



ASAN
Medical Center



UNIVERSITY OF ULSAN
COLLEGE OF MEDICINE

Surgical Techniques of CABG

김준범

2018 대한흉부심장혈관학회 전공의 연수교육

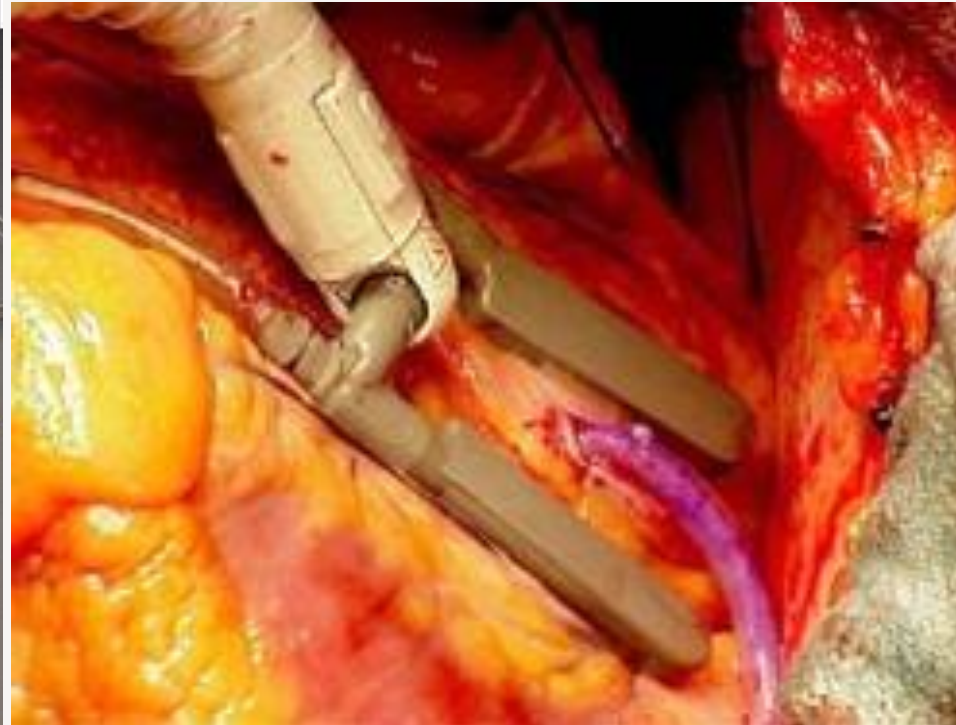
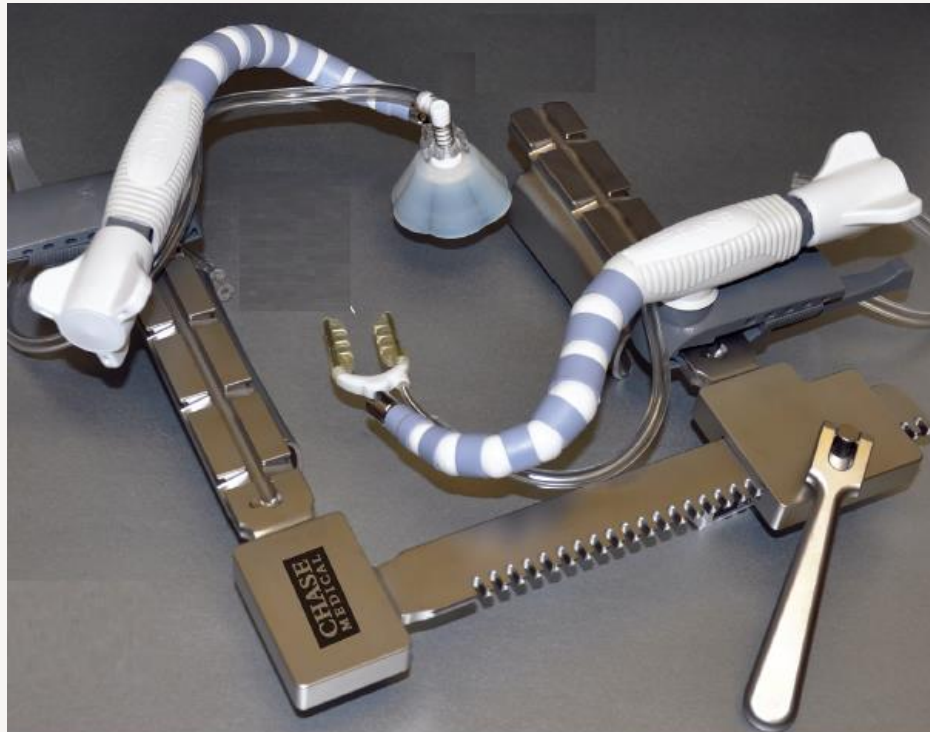
울산대학교 의과대학
서울아산병원 흉부외과학교실

Standard CABG

- **Use of CPB**
- Aortic cannulation
- Aortic clamping
- Cardioplegic arrest
- Contact of blood to the foreign materials
 - Inflammatory responses
 - Destruction of blood components



Off-Pump CABG



Cardiac stabilizing devices



Revival of Off-Pump CABG

•1967

- First performed by Kolessove in Soviet Union

•1970s~1980s

- CPB and cardioplegic arrest became routine
- OPCAB disappeared from the center stage

•1990s

- OPCAB has been rediscovered and refined.



Off-Pump vs. On-Pump CABG

- Continuous debates since revival of off-pump CABG in 1990's
- Off-pump CABG may be better in terms of...
 - Avoidance CPB-related complications
 - Less bleeding
 - Less renal dysfunction
 - Less neurologic damages



Studies in Early 2000's

Pitfalls of Conventional CABG:
CPB Related Effects

Circulation

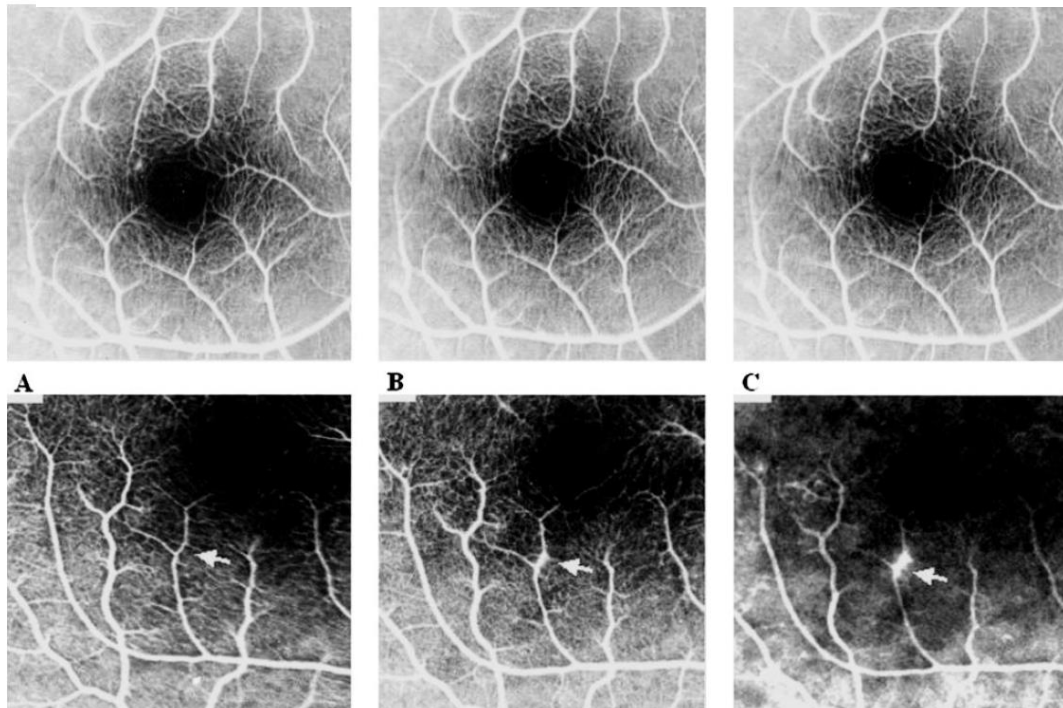
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American
Heart
Association®

Retinal and Cerebral Microembolization During Coronary Artery Bypass Surgery : A Randomized, Controlled Trial

Raimondo Ascione, Arup Ghosh, Barnaby C. Reeves, John Arnold, Mike Potts, Atul Shah and
Gianni D. Angelini

Circulation. 2005;112:3833-3838

**OPCAB:**

- Less embolism
- Less microbleeding



Pulmonary Outcomes of Off-Pump vs On-Pump Coronary Artery Bypass Surgery in a Randomized Trial*

*Gerald W. Staton, MD, FCCP; Willis H. Williams, MD;
Elizabeth M. Mahoney, ScD; Jeff Hu, MD; Haitao Chu, PhD;
Peggy G. Duke, MD; and John D. Puskas, MD*

(CHEST 2005; 127:892–901)

—Mortality and Pulmonary Readmissions Within 30 Days*

Variables	CAGB/CPB (n = 97)	OPCAB (n = 100)	p Value
Death within 30 d	2	1	NS
Readmission diagnoses			
Pulmonary edema	1	1	NS
Pneumonia	1	0	NS
Pleural effusion	2	4	NS

*From Puskas et al.³² Data are presented as No.

