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Accelerated Chest pain Evaluation with Stress imaging (ACES) Protocols Eliminate Testing Disparities in Patients with Chest Pain

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Abstract

Background—Patients from racial and ethnic minority groups presenting to the Emergency Department (ED) with chest pain experience lower odds of receiving stress testing compared to non-minorities. Studies have demonstrated that care pathways administered within the ED can reduce health disparities, but this has yet to be studied as a strategy to increase stress testing equity.

Methods—A secondary analysis from three randomized clinical trials involving ED patients with acute chest pain was performed to determine whether a care pathway, Accelerated Chest pain Evaluation with Stress imaging (ACES), reduces the racial disparity in index visit cardiac testing between African American (AA) and White patients. 334 participants with symptoms and findings indicating intermediate to high risk for acute coronary syndrome were enrolled in 3 clinical trials. Major exclusions were ST-segment elevation, initial troponin elevation, and hemodynamic instability. Participants were randomly assigned to receive usual inpatient care, or ACES. The ACES care pathway includes placement in observation for serial cardiac markers, with an expectation for stress imaging. The primary outcome was index visit objective cardiac testing, compared among AA and White participants.

Results—AA participants represented 111/329 (34%) of the study population, 80/220 (36%) of the ACES group and 31/109 (28%) of the usual care group. In usual care, objective testing

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occurred less frequently among AA (22/31, 71%) than White (69/78, 88%, $p = .027$) participants, primarily driven by cardiac catheterization (3% vs 24%, $p = .012$). In ACES, testing rates did not differ by race [AA 78/80 (98%) vs White 138/140 (99%) $p = .623$]. At 90 days, death, MI, and revascularization did not differ in either group between AA and White participants.

Conclusion—A care pathway with the expectation for stress imaging eliminates the racial disparity among AA and White participants with chest pain in the acquisition of index-visit cardiovascular testing.

Keywords

perfusion imaging; stress testing; invasive angiography; risk stratification; myocardial infarction; coronary revascularization

Background

Relative to non-minority patients, racial and ethnic minorities experience higher mortality from coronary heart disease.^{1,2} The underpinnings of this may partially relate to disparities in care delivery and cardiac testing. Patients from racial and ethnic minority groups presenting to the Emergency Department (ED) with chest pain experience a 32% lower odds of receiving stress testing compared to non-minorities.³ Accordingly, interventions to reduce disparities in cardiovascular care were identified by the Institute of Medicine as a high priority for comparative effectiveness research.⁴

We have recently tested a diagnostic pathway in three randomized clinical trials to assess the comparative effectiveness of observation unit strategies relative to usual care.^{5–7} We have named this protocol-driven chest pain care pathway Accelerated Chest pain Evaluation with Stress imaging (ACES); this protocol uses serial troponins with an expectation for stress testing to identify patients with intermediate to high risk findings for discharge or invasive management. The ACES care pathway expectation for stress testing involves less clinician judgment about whether stress testing should be performed. We hypothesized this care pathway would reduce racial disparities in objective cardiac testing. Accordingly, we sought to determine if an ACES approach, relative to an existing customary care approach, would reduce racial disparities in objective cardiac testing among patients with acute chest pain.

Methods and Measures

Design

From 2008 through 2011, three randomized trials were performed involving patients with chest pain recruited from the ED of (NAME WITHHELD FOR PEER REVIEW) (Registered with Clinicaltrials.gov as NCT00678639, NCT00869245, and NCT01035047). The medical center is a large tertiary care facility serving an urban, suburban, and rural population with an annual ED volume of 90,000–100,000 visits during the study period. Two of these trials randomized participants to ACES versus inpatient care and the third compared two ACES protocols that incorporated different imaging strategies. Inpatient care was provided by the Cardiology, Family Medicine, Internal Medicine, or Hospitalist services. ACES care was provided in the observation unit staffed by Emergency Physicians,

Physician Assistants, and Nurse Practitioners. This analysis combined the data from these three trials into one dataset with participants categorized as receiving ACES or usual care.

