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Coronary Revascularization and Circulatory Support Strategies in Patients with Myocardial Infarction, Multi-vessel Coronary Artery Disease, and Cardiogenic Shock: Insights from an International Survey

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Abstract

Background: Cardiogenic shock (CS) complicating acute myocardial infarction (MI) is associated with high mortality. In the absence of data to support coronary revascularization beyond the infarct artery and selection of circulatory support devices or medications, clinical practice may vary substantially.

Methods: We distributed a survey to interventional cardiologists and cardiothoracic surgeons through relevant professional societies to determine contemporary coronary revascularization and circulatory support strategies for MI with CS and multi-vessel coronary artery disease (CAD).

Results: A total of 143 participants completed the survey between 1/2019 and 8/2019. Overall, 55.2% of participants reported that standard approach to coronary revascularization was single vessel PCI of the infarct related artery (IRA) with staged PCI of non-culprit lesions. Single vessel PCI of the IRA only (28.0%), emergency multi-vessel PCI (11.9%), and coronary artery bypass grafting (CABG) (4.9%) were standard approaches at some centers. A plurality of survey respondents (46.9%) believed initial PCI with staged CABG for multi-vessel CAD would be associated with the most favorable outcomes. A minority of respondents believed PCI-only strategies (23.1%) and CABG alone (6.3%) provided optimal care, and 23.1% were unsure of

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the best strategy. After PCI for CS, Impella (76.9%), intra-aortic balloon pump (IABP) (12.8%), and extra-corporeal membrane oxygenation (ECMO) (7.7%) were preferred. After CABG, IABP (34.3%), Impella (32.2%), and ECMO (28%) were preferred.

Conclusions: This survey indicates substantial heterogeneity in clinical care in CS. There is evidence of provider uncertainty and clinical equipoise regarding the optimal management of patients with MI, multi-vessel CAD, and CS.

Short Abstract:

We sought to determine contemporary practice patterns of coronary revascularization and circulatory support in patients with MI, multi-vessel coronary artery disease (CAD), and cardiogenic shock. A survey was distributed to interventional cardiologists and cardiothoracic surgeons through relevant professional societies. Survey respondents identified substantial heterogeneity in clinical care and evidence of provider uncertainty and clinical equipoise regarding the optimal management of patients with MI, multi-vessel CAD, and CS.

Keywords

Cardiogenic shock; coronary artery bypass grafting; myocardial infarction; percutaneous coronary intervention; mortality; multi-vessel coronary artery disease

Background:

Cardiogenic shock (CS) complicating acute myocardial infarction (MI) is associated with high mortality.[1] Emergency revascularization of the infarct-related coronary artery (IRA) for CS improves survival,[2] but the 35-45% 30-day mortality rate associated with this approach has persisted for decades despite advances in revascularization techniques, pharmacology, and mechanical circulatory support (MCS).[3] Beyond emergency infarct-artery revascularization, no interventions have been proven to reduce mortality in CS. In patients with MI, CS, and multivessel coronary artery disease (CAD), emergent multi-vessel percutaneous coronary intervention (PCI) was associated with a greater risk of 30-day death or severe renal failure compared to infarct-artery PCI only.[4] Intra-aortic balloon counter-pulsation did not reduce 30-day mortality in a large randomized trial of patients with MI complicated by CS.[5] Other MCS strategies have not been tested in adequately powered clinical trials.[6] In the absence of robust data to support the performance of revascularization beyond the infarct artery in patients with multivessel CAD, the selection of circulatory support devices or medications, clinical practice may vary substantially. Current procedure based registries do not allow for an assessment of contemporary treatment patterns of shock because they do not adequately capture a true denominator. We sought to determine contemporary practice patterns with regard to coronary revascularization, medical therapies, and circulatory support strategies in patients with MI, multi-vessel CAD, and CS.

Methods:

We distributed a digital survey (http://is.gd/CABG_SHOCK, Supplemental Figure 1) to interventional and critical care cardiologists and cardiothoracic surgeons directly (to relevant faculty of the 2019 Society for Cardiovascular Angiography and Interventions Scientific

Sessions) and through relevant United States professional societies (American College of Cardiology and Society of Thoracic Surgeons). Responses were collected from 1/2019 through 8/2019. Categorical data are presented as number and percentages and were compared using chisquare analysis and the Fisher's exact test when appropriate. Statistical analysis was performed using SPSS version 26 (IBM, Armonk, NY). Two-sided P-values <0.05 were considered to be statistically significant. The study was approved by the New York University School of Medicine Institutional Review Board. No extramural funding was used to support this work. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents.