OPCAB:

- early extubation
- better gas exchange



ELSEVIER

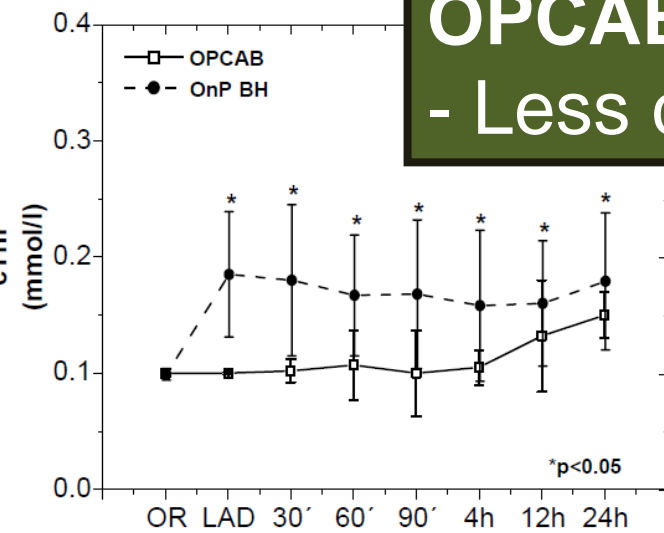
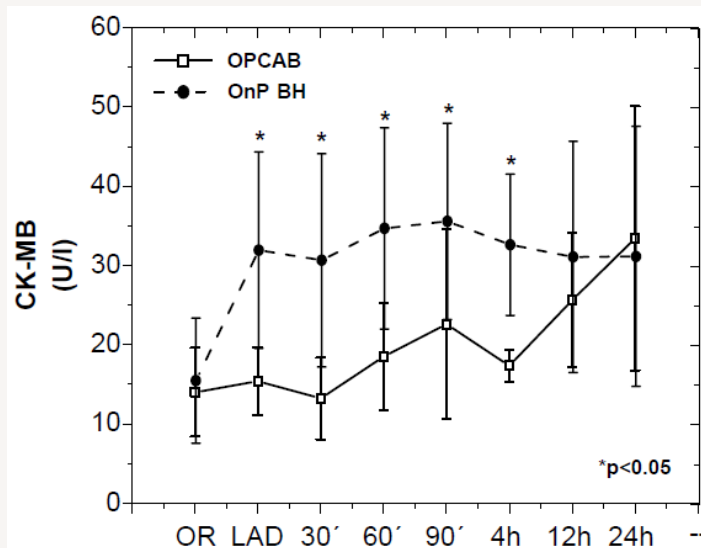
European Journal of Cardio-thoracic Surgery 27 (2005) 1057-1064

EUROPEAN JOURNAL OF
CARDIO-THORACIC
SURGERY

www.elsevier.com/locate/ejcts

On-pump beating heart versus off-pump coronary artery bypass surgery—evidence of pump-induced myocardial injury[☆]

Ardawan Julian Rastan*, Hartmuth Bruno Bittner, Jan Fritz Gummert, Thomas Walther, Claudia V. Schewick, Evaldes Girdauskas, Friedrich Wilhelm Mohr



OPCAB:
- Less cardiac injury



Artificial Organs

32(11):891–897, Wiley Periodicals, Inc.

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Economic Evaluation of Coronary Artery Bypass Grafting Surgery With and Without Cardiopulmonary Bypass: Cost-Effectiveness and Quality-Adjusted Life Years in a Randomized Controlled Trial

*Sharif Al-Ruzzeh, †David Epstein, *Shane George, *Mahmoud Bustami, *Jo Wray,
*Charles Ilsley, †Mark Sculpher, and *Mohamed Amrani

Mean costs by CPB and OPCAB groups to 6 months

	CPB		OPCAB		Difference		<i>P</i> value
	Mean	SE	Mean	SE	Mean	SE	
Theater procedure	1673	43	1304	26	369	50	<0.001
Postoperative recovery	5107	530	3871	309	1235	615	0.05
Readmissions	235	117	361	224	-126	270	0.64
Total cost	7015	550	5537	381	1478	670	0.03

OPCAB: More cost-effective



Findings Summary

Findings Favoring On-Pump CABG or OPCAB

Findings favoring OPCAB

Probably less bleeding

Probably less renal dysfunction

Probably less short-term neurocognitive dysfunction, especially if aorta is calcified

Possibly shorter overall length of hospital stay

Findings favoring on-pump CABG

Less technically demanding

Shorter "learning curve"

Possibly better long-term graft patency

Easier to graft posterior (circumflex) bypass targets

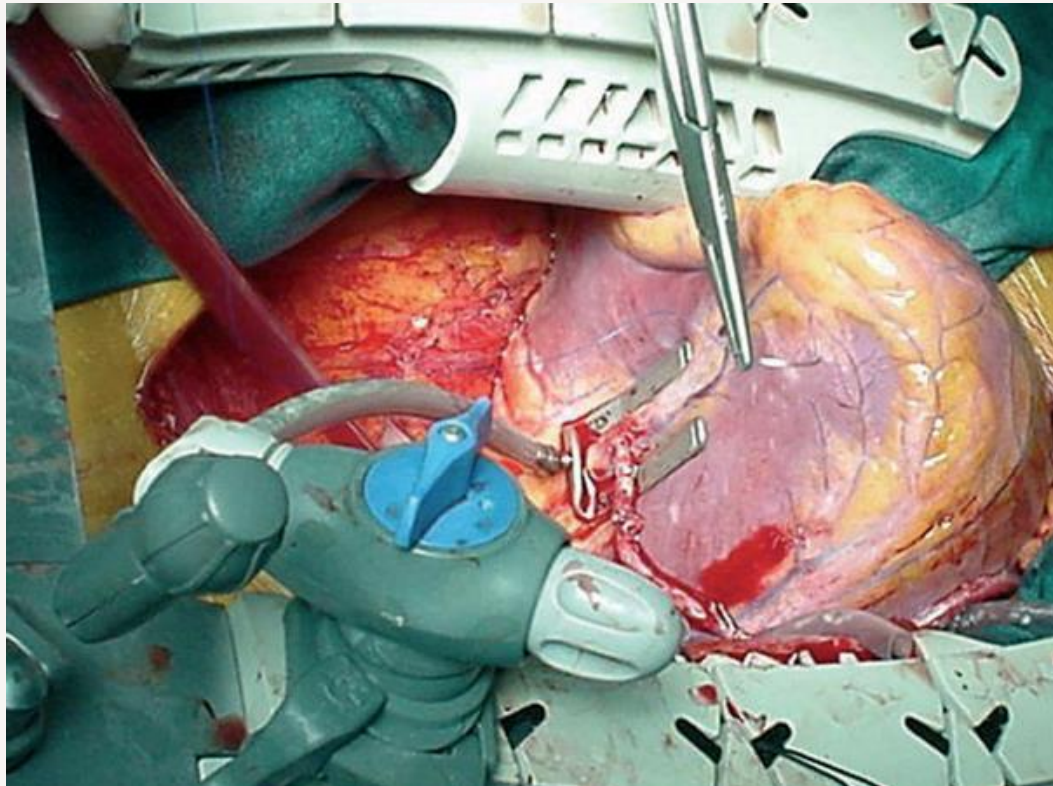
Probably more bypass grafts constructed

Contraindications



Absolute Contraindication of Off-Pump CABG

- Unstable hemodynamics during CABG
(Cardiac positioning: posterior surface)