Subject selection criteria

To be enrolled in the randomized trials, participants had symptoms prompting an evaluation for possible acute coronary syndrome and no contraindications for cardiac magnetic resonance (CMR) testing. Exclusion criteria included new ST-segment elevation or depression, hypotension (systolic <90 mm Hg), and an initial troponin value above the institutional normal value. Low risk patients were excluded, thus inclusion required a care provider assessment of intermediate to high risk chest pain using the ACC/AHA risk stratification framework, and/or a Thrombolysis in Myocardial Infarction (TIMI) Risk score of ≥ 1 .⁵⁻⁸ Race and ethnicity were self-reported to the study coordinator at the time of enrollment or obtained from the electronic medical record. Participants reporting race other than AA or White were excluded from this analysis (n=5).

Outcome measures and covariates

The primary outcome for this analysis included the rate of objective cardiac testing during the index visit. Objective cardiac testing was defined as stress (exercise or dobutamine) echocardiography, cardiac nuclear stress imaging, coronary computed tomographic angiography, invasive catheter coronary angiography, stress cardiac magnetic resonance imaging, or stress treadmill testing.

For outcomes after the index visit, participants were followed over the course of a year from randomization using both record review and telephone contact. Secondary outcome measures included major adverse cardiac events at 90 days, and cardiac-related hospital readmissions measured at 1 year. Major adverse cardiac events were the composite of death (all cause), myocardial infarction, and coronary revascularization. Myocardial infarction was defined and adjudicated by 2 investigators in accordance with the universal definition at the time the trials enrolled,⁹ requiring a gradual rise and fall of troponin, with appropriate clinical symptoms. In the case of any disagreement, the first 2 adjudicators discussed the discordant case with an attempt to reach agreement. If disagreement persisted, a third adjudicator was utilized. For hospital readmissions, cardiac-relatedness was assessed using a definition previously described¹⁰, requiring one of the following criteria: 1) cardiac procedures performed [Cardiac imaging or stress testing (excluding resting echo), coronary revascularization, pacemaker / defibrillator placement], 2) primary reason for admission is concern for ACS, or 3) discharge diagnosis related to chest pain, MI, ACS, heart failure, or other cardiac disease.

Statistical Analysis

Sample size was determined based on the available number of participants (n=334). The three separate databases were combined into a single dataset. Our first objective was to examine if testing disparities were observed between racial groups. Chi-square and Fisher exact tests were used to assess differences between AA and White participants in demographics, test utilization, and outcomes, separately by care pathway. Next, separate logistic regression models for usual care and ACES groups were used to assess the

association of race after adjusting for possible confounders. Covariates considered included age at enrollment, gender, insurance status, smoking status, hypertension, diabetes, hyperlipidemia, prior MI, prior coronary revascularization, and TIMI score. A backwards stepping algorithm was used to remove non-significant covariates from the model; race was forced to remain in all models.

Results

From 2008 to 2011, 334 participants were enrolled in the three clinical trials, and 5 were excluded from this analysis based on reported race other than AA or White. The median age of the participants was 55 years (Q1 = 47 years, Q3 = 63 years) (Table 1), with 61/329 (19%) of participants being at least 65 years old. AA participants represented 111/329 (34%) of the total study population, 80/220 (36%) of the ACES group and 31/109 (28%) of the usual care group. Insurance was private (non-Governmental) in 42/111 (38%) of AA and in 110/218 (50%) of White participants. AA patients had a greater prevalence of hypertension ($p < .001$), diabetes ($p = .020$), and prior heart failure ($p = .025$), and they tended to have higher TIMI scores¹¹ ($p = .003$).

