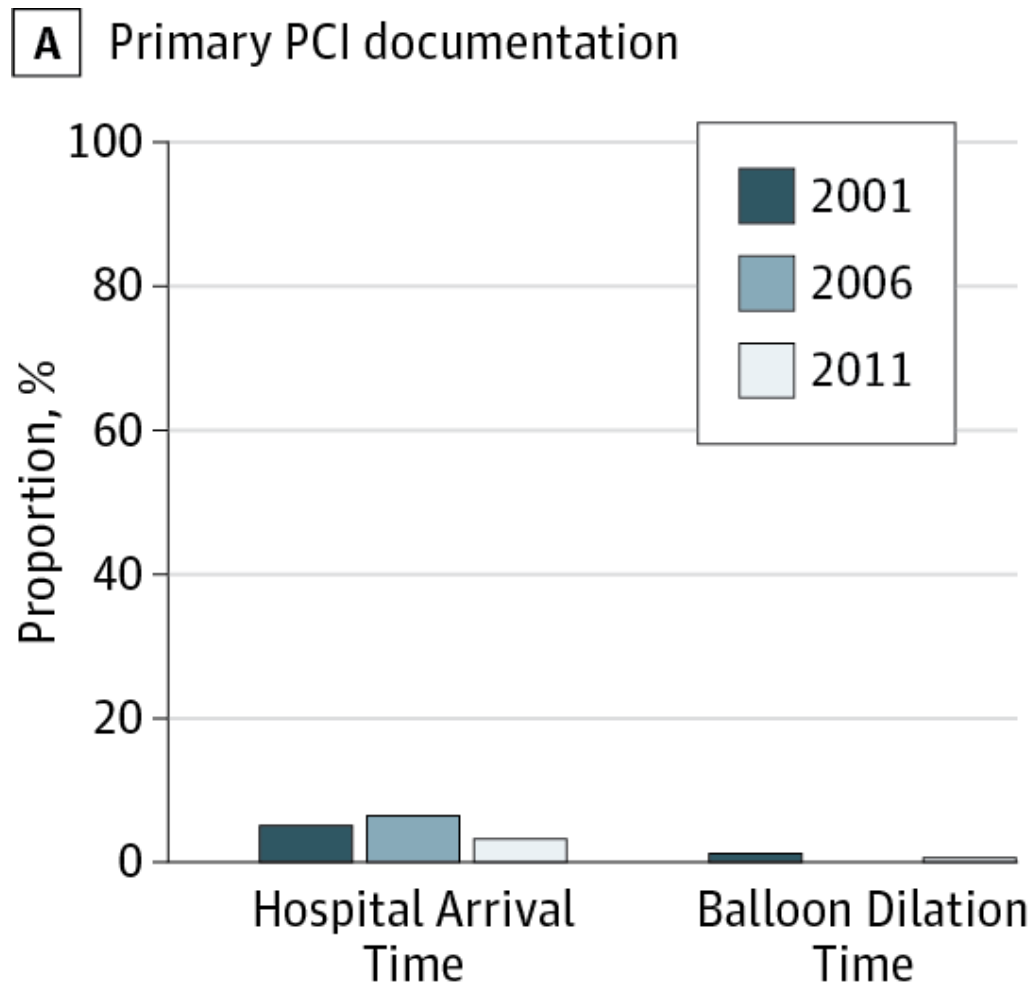


Figure 2. Trends in Percutaneous Coronary Intervention (PCI) Quality Metrics. A, Proportion of primary PCI procedures with recording of hospital arrival time ($P = .10$) and balloon dilation time ($P = .86$). B, Proportion of documentation of PCI with missing procedural success indicators ($P = .03$) and successful procedures among PCIs with complete documentation of success indicators ($P < .001$).