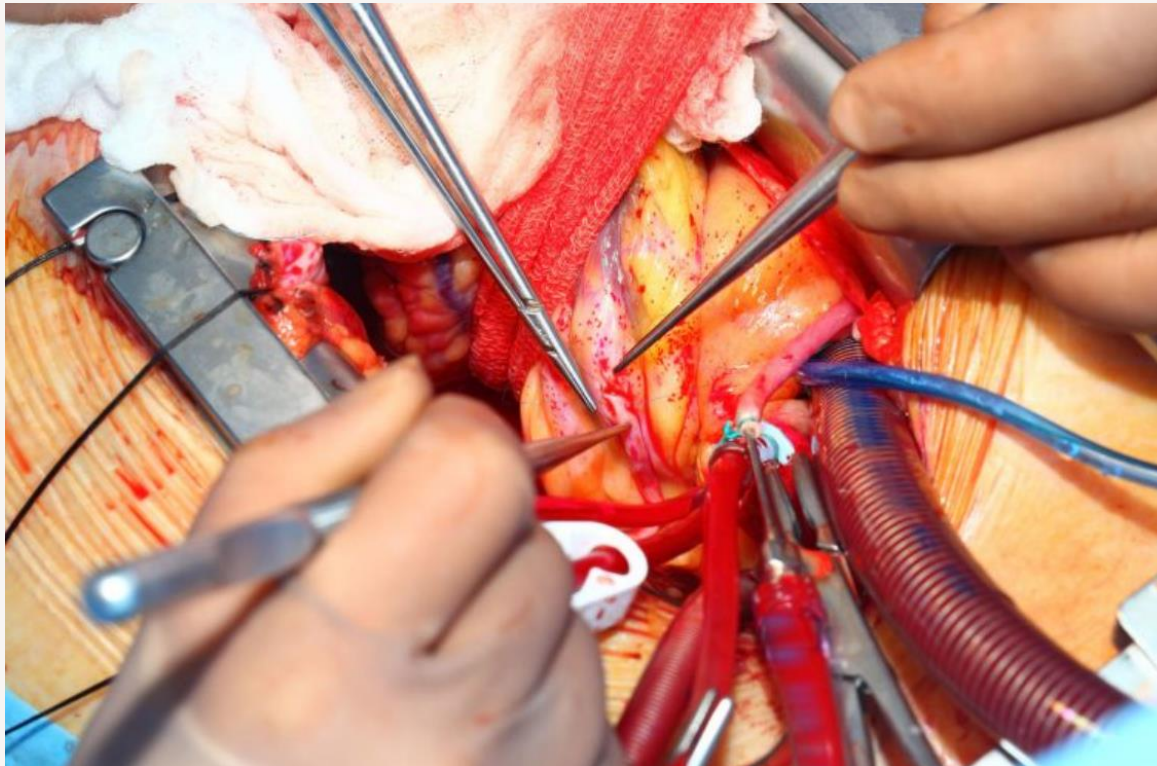
Absolute Contraindication of On-Pump CABG

- No adequate arterial cannulation site



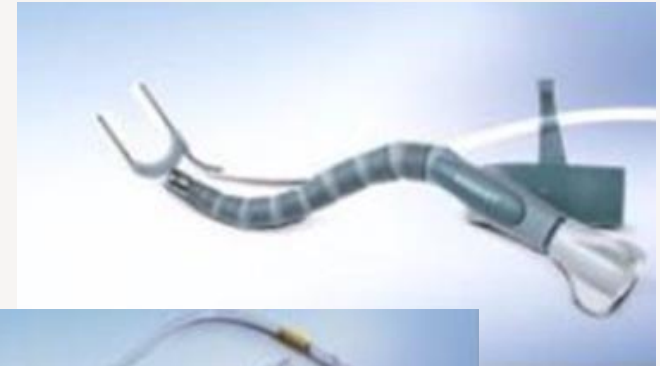
On-Pump CABG

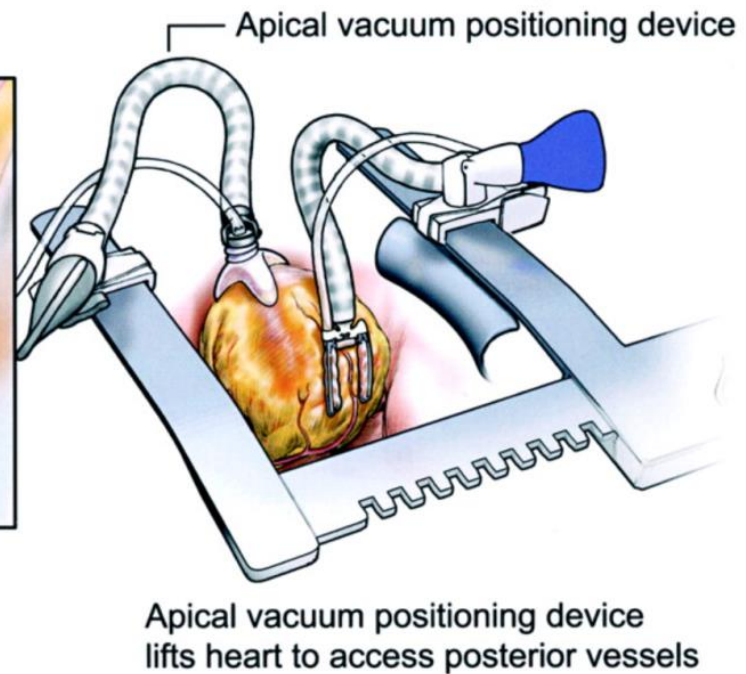
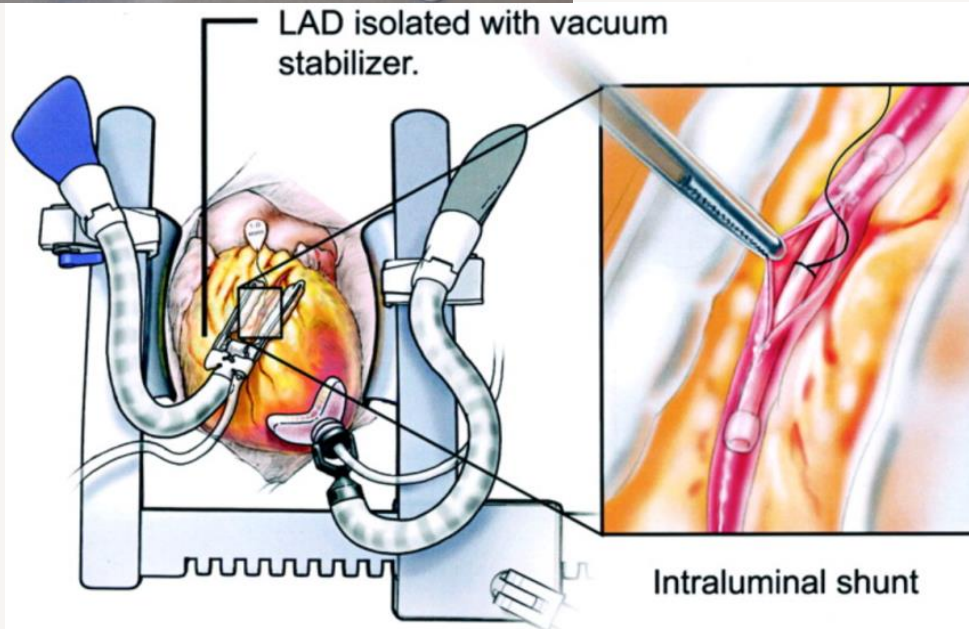
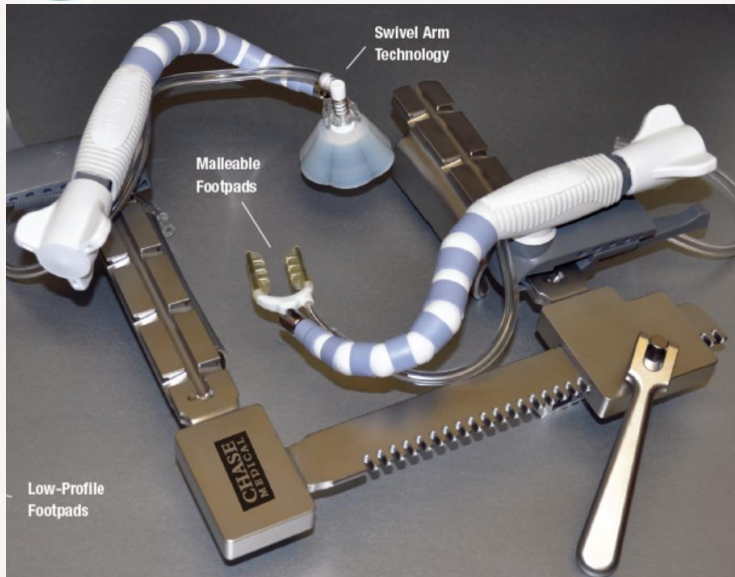
- Pump
- Gauzes or Hands