Objective testing during the index visit is summarized in Table 2. In the usual care group, objective testing by at least one modality was performed in 22/31 (71%) AA patients and 69/78 (88%) White patients ($p = .027$). There was less use of cardiac catheterization among AA vs White patients (3% vs 24%, $p = .012$). Nineteen patients had cardiac catheterization without noninvasive testing at any time during the index visit (18 White patients, 1 AA patient). There was little difference in the use of stress CMR, stress echo, or coronary computed tomographic angiography between AA and White patients [13% vs 10% ($p = .738$), 55% vs 60% ($p = .604$), and 3% vs 1% ($p = .490$), respectively]. Unadjusted, the odds of having an objective test done were 3.14 times higher for Whites compared to AAs (95% CI: 1.11, 8.88). After adjustment for age, gender, insurance status, smoking status, hypertension, diabetes, hyperlipidemia, prior MI, prior coronary revascularization, and TIMI score, the odds of having an objective test done were 3.03 times higher for Whites compared to AAs (95% CI: 0.92, 10.0). However, none of these covariates were significantly associated with objective testing and all fell out of the model using a backward stepping algorithm. Unadjusted, the odds of having a cardiac catheterization done were 9.66 times higher for Whites compared to AAs (95% CI: 1.23, 75.6). After adjustment for age, gender, insurance status, smoking status, hypertension, diabetes, hyperlipidemia, prior MI, prior coronary revascularization, and TIMI score, the odds of having a cardiac catheterization done were 12.5 times higher for Whites compared to AAs (95% CI: 1.36, 116). Only hypertension and prior coronary revascularization were significantly associated with objective testing, and the odds of having a cardiac catheterization done were 11.8 times higher for Whites compared to AA after adjusting for those two covariates (95% CI: 1.43, 97.6).

In the ACES group, 78/80 (98%) AA participants and 138/140 (99%) White participants had objective testing ($p = .623$, OR=1.77, 95% CI: 0.24, 12.8). No adjusted models were run due to the small number of patients without testing. Invasive angiography was performed in 4/80 (5%) AA ACES, and 13/140 (9%) White ACES participants ($p = .303$). Unadjusted, the odds of having a cardiac catheterization done were 1.95 times higher for Whites compared

to AA (95% CI: 0.61, 6.18). After adjustment for age, gender, insurance status, smoking status, hypertension, diabetes, hyperlipidemia, prior MI, prior coronary revascularization, and TIMI score, the odds of having a cardiac catheterization done were 1.93 times higher for Whites compared to AAs (95% CI: 0.54, 6.88). Only gender was significantly associated with objective testing, and the odds of having a cardiac catheterization done were 1.88 times higher for Whites compared to AAs after adjusting for gender (95% CI: 0.59, 6.04).

No participants died during the 90-day clinical outcome assessment period. Myocardial infarction occurred in 1/31 (3%) AA vs 8/78 (10%) White usual care participants ($p = .441$), and in 2/80 (3%) AA ACES and 4/140 (3%) White ACES participants ($p = 1.0$). In the White usual care group, there were three peri-procedural myocardial infarction events (determined by adjudicators) and one other event that occurred after invasive angiography in a patient who went on to bypass surgery.

Revascularization across both groups was more common in Whites [1/111 (1%) vs 18/218 (8%), $p=0.009$]. In the usual care group, revascularization was performed in 1/31 (3%) AA and 12/78 (15%) White participants ($p = .104$); no AA ACES (0/80) and 6/140 (4%) White ACES participants received revascularization ($p = .089$).

At 1 year, cardiac hospital readmissions occurred in 58/329 (18%) of the entire study group. By group and race, cardiac related hospital readmissions occurred in 12/31 (39%) AA usual care vs 19/78 (24%) White usual care participants ($p = .134$), and in 13/80 (16%) AA ACES and 14/140 (10%) White ACES participants ($p = .169$). Cardiac related hospital readmissions were more frequent among patients with ACS at 90 days (11/25, 44%) compared to those without ACS at 90 days (47/302, 16%), $p=0.001$.

