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BSN-HONORS THESIS

Prevalence of secondary ST-T wave ECG abnormalities confounding the diagnosis of acute myocardial ischemia in patients presenting to the emergency department with a chief complaint of chest pain

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Class of 2017

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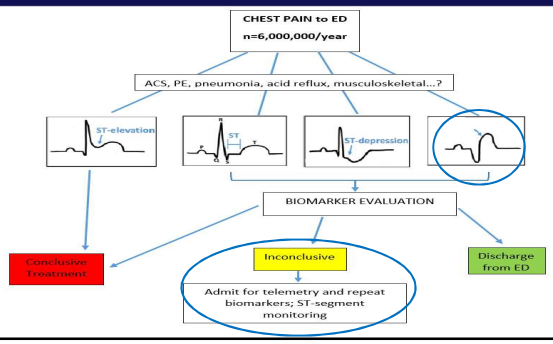
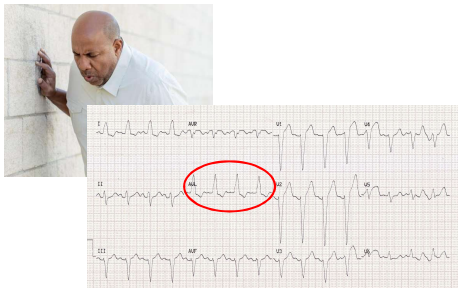


Example

- John, 63
- Overweight
- 30 year smoker
- Hypertension



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Secondary Repolarization Changes

"Abnormalities in the ST segment and T wave that occur as a direct result of changes in the sequence and/or duration of ventricular depolarization, manifested electrocardiographically as changes in QRS shape and/or duration"

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Background

AHA Scientific Statement

Practice Standards for Electrocardiographic Monitoring in Hospital Settings

An American Heart Association Scientific Statement From the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young

Endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses

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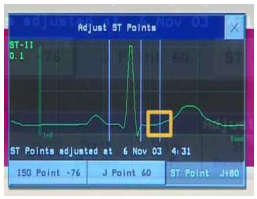
Guidelines

"Class III: Cardiac monitoring is not indicated because a patient's risk of serious even is so low that monitoring has no therapeutic benefit"

Class III for ST-segment monitoring include: LBBB, frequent intermittent RBBB, ventricular pacing, coarse A fib, intermittent ventricular rhythm



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ST-segment Monitoring Confounders

- Secondary ST changes induced by non-ischemic causes
  - LBBB
  - LVH with strain
  - Pacing
  - Ventricular rhythm
- Causes that interfere with proper ST measurement
  - Coarse Afib/flutter
  - RBBB

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Knowledge Gap

Clinical utility of telemetry monitoring chest pain patients with non-ischemic ST-segment changes

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Purpose

Define the frequency of chest-pain patients with ST confounders and evaluate the clinical significance of these ECG abnormalities

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Specific Aim 1: Determine the magnitude of the problem among patients seen at the ED for chest pain:

Aim 1(a). What is the distribution of ischemic vs. non-ischemic causes of chest pain?

Aim 1(b). What percentage of patients admitted to a telemetry unit to rule out ACS had a final diagnosis of non-ischemic chest pain?

Aim 1(c). What is the prevalence of ECG abnormalities that lead to secondary non-ischemic ST changes or interfere with proper ST measurement?

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Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

Aim 2(a). Is there a relationship between the presence of non-ischemic ST confounders and demographic and clinical characteristics of patients?

Aim 2(b). Is there a relationship between the presence of non-ischemic ST confounders and chest pain etiology?

Aim 2(c). Is there a relationship between the presence of non-ischemic ST confounders and course of hospitalization?