Results:

A total of 143 participants representing 120 institutions completed the survey, including 78 interventional and critical care cardiologists and 65 cardiothoracic surgeons. The digital survey response rate was 3.0%. Characteristics of survey respondents are shown in Table 1. A majority of participants were located in the United States or Canada (80.4%) and many worked at academic medical centers (46.2%) or university-affiliated hospitals (22.4%). Participants frequently represented high-volume institutions that cared for >100 ST-segment elevation MI patients each year (59.4%) and >10 patients with MI with multivessel CAD complicated by CS each year (79.7%), and most had established programs in advanced heart failure (68.5%) and MCS (63.6%).

Overall, 55.2% of participants reported that the institutional standard approach to coronary revascularization for MI, CS, and multi-vessel CAD was single vessel PCI of the infarct related artery (IRA) with staged PCI of non-culprit severe disease. The remaining participants reported single vessel PCI of the infarct-related artery only (28.0%), multi-vessel PCI of all lesions during the index revascularization procedure (11.9%), and multivessel CABG (4.9%) as the standard institutional approaches to revascularization for MI, CS, and multi-vessel CAD (Figure 1). However, 46.9% of participants believed that initial PCI with staged CABG would be associated with the most favorable outcomes in patients MI, CS and multivessel CAD. In contrast, 23.1% indicated PCI-only strategies would provide the greatest benefit, 6.3% indicated that surgical revascularization with CABG only would be optimal, and 23.1% were unsure of which revascularization strategy would yield the greatest benefit. Responses varied by cardiovascular specialty training ($p<0.001$), as shown in Figure 1. Participant responses stratified by practice setting and years of specialty practice are shown in Supplemental Table 1.

Among cardiologists who completed the survey, common MCS therapies used after PCI in MI with multivessel CAD and CS included the Impella percutaneous left ventricular assist device (VAD) (85.9% of respondents), intra-aortic balloon pump (IABP) (55.1%), ECMO (43.6%), and surgical VADs (21.8%). However, 76.9% of cardiologists preferred Impella, 12.8% preferred IABP, and 7.7% preferred ECMO for MCS after PCI for CS. Survey respondents reported that patients with residual cardiogenic shock after PCI were also commonly treated with norepinephrine (75.6%), dobutamine (41.0%), dopamine (37.2%), vasopressin (34.6%), and epinephrine (23.1%).

Based on responses from all survey participants, including cardiologists and cardiothoracic surgeons, MCS therapy after CABG for MI, multivessel CAD, and CS frequently included ECMO (62.2%), Impella (51.7%), and surgical VAD (20.3%). However, the preferred MCS strategy after CABG was IABP in 34.3%, Impella in 32.2%, and ECMO in 28%. Participants reported that patients with residual cardiogenic shock after CABG were also commonly treated with norepinephrine (75.5%), epinephrine (67.8%), vasopressin (50.3%), milrinone (50.3%) and dobutamine (49.0%) at their centers. Approaches to circulatory support after PCI and CABG in MI with multivessel CAD complicated by CS are shown in Table 2.

Discussion:

These data demonstrate heterogeneity in the contemporary approach to coronary revascularization, MCS use, and pharmacology among patients with MI, multivessel CAD and CS. Although most survey respondents indicated that PCI-based coronary revascularization strategies represented the current standard of practice, cardiothoracic surgeons were more likely than cardiologists to believe in superiority of CABG-based strategies for MI with CS and multivessel CAD. Among cardiothoracic surgeons who favored surgical revascularization for CS, most indicated that acute IRA PCI followed by CABG would yield the most favorable outcomes.

Approaches to MCS and pharmacology varied based on the preferred mode of coronary revascularization; most respondents reported ECMO and epinephrine were frequently selected for use after CABG, while cardiologists reported Impella and norepinephrine use for CS after PCI. In light of this heterogeneity, trials to establish optimal approaches to CS care are urgently needed. Ongoing randomized trials evaluating Impella (Danish-German cardiogenic shock trial [DanGer Shock, NCT01633502], planned enrollment: 360) and ECMO (Extracorporeal Life Support in Cardiogenic Shock trial [ECLS-SHOCK, NCT03637205], planned enrollment: 420; Testing the Value of Novel Strategy and Its Cost Efficacy in Order to Improve the Poor Outcomes in Cardiogenic Shock, [EUROSHOCK, NCT03813134], planned enrollment: 428) in patients with MI and CS will provide key insights into the role for MCS in CS.[7] Still, prospective studies evaluating optimal pharmacology for MI with CS are lacking and the optimal approach to coronary revascularization remains uncertain. Outcomes associated with acute PCI of the infarct-artery with balloon angioplasty to restore coronary flow followed by urgent multivessel surgical revascularization with CABG versus initial infarct-artery only PCI with or without staged non-culprit PCI should be evaluated in a prospective manner, preferably in a randomized control trial.