Discussion

The results of our analysis suggest a protocol-driven care pathway with an expectation for stress imaging can eliminate the racial disparity in index visit cardiac testing observed in customary care practices. In our control group, White participants more frequently received cardiac testing, and more commonly underwent invasive angiography versus AA participants. These variations in care are consistent with the findings of others^{3,12}, and were not observed in the ACES group. Further, White participants more commonly received revascularization procedures, also consistent with findings of others.¹³ Paradoxically, we found those procedures to be associated with an increase in post-procedural troponin elevations (Type IV and V myocardial infarction). What is important here is that the ACES improved safety by reducing the number of caths overall and thereby reducing the number of MI's from a procedure that did not contribute to a reduction in deaths. One can work out the numbers but it is possible that the lesser exposure to further testing in the AA group was actually a benefit---reduction is exposure to demonstrable (real) hazard

In our prior work, we demonstrated that the protocol-driven ACES pathway reduced index visit cost, cost at 1 year, and invasive procedures when considering all races together.^{10,14,15} These earlier findings, combined with our new analysis, illustrate that eliminating the racial disparity in cardiovascular testing does not necessarily mean accumulating incremental

healthcare expenditures. Rather, the ACES approach appears to achieve high rates of index visit noninvasive cardiac testing which in turn reprioritizes the selection of patients for invasive angiography. The absence of ACS events between index visit discharge and 90 days suggest this reallocation of testing resources did not harm patient outcomes.

Recent investigations have demonstrated that many low risk patients do not require stress imaging, and can be effectively triaged using clinical decision aids and serum troponin measurements.^{16,17} However, no such decision aids exist to identify intermediate to high risk patients unlikely to benefit from objective cardiac testing, and guidelines recommend testing in all of these patients. Therefore, the ACES care pathway involves the ordering of stress imaging. Mechanistically, this effectively eliminates two clinical decisions; 1) whether testing should be obtained and 2) if testing should be obtained, should it be invasive or non-invasive testing? These decisions remain unresolved in usual hospital care until the receiving team conducts the initial evaluation. Our analysis suggests these decision nodes are in the causal pathway for index visit testing disparities.

Our findings suggesting an ACES pathway as a solution to index visit racial disparities in cardiovascular testing are tempered with limitations. Our analysis was conducted in a single institution and involved the collation of data from prior randomized clinical trials. The consistency of our findings with those of others suggest our baseline disparities observed in the usual care group are representative, and our intervention was randomized without respect to race which should reduce the effect of these limitations. Further, our racial groups were limited to AA and White participants, and we cannot extrapolate to other racial or ethnic groups. Finally, we observed White participants to experience serum troponin elevations more commonly, particularly after revascularization, and these events were adjudicated as myocardial infarctions by a consensus of investigators. The impact of these events on clinical outcomes is not certain.

In conclusion, this analysis demonstrates the protocol-driven chest pain care pathway ACES decreases overall number of cardiac catheterizations and eliminates the racial disparity observed in the acquisition of index-visit cardiovascular testing observed among AA and White patients that present to emergency departments with chest pain at intermediate risk for ACS. Further research should be designed to prospectively test the effect of ACES on racial disparities.