Off-Pump CABG

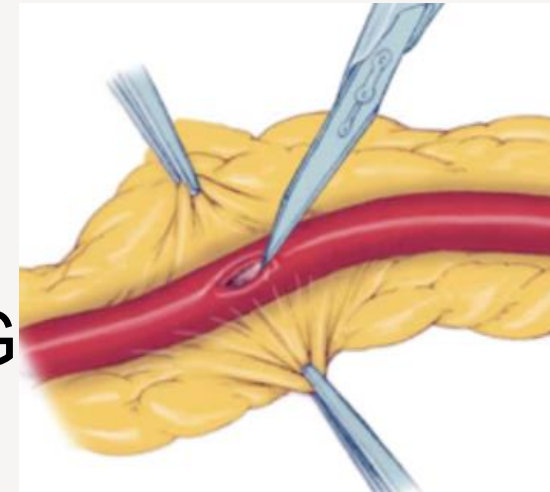
- Stabilizer
- Apical stabilizer (suction)
- CO2 blower
- Coronary shunt





On- and Off-Pump CABG

- Anastomosis order:
“LAD first” vs. “LAD last”
- Coronary atriotomy:
More caution in on-pump CABG
- Length / configuration adjustment
Easier with off-pump CABG





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On- vs. Off-Pump CABG



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

NOVEMBER 5, 2009

VOL. 361 NO. 19

ROOBY Trial By Residents >60%

and Dimitri Novitzky, M.D., Ph.D., for the Veterans Affairs Randomized On/Off Bypass (ROOBY) Study Group

METHODS

We randomly assigned 2203 patients scheduled for urgent or elective CABG to either on-pump or off-pump procedures. The primary short-term end point was a composite of death or complications (reoperation, new mechanical support, cardiac arrest, coma, stroke, or renal failure) before discharge or within 30 days after surgery. The primary long-term end point was a composite of death from any cause, a repeat revascularization procedure, or a nonfatal myocardial infarction within 1 year after surgery. Secondary end points included the completeness of revascularization, graft patency at 1 year, neuropsychological outcomes, and the use of major resources.



Off-Pump or On-Pump Coronary-Artery Bypass Grafting at 30 Days

André Lamy, M.D., P.J. Devereaux, M.D., Ph.D., Dorairaj Prabhakaran, M.D.,
David P. Taggart, Ph.D., Shengshou Hu, M.D., Ernesto Paolasso, M.D.,

CORONARY Investigators Trial Expert surgeons only! (> 100 cases)

Toomas-Andres Sulling, M.D., Richard P. Whitlock, M.D., Yongning Ou, M.Sc.,
Jennifer Ng, M.Sc., Susan Chrolavicius, B.A., and Salim Yusuf, D.Phil.,
for the CORONARY Investigators*

BACKGROUND

The relative benefits and risks of performing coronary-artery bypass grafting (CABG) with a beating-heart technique (off-pump CABG), as compared with cardiopulmonary bypass (on-pump CABG), are not clearly established.

METHODS

At 79 centers in 19 countries, we randomly assigned 4752 patients in whom CABG was planned to undergo the procedure off-pump or on-pump. The first coprimary outcome was a composite of death, nonfatal stroke, nonfatal myocardial infarction, or new renal failure requiring dialysis at 30 days after randomization.

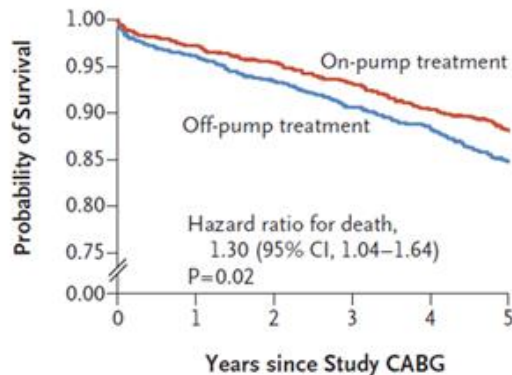
5-Year Outcomes

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Five-Year Outcomes after On-Pump and Off-Pump Coronary-Artery Bypass

A. Laurie Shroyer, Ph.D., Brack Hattler, M.D., Todd H. Wagner, Ph.D., Joseph F. Collins, Sc.D., Janet H. Baltz, R.N., Jacquelyn A. Quin, M.D., G. Hossein Almassi, M.D., Elizabeth Kozora, Ph.D., Faisal Bakaeen, M.D., Joseph C. Cleveland, Jr., M.D., Muath Bishawi, M.D., and Frederick L. Grover, M.D., for the Veterans Affairs ROOBY-FS Group*



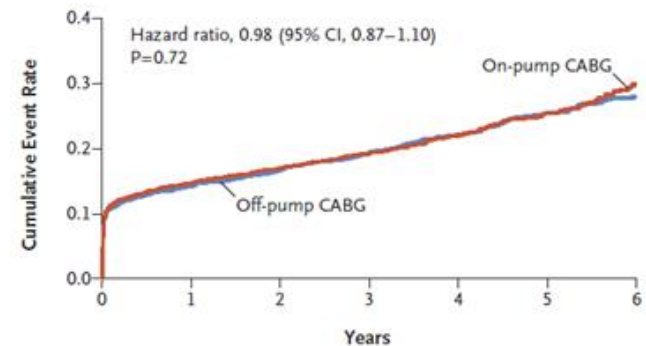
ROOBY:
On-pump better

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Five-Year Outcomes after Off-Pump or On-Pump Coronary-Artery Bypass Grafting

André Lamy, M.D., P.J. Devereaux, M.D., Ph.D., Dorairaj Prabhakaran, M.D., David P. Taggart, Ph.D., Shengshou Hu, M.D., Zbynek Straka, M.D., Leopoldo S. Piegas, M.D., Alvaro Avezum, M.D., Ahmet R. Akar, M.D., Fernando Lanas Zanetti, M.D., Anil R. Jain, M.D., Nicolas Noiseux, M.D., Chandrasekar Padmanabhan, M.D., Juan-Carlos Bahamondes, M.D., Richard J. Novick, M.D., Liang Tao, M.D., Pablo A. Olavegogeoascoechea, M.D., Balram Airan, M.D., Toomas-Andres Sulling, M.D., Richard P. Whitlock, M.D., Yongning Ou, M.Sc., Peggy Gao, M.Sc., Shirley Pettit, R.N., and Salim Yusuf, D.Phil., for the CORONARY Investigators*



CORONARY Investigator:
Comparable on- and off-pump

Big Fight at Asan Medical Center
The winner has not been determined



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Cardiac Surgery

Long-Term Survival Following Coronary Artery Bypass Grafting

Off-Pump Versus On-Pump Strategies



Joon Bum Kim, MD, PhD,* Sung-Cheol Yun, PhD,† Jae Wong Lim, MD,* Soo Kyung Hwang, MD,*
Sung-Ho Jung, MD,* Hyun Song, MD, PhD,‡ Cheol Hyun Chung, MD, PhD,*
Jae Won Lee, MD, PhD,* Suk Jung Choo, MD, PhD*

Seoul, South Korea

Objectives

This study sought to compare long-term survival after off- and on-pump coronary artery bypass grafting (CABG).

Background

Although several large-scale clinical trials have compared the surgical outcomes between off- and on-pump CABG, the long-term survival has not been compared between the 2 surgical strategies in a reasonably sized cohort.

Methods

We evaluated long-term survival data in 5,203 patients (age 62.9 ± 9.1 years, 1,340 females) who underwent elective isolated CABG (off-pump: $n = 2,333$; on-pump: $n = 2,870$) from 1989 through 2012. Vital statuses were validated using the Korean National Registry of Vital Statistics. Long-term survival was compared with the use of propensity scores and inverse probability weighting to adjust selection bias.