Limitations:

There are a few limitations of this survey-based study. First, institutional practice patterns were based solely on survey respondents and were not independently verified. A greater proportion of cardiologists (94%) practiced in North America compared to cardiothoracic surgeons (63%) who completed the survey. Survey questions regarding common MCS and vasoactive therapies did not incorporate heterogeneity in clinical presentations

of cardiogenic shock or define specific clinical scenarios. We did not query survey respondents regarding therapies that are not approved by the United States Food and Drug Administration (e.g. levosimendan). Combinations of MCS and vasoactive pharmacology were not evaluated. The survey included relatively few centers without heart failure or mechanical circulatory support programs and consequently, and the results of this survey are unlikely to reflect practice patterns at small, community hospitals. Invitations to complete the survey were distributed by email through some, but not all, relevant professional societies. Nevertheless, these data represent contemporary management strategies and perspectives on the optimal treatment of MI with multivessel CAD and CS from 120 hospitals worldwide.

Conclusion:

In conclusion, data from our survey indicate substantial heterogeneity in clinical care and provider uncertainty regarding the optimal management of patients with MI, multivessel CAD, and CS that suggest equipoise for future clinical trials.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Disclosures:

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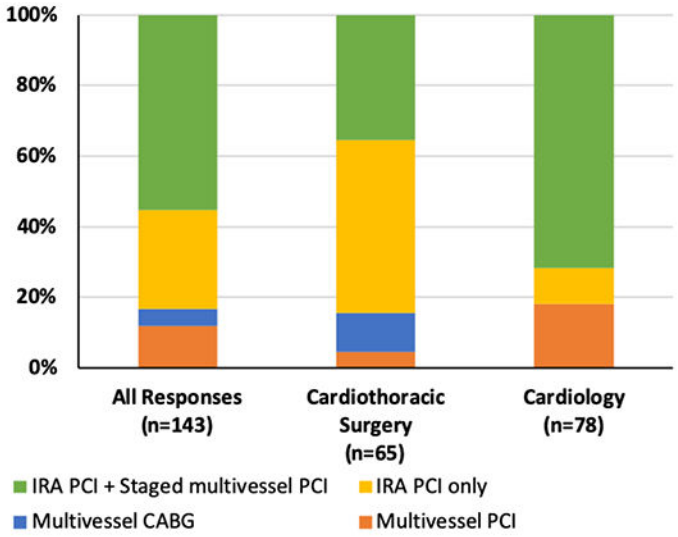
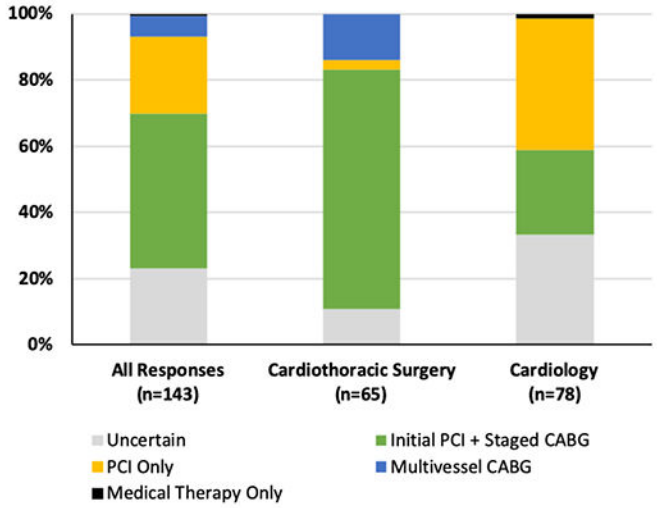
(A) What is the standard approach to revascularization in a patient with acute MI with cardiogenic shock and multivessel disease?



* p<0.001 for comparison by specialty training.

(B) What revascularization strategy do you believe is associated with the best outcomes in AMI with cardiogenic shock and multivessel CAD?



* p<0.001 for comparison by specialty training.