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Table 1.
Demographics

	<u>Usual Care</u>			<u>ACES</u>		
	<u>AA (n=31)</u> # (%)	<u>White (n=78)</u> # (%)	<u>p-value</u>	<u>AA (n= 80)</u> # (%)	<u>White (n= 140)</u> # (%)	<u>p-value</u>
Age (years) – median (Q1, Q3)	58 (51, 64)	57.5 (47, 66)	.9785	54 (48, 60)	53.5 (45, 62)	.5675
Age 65 years	6 (19)	20 (26)	.4872	10 (13)	25 (18)	.2960
Male sex	13 (42)	46 (59)	.1073	35 (44)	67 (48)	.5568
<u>Insurance</u>			.5578			.0023
Government	15 (48)	29 (37)		21 (26)	42 (30)	
Private	11 (35)	33 (42)		31 (39)	77 (55)	
Self pay	5 (16)	16 (21)		28 (35)	21 (15)	
Hypertension *	29 (94)	58 (74)	.0243	64 (80)	75 (55)	.0002
Diabetes mellitus *	14 (47)	24 (31)	.1212	28 (35)	32 (23)	.0517
Current smoking	13 (42)	25 (32)	.3286	34 (43)	48 (34)	.2255
Hyperlipidemia *	24 (77)	58 (74)	.7384	47 (59)	82 (60)	.8232
Prior Heart Failure *	3 (10)	1 (1)	.0742	5 (6)	3 (2)	.1396
Prior MI *	5 (16)	17 (22)	.5061	11 (14)	13 (9)	.2913
Prior coronary revascularization	4 (13)	20 (26)	.1477	7 (9)	10 (7)	.6676
Prior CVA *	5 (16)	3 (4)	.0420	5 (6)	6 (4)	.5078
<u>TIMI risk score at enrollment</u>			.0360			.0443
0	1 (3)	1 (1)		3 (4)	7 (5)	
1	6 (19)	12 (15)		15 (19)	32 (23)	
2	5 (16)	34 (44)		30 (38)	69 (49)	
3	16 (52)	19 (24)		28 (35)	23 (16)	
4	3 (10)	11 (14)		4 (5)	7 (5)	
5	0 (0)	1 (1)		0 (0)	2 (1)	

* Some missing data

Table 2.
Cardiac Testing and Disposition During the Index Hospital Visit

	<u>Usual Care</u>			<u>ACES</u>		
	<u>AA (n=31)</u> # (%)	<u>White (n=78)</u> # (%)	<u>p-value</u>	<u>AA (n= 80)</u> # (%)	<u>White (n= 140)</u> # (%)	<u>p-value</u>
<u>Any Objective Cardiac Testing</u>	22 (71)	69 (88)	.0265	78 (98)	138 (99)	.6230
Stress CMR	4 (13)	8 (10)	.7384	58 (73)	106 (76)	.5985
Stress echo	17 (55)	47 (60)	.6043	21 (26)	31 (22)	.4903
Stress nuclear imaging	0 (0)	0 (0)	---	0 (0)	1 (1)	1.0
Cardiac catheterization	1 (3)	19 (24)	.0117	4 (5)	13 (9)	.3034
Coronary computed tomographic angiography	1 (3)	1 (1)	.4898	0 (0)	3 (2)	.5553
Index visit length of stay (hours)*	30.4 (26.8, 43.7)	29.3 (25.8, 48.7)	.8931	24.3 (18.2, 28.1)	24.0 (17.3, 28.2)	.8498

Table 3.
Clinical outcomes

	<u>Usual Care</u>			<u>ACES</u>		
	<u>AA (n=31)</u> # (%)	<u>White (n=78)</u> # (%)	<u>p-value</u>	<u>AA (n= 80)</u> # (%)	<u>White (n= 140)</u> # (%)	<u>p-value</u>
Index visit through 90 days						
Death	0	0	---	0	0	---
Myocardial infarction	1 (3)	8 (10)	.4411	2 (3)	4 (3)	1.0
Revascularization	1 (3)	12 (15)	.1044	0 (0)	6 (4)	.0888
Composite	2 (6)	15 (19)	.1434	2 (3)	6 (4)	.7137
1 year						
Cardiac-related hospital readmission (through 1 year)	12 (39)	19 (24)	.1341	13 (16)	14 (10)	.1690

Abbreviations list:

AA = African American

ACC = American College of Cardiology

ACES = Accelerated chest pain evaluation with stress imaging

ACS = Acute coronary syndrome

AHA = American Heart Association

ED = Emergency department

CMR = Cardiac magnetic resonance

MACE = Major adverse cardiac events

MI = Myocardial infarction

TIMI = Thrombolysis in myocardial infarction