Results

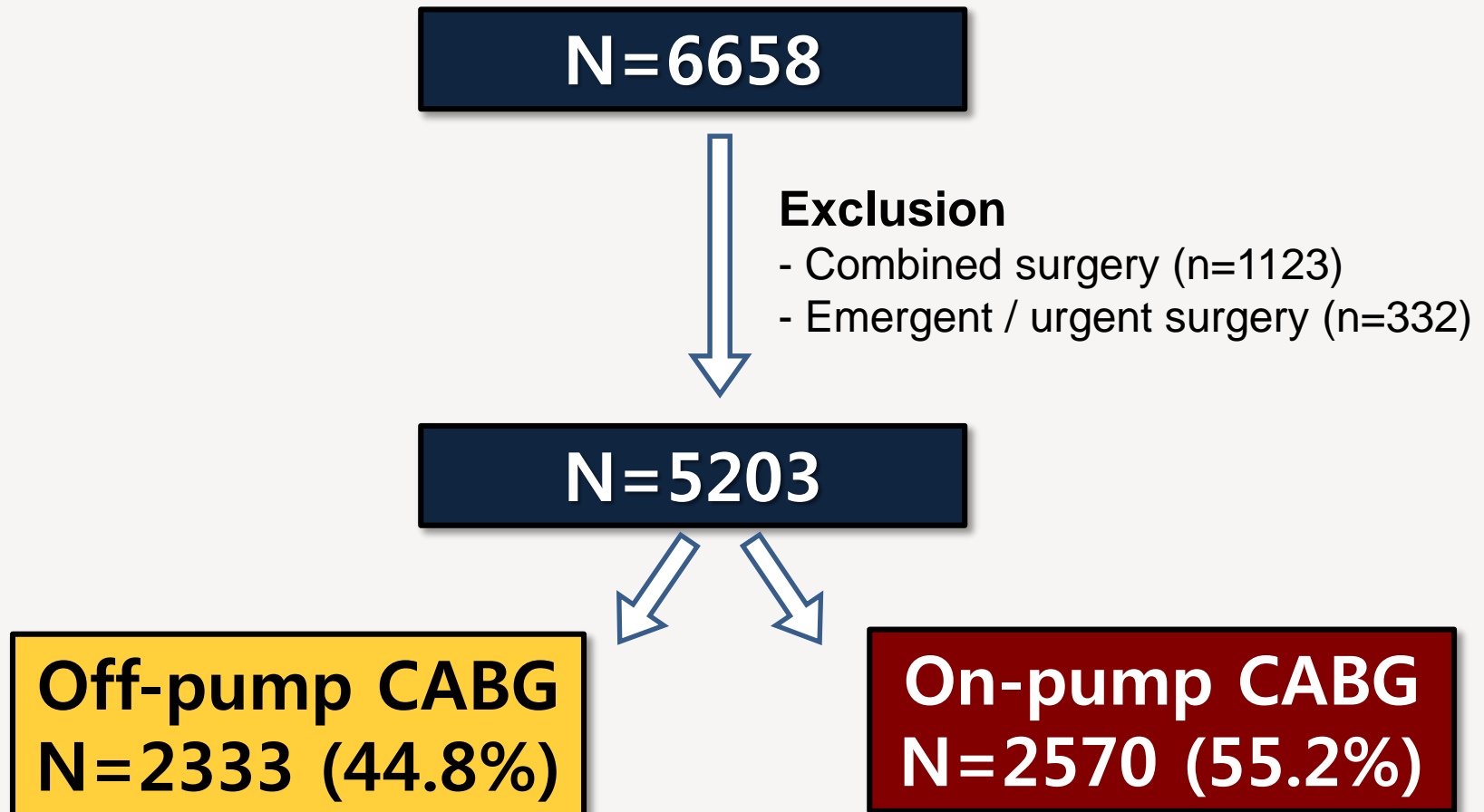
Patients undergoing on-pump CABG had a higher number of distal anastomoses than those undergoing off-pump CABG (3.7 ± 1.2 vs. 3.0 ± 1.1 ; $p < 0.001$). Survival data were complete in 5,167 patients (99.3%), with a median follow-up duration of 6.4 years (interquartile range: 3.7 to 10.5 years; maximum 23.1 years). During follow-up, 1,181 patients (22.7%) died. After adjustment, both groups of patients showed a similar risk of death at 30 days (odds ratio: 0.70; 95% confidence interval [CI]: 0.35 to 1.40; $p = 0.31$) and up to 1 year (hazard ratio [HR]: 1.11; 95% CI: 0.74 to 1.65; $p = 0.62$). For overall mortality, however, patients undergoing off-pump CABG were at a significantly higher risk of death (HR: 1.43; 95% CI: 1.19 to 1.71; $p < 0.0001$) compared with those undergoing on-pump CABG. In subgroup analyses, on-pump CABG conferred survival benefits in most demographic, clinical, and anatomic subgroups compared with off-pump CABG.

Conclusions

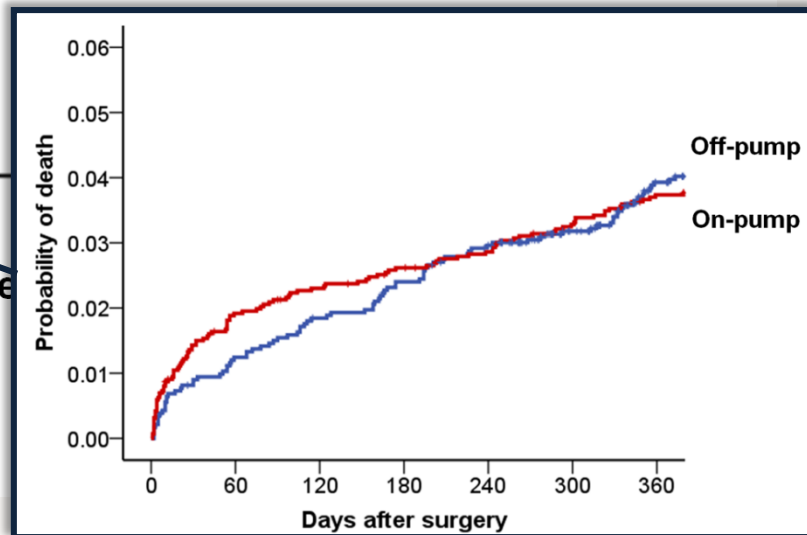
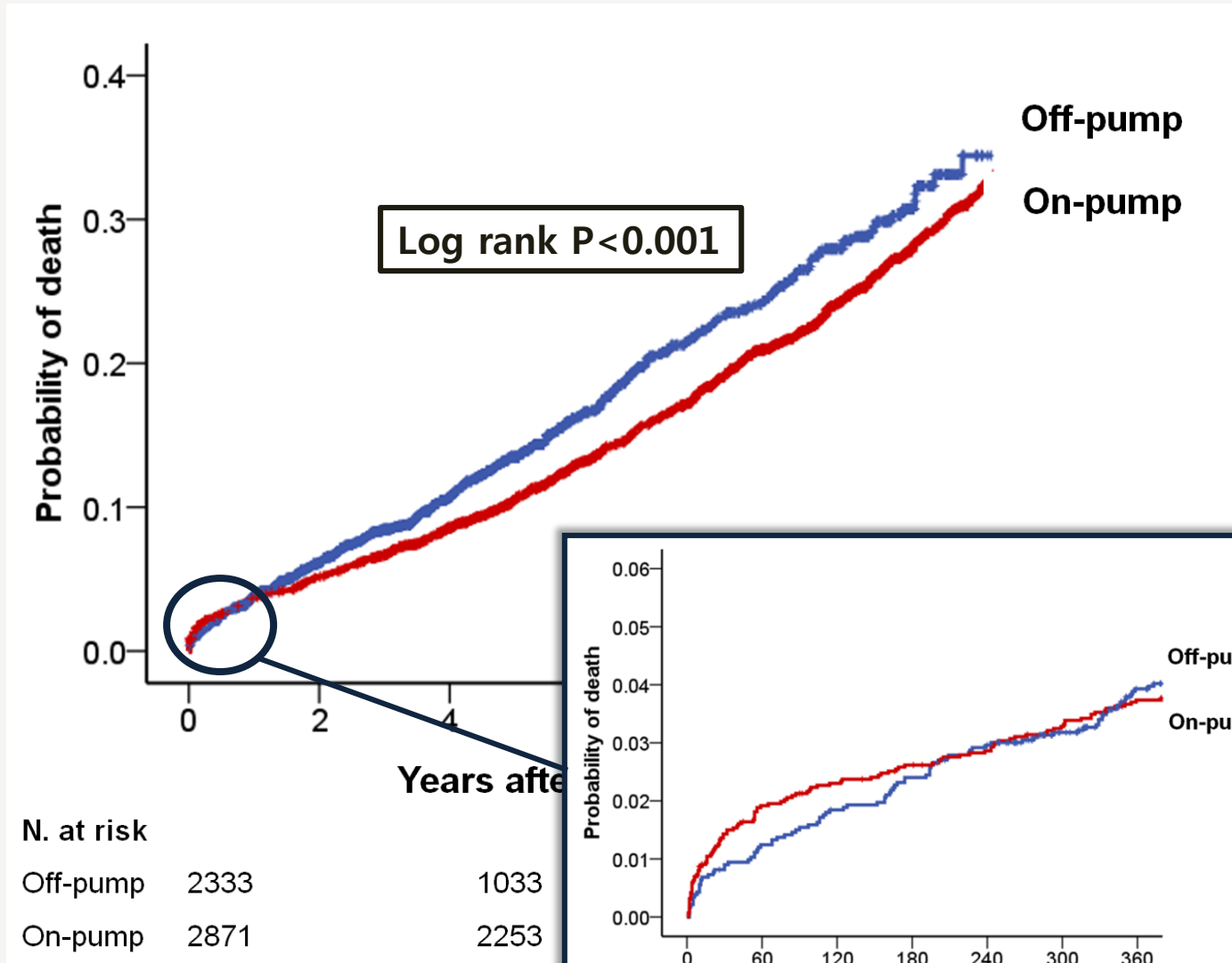
In patients undergoing elective isolated CABG, on-pump strategy conferred a long-term survival advantage compared with off-pump strategy. (J Am Coll Cardiol 2014;63:2280–8) © 2014 by the American College of Cardiology Foundation