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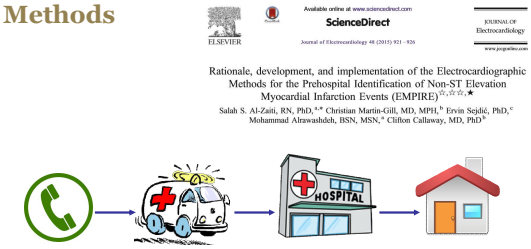
Methods



9-1-1 → ECG → Labs & Clinical Data → Discharge

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Demographic and Clinical Data

- Age, sex, race
- CAD risk factors
  - Smoking history, obesity class
  - HTN, DM, HLD, CAD
  - Past cardiac history
- Clinical presentation
  - Chest pain equivalent
  - Presenting ECG and labs

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Clinical Outcomes

- Etiology
  - ACS
  - Non-ischemic cardiopulmonary
  - Non-cardiac
  - Undifferentiated
- Admission status, length of stay
  - Discharge from ED (LOS < 12 hrs)
  - Admitted overnight (12 hrs<LOS<36 hrs)
  - Admitted for treatment (LOS > 36 hrs)
- ST-segment monitoring confounders

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Secondary ST Changes Induced by Non-Ischemic Causes	Left Bundle Branch Block	QRS area >1/4 of (QRS duration × maximum R amplitude) in lead I or V6, QRS >120 ms, QRS balance negative in lead V1 and V2 (Tan, Sungar, Myers, Sandri, & Froelicher, 2009).	Y/N
	Left ventricular hypertrophy with strain	S in V1 + R in V5 > 35 mm, with ST depression and T wave inversion (Hancock et al., 2009).	Y/N
	Ventricular Pacing	Prolonged QRS complexes with discordant T waves during the presence of ventricular pacemaker spikes (Zehender et al., 1992).	Y/N
	Ventricular Rhythm	Prolonged QRS complexes due to non-sinus activity below the AV node (e.g., ventricular tachycardia or third degree heart block) (Goldberger et al., 2008).	Y/N
Causes that Interfere with Proper ST-segment Measurement	Coarse Atrial fibrillation/flutter	R-R interval variability with lack of discernible P wave and visible atrial waveforms causing artifact; fluctuating ST amplitudes from chaotic atrial activity (Tan, Sungar, Myers, Sandri, & Froelicher, 2009; Drew et al., 2004)	Y/N
	Right Bundle Branch Block	QRS duration>120 ms, QRS area in lead 1 positive, no terminal S wave in lead V1, S amplitude + ST junction <100 mV and <R amplitude in lead V1 (Tan, Sungar, Myers, Sandri, & Froelicher, 2009).	Y/N

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Data Collection and Coding

- ECG's de-identified
- 3 reviewers for ECG (blinded from outcomes)
- Reviewer for clinical outcomes based on EMR

	ECG Abnormality	Description	Coding
Ischemic Changes	ST Elevation	New ST elevation at J point in 2 contiguous leads with cut-points: ≥0.1 mV in all leads other than V2-V3; ≥0.2 mV men less than 40, ≥0.25 mV men over 40, ≥0.15 mV in women (Thygesen et al., 2012).	Y/N
	ST Depression	New horizontal or down-sloping ST depression ≥0.05 mV in two contiguous leads (Thygesen et al., 2012).	Y/N

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Statistical Analysis

- SPSS software
- Categorical and continuous variables
- Descriptive analysis
- Independent T-test or Mann-Whitney U test
- Chi-square
- $p<0.05$ significance

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Results – Baseline Characteristics

n=750	
Demographics	
Age	Mean 59±17 years (19-100)
Sex (Male)	433 (58%)
Race (Black)	301 (40%)
CAD Risk Factors	
Obesity class	
Normal	303(41%)
Overweight	160 (21%)
Obese	285 (38%)
Smoking History	
Never	307 (41%)
Quit	273 (37%)
Current	163 (22%)
Hypertension	547 (73%)
Diabetes Mellitus	210 (28%)
Hyperlipidemia	262 (35%)
Coronary Artery Disease	256 (34%)
Angina	146 (20%)
History of MI	231 (31%)
History of CHF	135 (18%)
Past PCI	172 (23%)
Past CABG	70 (9%)

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Results – Baseline Characteristics