Figure 1:

Participant responses to the questions: “What is the standard approach to revascularization in a patient with acute MI with cardiogenic shock and multivessel disease?” (Panel A) and “What revascularization strategy do you believe is associated with the best outcomes in AMI with cardiogenic shock and multivessel CAD?” (Panel B).

Table 1.

Characteristics of survey participants and their institutions

Characteristics of Survey Participants	n (%)
Specialty Training	
Interventional Cardiology	76 (53.1%)
Critical Care Cardiology	2 (1.4%)
Cardiothoracic Surgery	65 (45.5%)
Years in Specialty Practice	
1-5 Years	26 (18.2%)
6-10 Years	27 (18.9%)
11-20 Years	38 (26.6%)
21-30 Years	37 (25.9%)
>30 Years	15 (10.5%)
Practice Setting	
Academic Medical Center	67 (46.9%)
University Affiliate	32 (22.4%)
Private Hospital	30 (21.0%)
Public Hospital	14 (9.8%)
Hospital Location	
United States of America	113 (79.0%)
Canada	2 (1.4%)
Other †	28 (19.6%)
Hospital Annual STEMI Volume *	
<50	19 (13.3%)
51-100	31 (21.7%)
101-200	37 (25.9%)
201-300	20 (14%)
300+	28 (19.6%)
Unknown / Not Reported	8 (5.6%)
Annual Volume of MI Complicated by Cardiogenic Shock *	
<10	12 (8.4%)
11-25	53 (37.1%)
26-50	47 (32.9%)
51-100	17 (11.9%)
100+	8 (5.6%)
Unknown / Not Reported	6 (4.2%)
Annual Volume of MI Complicated by Cardiogenic Shock with Multivessel CAD *	
<10	29 (20.3%)
11-25	59 (41.3%)
26-50	28 (19.6%)
51-100	12 (8.4%)

Characteristics of Survey Participants	n (%)
100+	4 (2.8%)
Unknown / Not Reported	11 (4.9%)

*As per survey respondents. MI volumes may be estimates.

†International survey respondents represent the following 18 countries: Argentina, Australia, Austria, Brazil, Chile, China, Colombia, Egypt, Germany, Greece, Indonesia, Iran, Italy, Mexico, Poland, Russia, Thailand, and the United Kingdom.

Table 2.

Circulatory support after PCI and CABG in MI with multivessel CAD complicated by cardiogenic shock *

Circulatory Support in MI with Multivessel CAD Complicated by Cardiogenic Shock	CABG (n=143)	PCI (n=78)*	p-value
In patients with MI, cardiogenic shock, and multivessel disease undergoing revascularization by PCI or CABG, what is the preferred method of mechanical circulatory support at your center?			
IABP	49 (34.3%)	10 (12.8%)	<0.001
Impella	46 (32.2%)	60 (76.9%)	
ECMO	40 (28%)	6 (7.7%)	
Surgical VAD	3 (2.1%)	0 (0%)	
Other	2 (1.4%)	0 (0%)	
No Response	3 (2.1%)	2 (2.6%)	
Is there a minimum lactate threshold for which you would consider placement of a mechanical circulatory support device (other than IABP)?			
Yes	30 (21%)	20 (25.6%)	0.22 †
2-4 mmol/L	10 (33.3%)	8 (40.0%)	
4-10 mmol/L	17 (56.7%)	10 (50.0%)	
10-20 mmol/L	2 (6.7%)	0 (0%)	
Unknown	1 (3.3%)	2 (10.0%)	
No	108 (75.5%)	58 (74.4%)	
Unknown	5 (3.5%)	0 (0%)	
In patients with residual cardiogenic shock after PCI or CABG, which of the following interventions do you commonly use for circulatory / hemodynamic support?			
Norepinephrine	108 (75.5%)	59 (75.6%)	0.89
Epinephrine	97 (67.8%)	18 (23.1%)	<0.001
Vasopressin	72 (50.3%)	27 (34.6%)	0.035
Milrinone	72 (50.3%)	18 (23.1%)	<0.001
Dobutamine	70 (49.0%)	32 (41%)	0.32
Dopamine	34 (23.8%)	29 (37.2%)	0.051
Phenylephrine	33 (23.1%)	17 (21.8%)	0.99
Does your center have an algorithm for the stepwise escalation of hemodynamic / circulatory support post-PCI or post-CABG?			
Yes	23 (16.1%)	29 (37.2%)	0.0012
No	115 (80.4%)	48 (61.5%)	
Unknown	5 (3.5%)	1 (1.3%)	

* Cardiology participants only