Methods

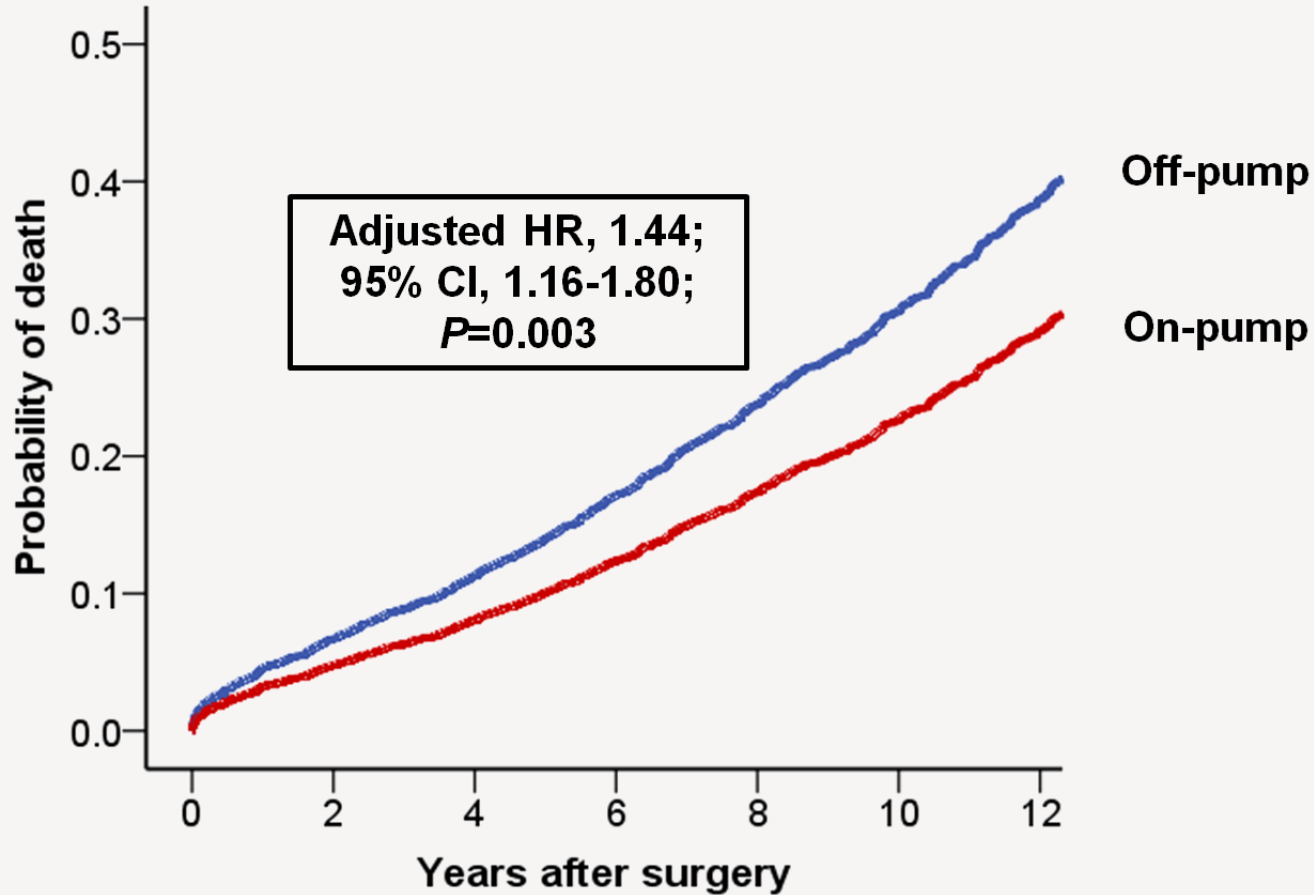
**CABG between April 1989 and April 2012
at the Asan Medical Center, Seoul, Korea,**



Unadjusted Death Rates



Adjusted Mortality (IPTW)



N. at risk

Off-pump	2333	1033	258
On-pump	2871	2253	1230

Korea Nationwide Results

- South Korea:



- Strong enthusiasm for off-pump CABG (>50%)
 - Universal nationwide claims database of the National Health Insurance Service (mandatory for all residents)
 - Detailed data on baseline, procedural and follow-up parameters are available. (100% complete)
- Sound environment to allow analyses on comparative effectiveness between the on- and off-pump CABG reflecting real-world practices.



28,650 patients
Aged 18 years or older receiving CABG
between Jan 2004 and Dec 2013

4,822 Excluded
96 Revascularization within 2 years before
4,649 Acute myocardial infarction at index day
77 Unstable hemodynamics