C Tests and contrast volume

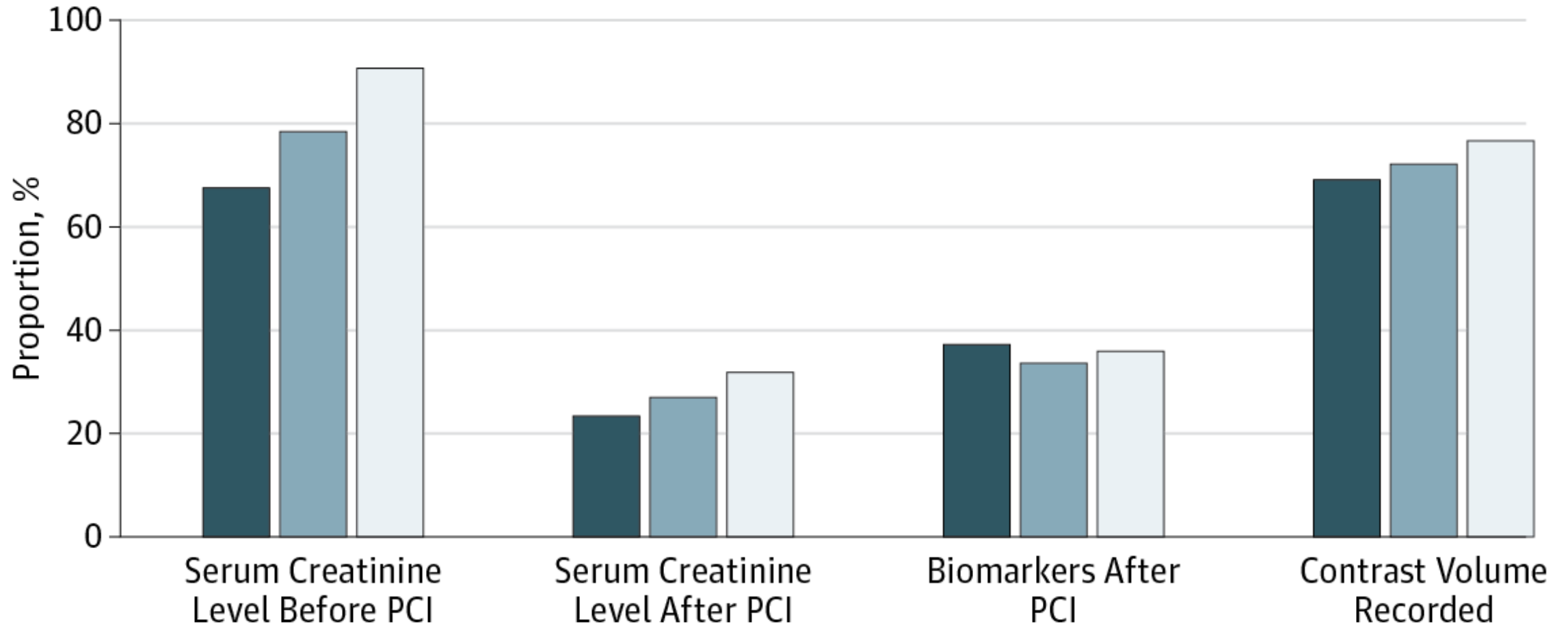


Figure 2. Continued. C, Proportion of PCI procedures with serum creatinine levels assessed before ($P < .001$) and after ($P < .001$) PCI, and cardiac biomarkers assessed after PCI ($P = .64$) (for the first PCI procedure if more than 1 procedure was performed during a hospitalization), as well as procedures with documentation of contrast volume ($P < .001$).