Clinical Presentation	
Chest Pain	645 (86%)
Shortness of Breath	215 (29%)
Positive Initial Troponin	96 (13%)
Serum Potassium Level	
Hypokalemia	113 (15%)
Normal	614 (82%)
Hyperkalemia	23 (3%)
Rhythm	
Sinus	646 (86%)
Ventricular Rhythm	8 (1%)
Atrial fibrillation/flutter	73 (10%)
Pacing	23 (3%)
Ischemic Changes	
ST-segment Elevation	55 (7%)
ST-segment Depression	153 (20%)
T Wave Inversion	223 (30%)
Course of Hospitalization	
Admitted	
Discharged from ED	193 (26%)
Admitted overnight	234 (31%)
Admitted for treatment	323 (43%)
Length of Stay (mean±SD)	2.3±3.6 days (0-51)
Final Impression	
ACS	130 (17%)
Non-ischemic cardiopulmonary	237 (32%)
Non-cardiac	69 (9%)
Undifferentiated CP	314 (42%)
PCI Done	65 (9%)
CABG Done	9 (1%)

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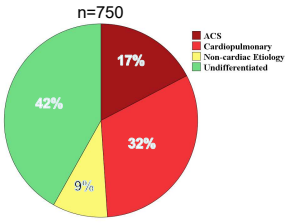
Specific Aim 1: Determine the magnitude of the problem among patients seen at the ED for chest pain:

Aim 1(a). What is the distribution of ischemic vs. non-ischemic causes of chest pain?



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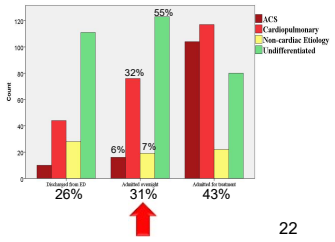
Specific Aim 1: Determine the magnitude of the problem among patients seen at the ED for chest pain:

Aim 1(b). What percentage of patients admitted to a telemetry unit to rule out ACS had a final diagnosis of non-ischemic chest pain?



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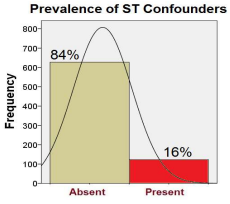
Specific Aim 1: Determine the magnitude of the problem among patients seen at the ED for chest pain:

Aim 1(c). What is the prevalence of ECG abnormalities that lead to secondary non-ischemic ST changes or interfere with proper ST measurement?

Causes that lead to Secondary Non-Ischemic ST Changes	
LBBB	22 (2.9%)
LVH with strain	27 (3.6%)
Pacing	23 (3.1%)
Ventricular Rhythm	8 (1.1%)
TOTAL	80 (10.7%)
Causes that Interfere with Proper ST Measurement	
Coarse AFIB	18 (2.4%)
Intermittent RBBB	32 (4.3%)
TOTAL	49 (6.5%)
Any ST Confounder	123 (16.4%)



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Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

Aim 2(a). Is there a relationship between the presence of non-ischemic ST confounders and demographic and clinical characteristics of patients?

Variables		Confounder Present (n=123)	Confounder Absent (n=627)	P Value
Demographics				
Age (years)	Mean 59±17	68 ± 16	57 ± 16	<0.001
Sex (Male)	433 (58%)	75 (61%)	358 (57%)	0.43
Race (Black)	301 (40%)	50 (41%)	251 (40%)	0.69
CAD Risk Factors				
Obesity class				0.37
Normal	303(41%)	55 (45%)	248 (40%)	
Overweight	160 (21%)	28 (23%)	132 (21%)	
Obese	285 (38%)	40 (32%)	245 (39%)	
Smoking History				0.41
Never	307 (41%)	56 (46%)	251 (40%)	
Quit	273 (37%)	44 (36%)	229 (37%)	
Current	163 (22%)	22 (18%)	141 (23%)	
Hypertension	547 (73%)	108 (88%)	439 (70%)	<0.001
Diabetes Mellitus	210 (28%)	49 (40%)	161 (26%)	0.001
Hyperlipidemia	262 (35%)	56 (46%)	206 (33%)	0.007
CAD	256 (34%)	71 (58%)	185 (30%)	<0.001
Angina	146 (20%)	40 (33%)	106 (17%)	<0.001
History of MI	231 (31%)	49 (40%)	182 (29%)	0.018
History of CHF	135 (18%)	44 (36%)	91 (15%)	<0.001
Past PCI	172 (23%)	43 (36%)	129 (21%)	0.002
Past CABG	70 (9%)	29 (24%)	41 (7%)	<0.001

Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

Aim 2(a). Is there a relationship between the presence of non-ischemic ST confounders and demographic and clinical characteristics of patients?

Variables		Confounder Present (n=123)	Confounder Absent (n=627)	P Value
Clinical Presentation				
Chest Pain	645 (86%)	105 (85%)	540 (86%)	0.83
Shortness of Breath	215 (29%)	42 (34%)	173 (28%)	0.15
Positive Initial Troponin	96 (13%)	21 (17%)	75 (12%)	0.122
Serum K^+ Level				0.28
Hypokalemia	113 (15%)	14 (12%)	99 (17%)	
Normal	614 (82%)	101 (84%)	451 (79%)	
Hyperkalemia	23 (3%)	5 (4%)	18 (3%)	
LOS (median [IQR])	1.0 (0.5-3.0)	**2.0 (1.0-3.0)**	1.0 (0.2-3.0)	**<0.001**
PCI Done	65 (9%)	13 (11%)	52 (8%)	0.41
CABG Done	9 (1%)	3 (2%)	6 (1%)	0.17

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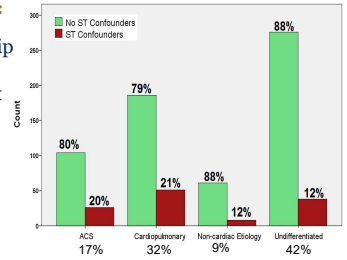
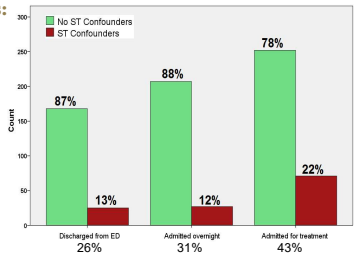
Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

Aim 2(b). Is there a relationship between the presence of non-ischemic ST changes and chest pain etiology?



Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

Aim 2(c). Is there a relationship between the presence of non-ischemic ST changes and course of hospitalization?



Specific Aim 2: Investigate the relationship between the presence of non-ischemic ST confounders and other important clinical variables:

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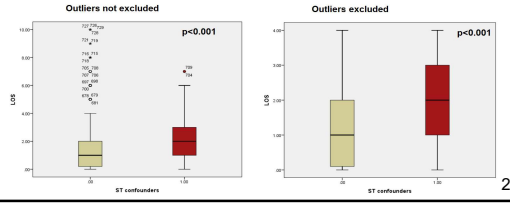

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Discussion

Overview

- 75% admitted
- 83% non-ischemic chest pain
- 1 in 6 patients had ST-segment monitoring confounders
- Older age, CAD risk factors related to ST confounders
- ACS and cardiopulmonary etiologies related to ST confounders
- 1 in 5 patients admitted had confounders, increased length of stay by 1 day

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Discussion

Limitations

- No data on false alarms in telemetry units
- Data on 30-day readmission, re-infarction, mortality not available yet

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Discussion

Conclusion

- ST-segment monitoring confounders prevalent among patients that present to the ED with chest pain
- Relationships exist between confounders and other important clinical variables

Discussion

Future Direction/Research

- Establish alternative methods for monitoring patients with confounders
- Implement more frequent vital signs, biomarkers evaluation
- Determine frequency of unnecessary treatment in ST-segment monitoring false alarms
- Enhance computerized algorithms specifically for confounders (LVH, LBBB)

Thank you!