23,828 patients

12,639 Off-pump

11,189 On-pump

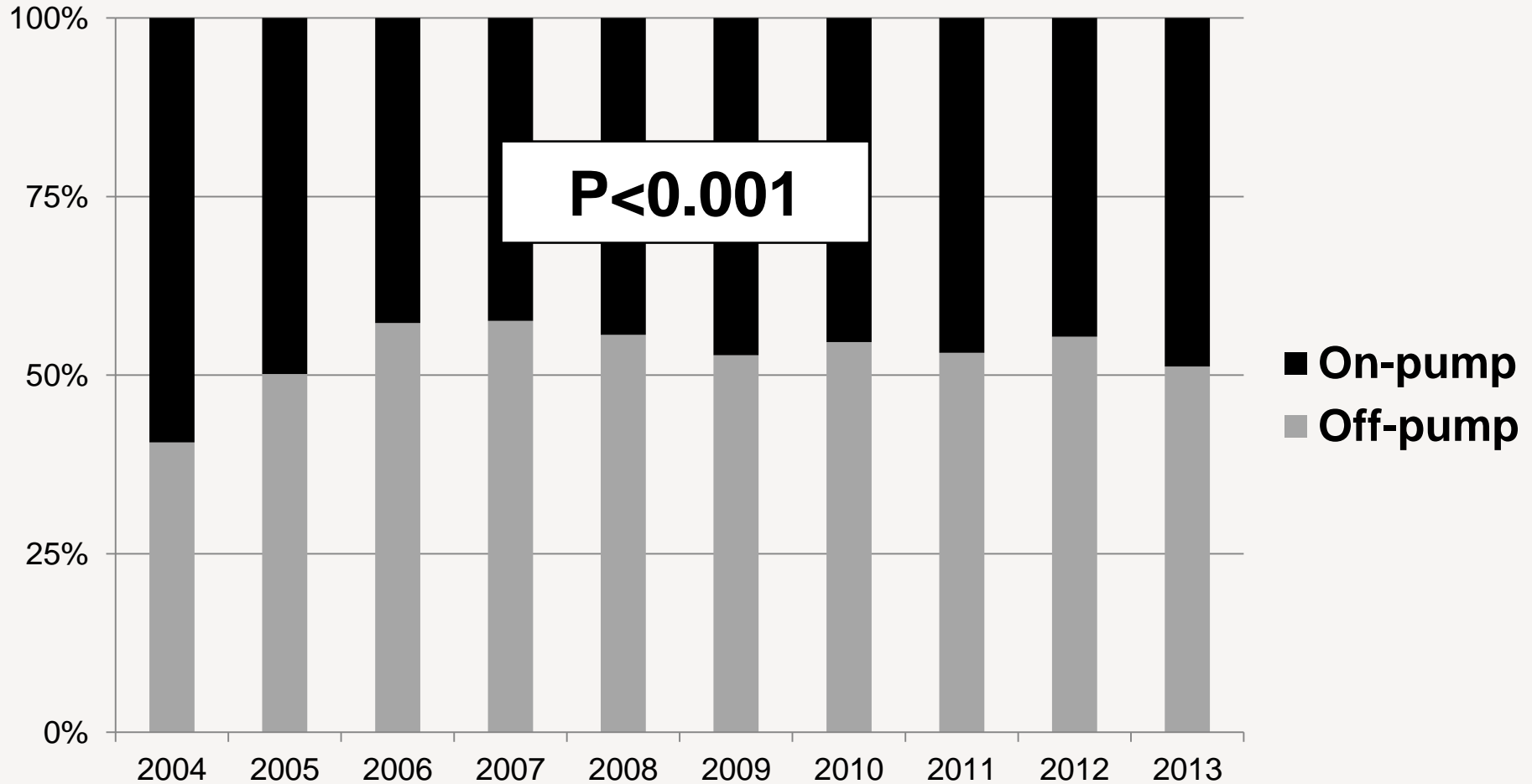
PS matching

6,483 Off-pump

6,483 Off-pump



Yearly Trends





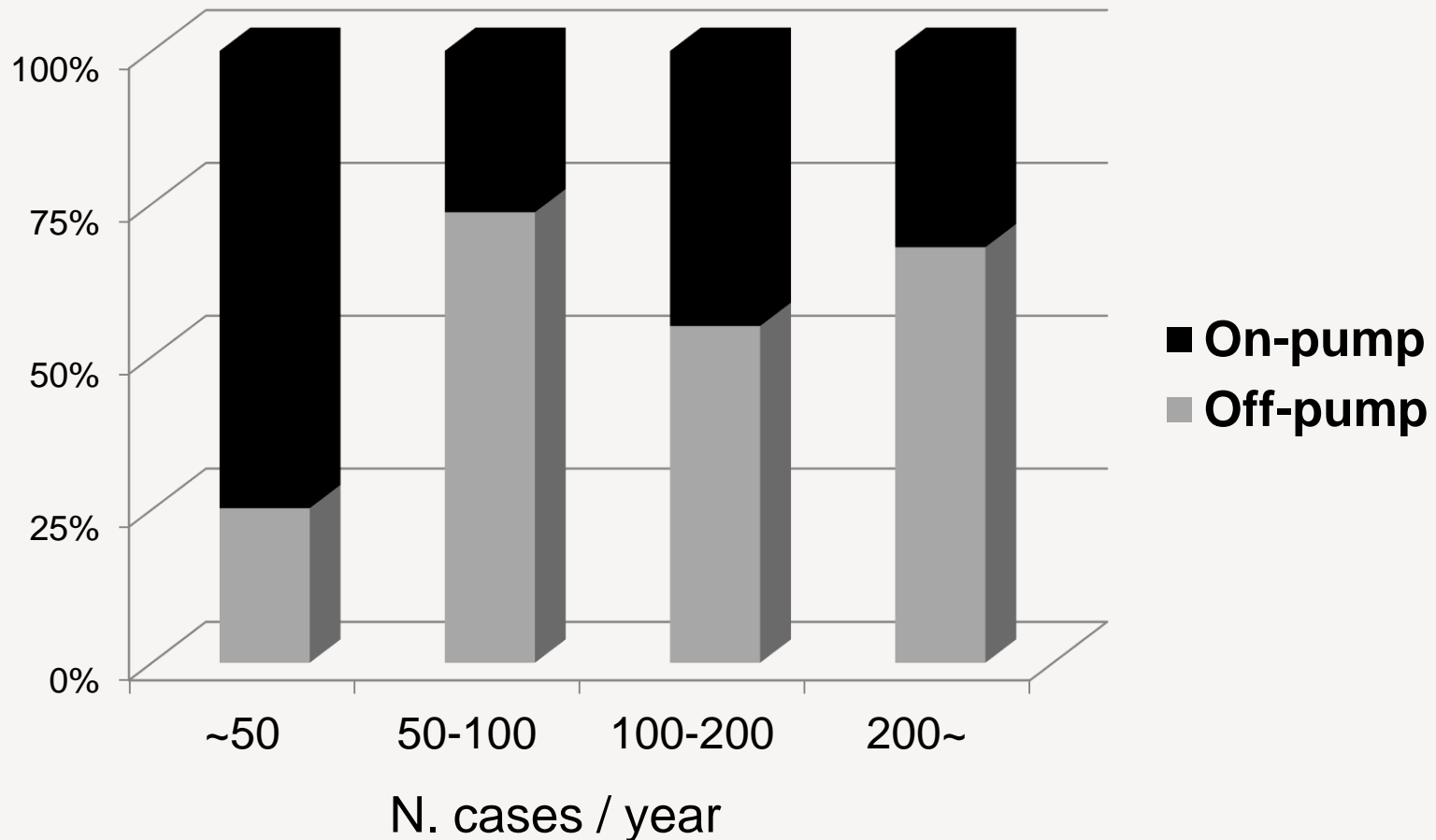
Worldwide Trends

15%~20% of CABG are performed using the
“Off-Pump Technique”

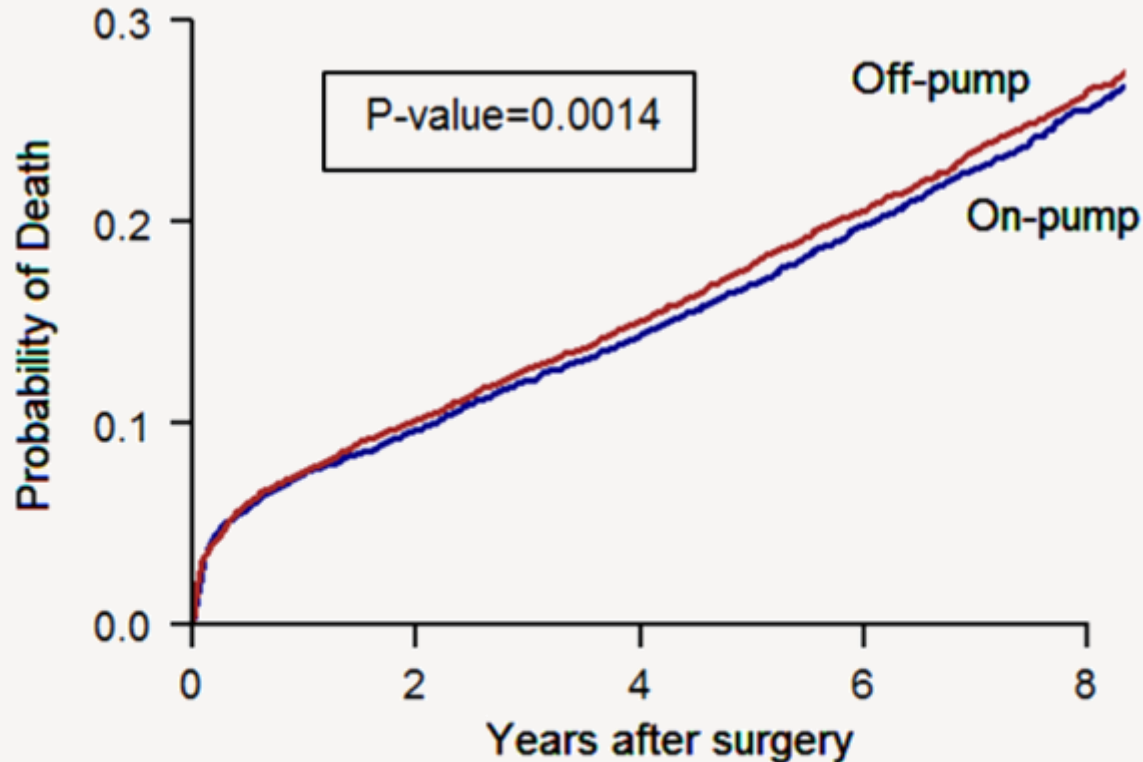
*The STS 2009 Report.
Adult Cardiac Database Executive Summary*