D Discharge medications

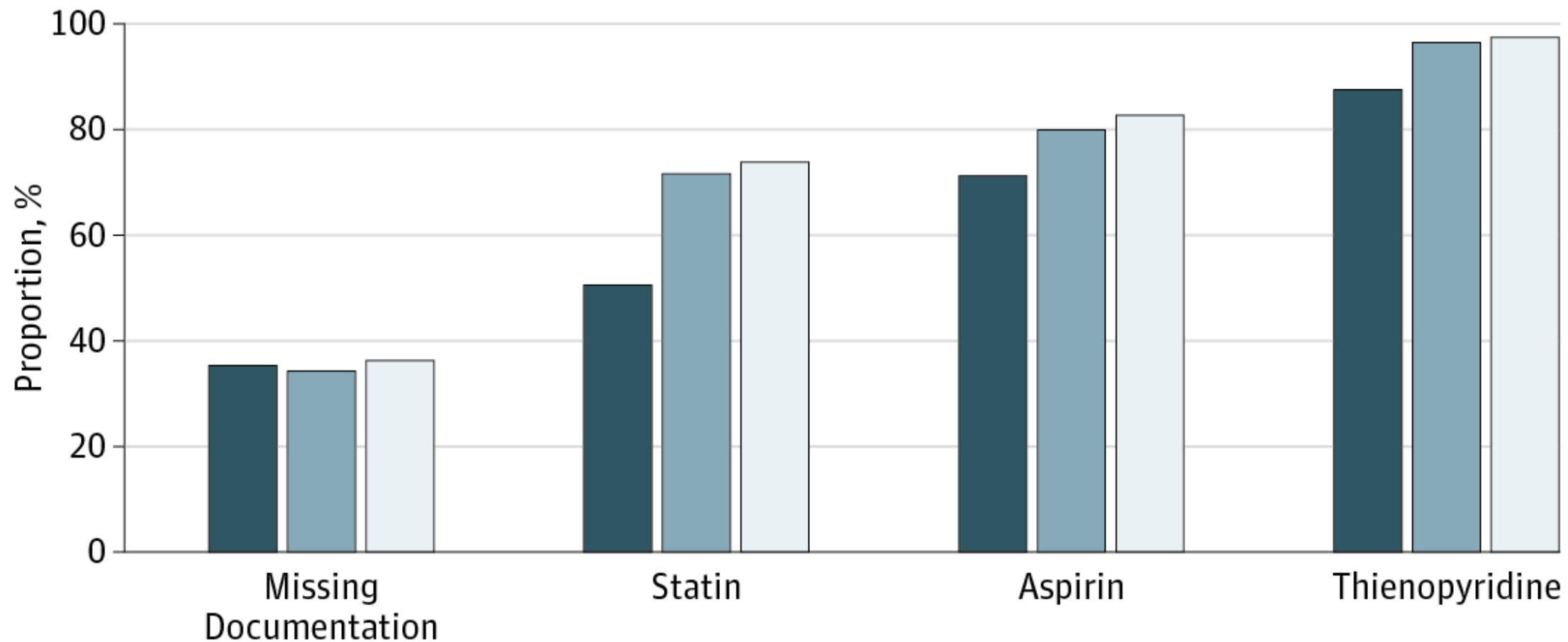


Figure 2. Continued. D, Proportion of patients with missing discharge medications ($P = .13$) and documentation of statin ($P < .001$), aspirin ($P < .001$), and thienopyridine (clopidogrel or ticlopidine) use ($P < .001$) among patients with stents.

	Unadjusted Rate (%)	P Value for Trend (Unadjusted)	Adjusted OR (95% CI)	P Value for Trend (Adjusted)
Death				.08
2001	0.8	.10	1 [Reference]	
2006	0.9		1.03 (0.26-4.05)	
2011	0.5		0.63 (0.23-1.72)	
Death or treatment withdrawal				.13
2001	1.0	.14	1 [Reference]	
2006	1.0		0.96 (0.26-3.55)	
2011	0.6		0.62 (0.23-1.70)	
Composite complications				.65
2001	1.9	.66	1 [Reference]	
2006	2.8		1.40 (0.61-3.25)	
2011	2.2		1.15 (0.45-2.90)	
Any bleeding				<.001
2001	12.4	<.001	1 [Reference]	
2006	10.7		0.77 (0.50-1.19)	
2011	7.7		0.53 (0.36-0.79)	
Major bleeding				.46
2001	1.1	.68	1 [Reference]	
2006	1.0		0.72 (0.19-2.68)	
2011	0.9		0.62 (0.18-2.16)	
Access bleeding				<.001
2001	4.8	<.001	1 [Reference]	
2006	4.8		0.93 (0.48-1.80)	
2011	1.3		0.23 (0.12-0.43)	
Blood transfusion				.33
2001	1.2	.31	1 [Reference]	
2006	1.2		0.94 (0.29-3.05)	
2011	0.9		0.72 (0.22-2.30)	

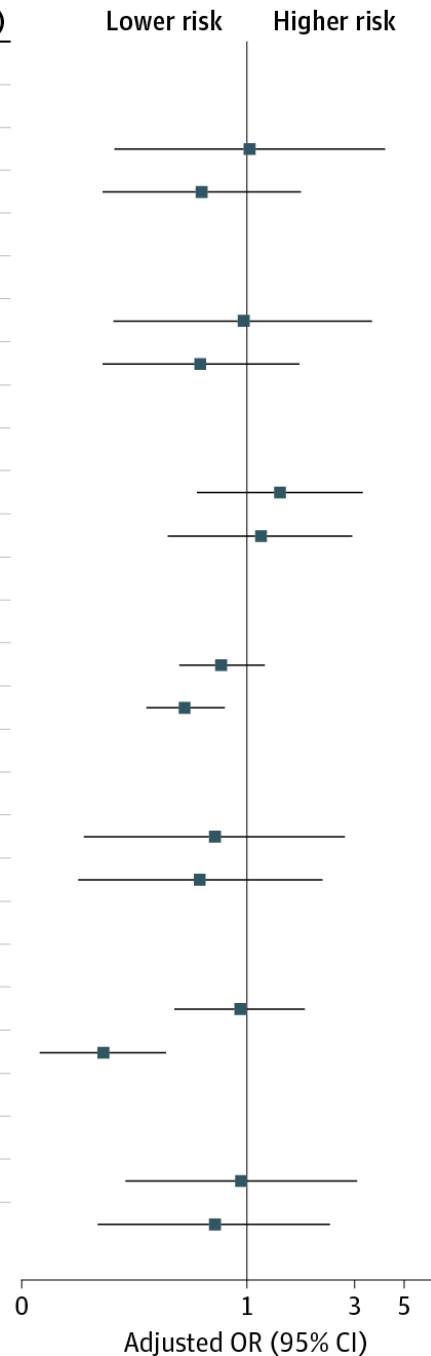


Figure 3. Unadjusted Rate and Adjusted Odds Ratios (ORs) of Adverse Outcomes in Patients Undergoing Percutaneous Coronary Intervention

Adjusted ORs of patient outcomes are shown along the horizontal axis with the vertical line demarking an OR of 1 (ie, no difference from year 2001); estimates to the right (ie, >1) are associated with higher risk of the outcome, and those to the left (ie, <1) indicate a lower risk of the outcome. The variables for risk adjustment include cardiogenic shock, ST-segment elevation myocardial infarction (STEMI) vs non-STEMI, estimated glomerular filtration rate, sex, and age. C = 0.77 for death, 0.76 for death or treatment withdrawal, 0.70 for composite complications, 0.64 for any bleeding, 0.63 for major bleeding, 0.69 for access bleeding, and 0.71 for blood transfusion. Composite end points were: death or withdrawal, stroke, or repeated target vessel revascularization.

Key Points

Question: How have the use and outcomes of invasive cardiac procedures in China changed over time?

Findings: In this nationally representative, retrospective study, the use of coronary catheterization and percutaneous coronary intervention (PCI) increased substantially between 2001 and 2011. There were notable changes in practice, including increased use of radial PCI and medicated stents, but there were persistent gaps in the quality of care as assessed by accepted process measures.

Meaning: Although the use of coronary catheterization and PCI in China has increased dramatically, there are opportunities to improve care.

Conclusion

- The use of catheterization and PCI in China has increased substantially from 2001 to 2011. However, changes in procedural volume have not been matched by the development of systems to ensure that the care delivered to these patients is evidence-based, safe, and efficient.
- Developing such a system is particularly important in a country with constrained resources and large variation among health care professionals.
- Although the Chinese Ministry of Health has initiated preliminary efforts to standardize the care of patients undergoing PCI, more work is necessary. A comprehensive strategy is needed, including development of a national system that prioritizes data collection, performance measurement, public reporting, and quality improvement.
- Our findings can serve as a foundation to guide efforts to further improve the quality of care and allocation of resources not only for China, but also for other developing countries with a rapidly growing cardiovascular disease burden, limited medical resources, and dynamic health care systems.