Trends Depending on Center Volumes

$P < 0.001$



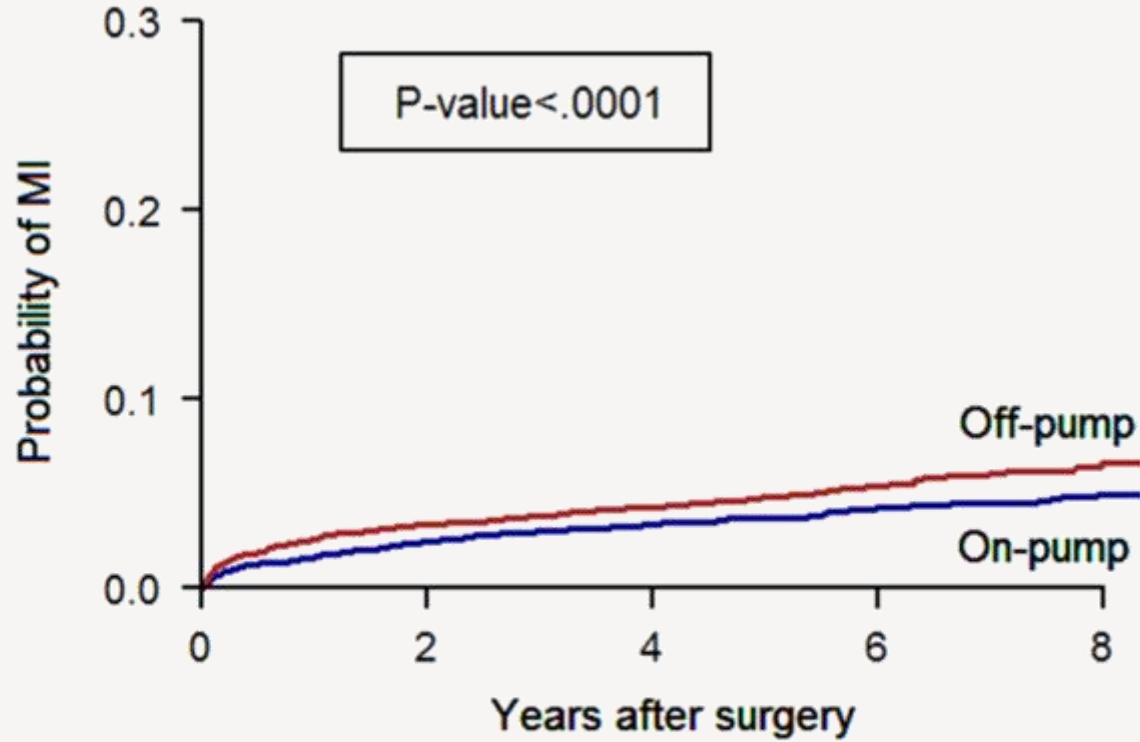
Adjusted Death in PS Matched Cohort



N. at risk

Off-pump	6483	5366	4160	2886	1565
On-pump	6483	5362	4150	2806	1589

Adjusted MI in PS Matched Cohort



N. at risk

Off-pump	6483	5216	4028	2779	1498
On-pump	6483	5256	4036	2724	1540

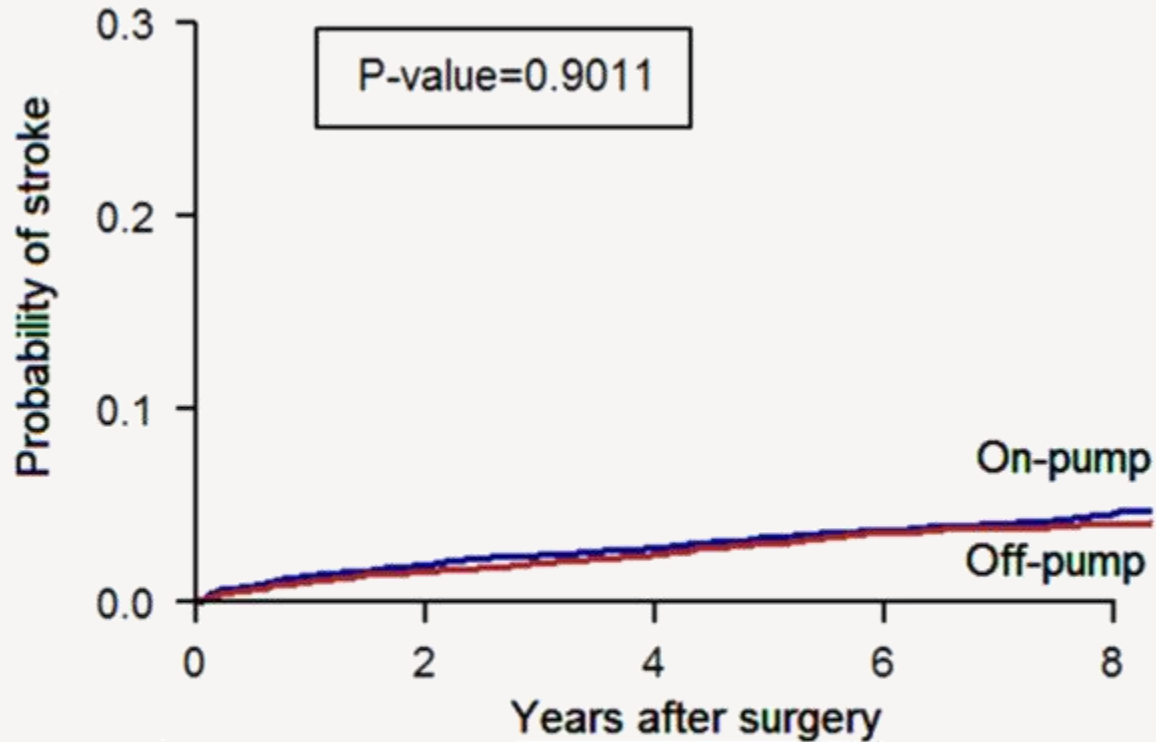
Adjusted Reintervention in Matched Cohort



N. at risk

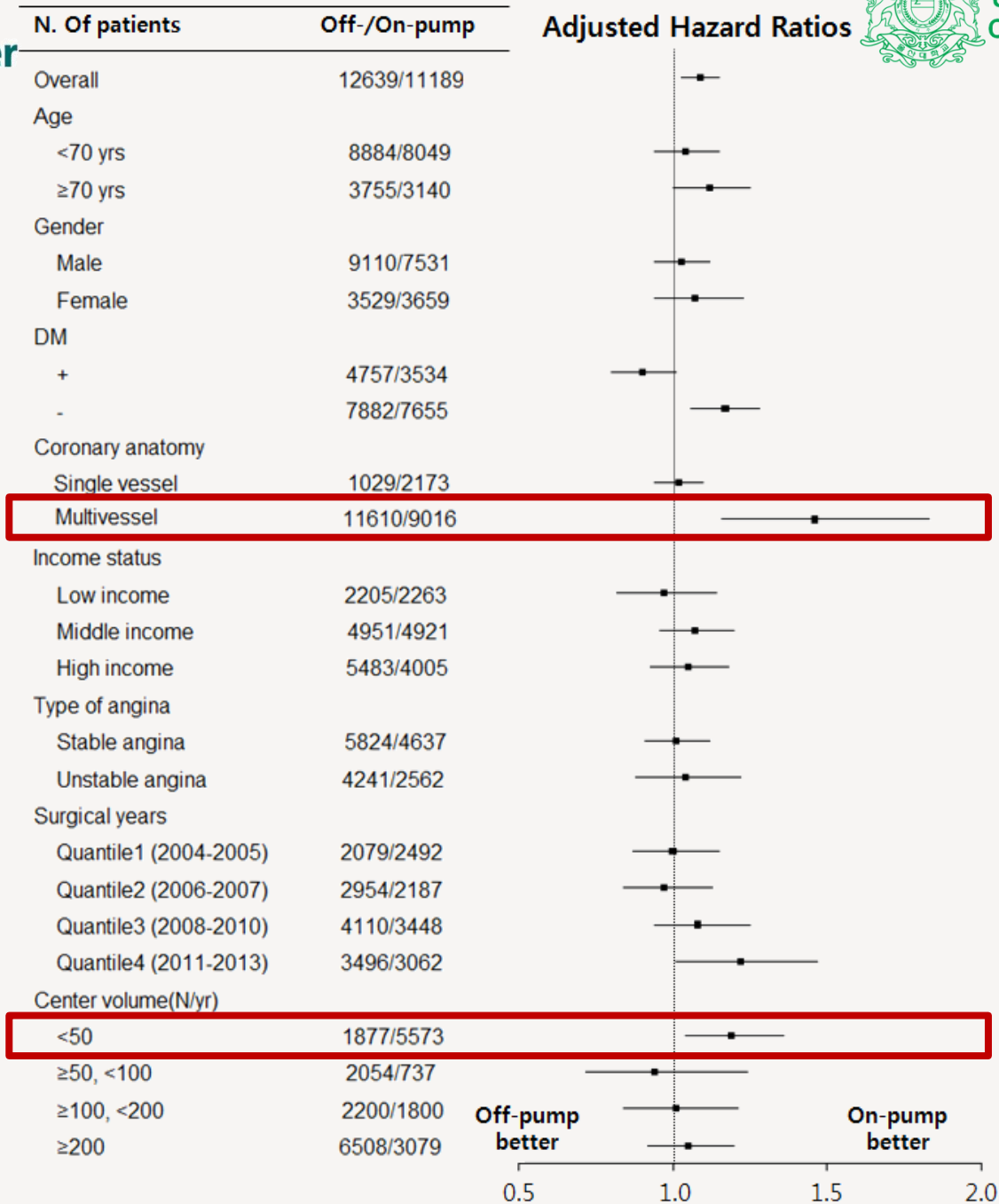
Off-pump	6483	5171	3922	2649	1417
On-pump	6483	5240	3995	2653	1481

Adjusted Stroke in PS Matched Cohort



N. at risk

Off-pump	6483	5301	4091	2809	1527
On-pump	6483	5290	4076	2734	1537



Other Techniques

- **On-pump beating CABG**
- **MIDCAB** (Minimally-Invasive Direct CABG)



- **TECAB** (Totally Endoscopic CABG)

