Original article

Accuracy of exercise stress test for diagnosed coronary heart disease compared with 640-slice coronary computed tomographic angiography or invasive coronary angiography

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Abstract:

Background: *Early diagnosis ischemic heart disease with Exercise Stress Test (EST) can prevent serious complications and death.* ***Objectives:*** *To study the accuracy of morphological changed diagnosis during EST compared with coronary Computed Tomographic Angiography (CCTA) or invasive coronary angiography for coronary artery disease detection.* ***Methods:*** *Cross sectional descriptive study was conducted. EST data during March 2012 to July 2015 were enrolled in this study. EST results were compared with the further Coronary CTA or CAG results.* ***Results:*** *Among 2,450 patients who had performed EST, 458 patients (19%) had positive EST results. Mean age was 61 years and 76% were male. A total 136 patients (29%) had received Coronary CTA and 212 patients (46%) had received CAG. Coronary CTA or CAG revealed significantly coronary arteries stenosis, which was more than 70% luminal stenosis, in 210 patients (60%). There were 81 patients (23%) had single vessel disease, 67 patients (19%) had double vessel disease and 62 patients (18%) had triple vessel disease. Normal coronary arteries were found around 10% among positive EST patients. Sensitivity, specificity, positive predictive value and negative predictive value of positive EST to detect coronary heart disease were 62%, 72%, 75% and 58%, respectively.* ***Conclusions:*** *EST is a good screening tool for early detection among patients who had symptom suspected ischemic heart disease.*

Keywords: ● *Exercise stress test* ● *Coronary CTA* ● *Coronary angiography*

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นิพนธ์ต้นฉบับ

ความแม่นยำในการวินิจฉัยภาวะหลอดเลือดหัวใจตีบจากการเดินสายพานเปรียบเทียบกับเอกซเรย์คอมพิวเตอร์หลอดเลือดหัวใจหรือการสวนหัวใจ

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[1]ภาควิชาอายุรศาสตร์ [2]แผนกโรคหัวใจและหลอดเลือด กองอายุรกรรม โรงพยาบาลพระมงกุฎเกล้า และวิทยาลัยแพทยศาสตร์ พระมงกุฎเกล้า

บทคัดย่อ

บทนำ *การตรวจวินิจฉัยโรคหลอดเลือดหัวใจตีบสามารถตรวจได้ด้วยการเดินสายพาน ซึ่งช่วยทำให้ผู้ป่วยได้รับการรักษาก่อนที่จะเกิดอาการรุนแรงได้* ***วัตถุประสงค์*** *เพื่อทดสอบความแม่นยำในการใช้ลักษณะการเปลี่ยนแปลงของคลื่นไฟฟ้าหัวใจในการวินิจฉัยภาวะกล้ามเนื้อหัวใจขาดเลือดจากหลอดเลือดหัวใจตีบด้วยการเดินสายพานเปรียบเทียบกับการตรวจเอกซเรย์คอมพิวเตอร์หลอดเลือดหัวใจ หรือการสวนหัวใจ* ***วิธีการศึกษา*** *เป็นการศึกษาเชิงพรรณนา ในผู้ที่มารับการตรวจด้วยการเดินสายพานในช่วงเดือนมีนาคม 2555 ถึงเดือนกรกฎาคม 2558 ณ แผนกโรคหัวใจและหลอดเลือด โรงพยาบาลพระมงกุฎเกล้า ทั้งสิ้น 2,450 ราย* ***ผลการศึกษา*** *พบการเดินสายพานผิดปกติ 458 ราย ในจำนวนนี้ได้รับการตรวจด้วยเอกซเรย์คอมพิวเตอร์หลอดเลือดหัวใจ หรือ การสวนหัวใจ 348 ราย พบมีการตีบของหลอดเลือดหัวใจมากกว่าร้อยละ 70 เป็นจำนวน 210 ราย คิดเป็นร้อยละ 60 และร้อยละ 10 ไม่พบความผิดปกติใดของหลอดเลือดหัวใจ ค่าความไว และค่าความจำเพาะ ของการวินิจฉัยภาวะกล้ามเนื้อหัวใจขาดเลือดโดยการเดินสายพานคิดเป็นร้อยละ 62 และร้อยละ 72 ตามลำดับ โดยมีค่า Positive Predictive Value ร้อยละ 75 และค่า Negative Predictive Value ร้อยละ 58* ***สรุป*** *การเดินสายพานสามารถนำมาใช้เป็นการตรวจเบื้องต้นได้ดีในผู้ป่วยที่สงสัยหลอดเลือดหัวใจตีบ*

คำสำคัญ: ● *เดินสายพาน* ● *เอกซเรย์คอมพิวเตอร์หลอดเลือดหัวใจ* ● *การสวนหัวใจ*

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Introduction

Coronary artery disease or myocardial ischemia is the leading cause of death and high burden of health care among Thai. Myocardial ischemia is caused by the narrowing or blockage of the coronary arteries which could result in life-threatening symptoms. Exercise Stress Test (EST) is a conventionally diagnostic tool to detect coronary artery disease with pooled sensitivity 68% and specificity 77%.[1] The sensitivity of EST compared with invasive coronary angiography which is the gold standard for coronary artery narrowing diagnosis was 79.36%.[2] Even the EST is a convenient and inexpensive diagnostic method, it can lead to false positive results in patients with preexisting abnormal electrocardiography such as left ventricular hypertrophy or right bundle branch block. Female gender and upslope ST segment depression during exercise phase were associated with false positive EST results.[3]

The emerging non-invasive method for coronary artery disease detection is Coronary Computed Tomographic Angiography (CCTA). Meta-analysis using aggregated data from studies that excluded patients with non-diagnostic CTA examinations reported sensitivity 97.2% to 100% and specificity 87.4% to 89%.[4] 640-Slice CT scanner is the longest coverage scanner that can reduce the chance of non-diagnostic CTA examination.

The precision of EST compares with the modern non-invasive method for CAD detection is lacked so this study aims to test the accuracy of morphological changed criteria for positive EST compared with significant coronary artery stenosis detection from 640-Slice CCTA or invasive coronary angiography (CAG).

Methods

Study population

The observational, cross-sectional study, was conducted and enrolled EST data between March 2012 through July 2015 at Phramongkutklao Hospital. The inclusion criteria were EST data from patients aged 18-80 years and underwent EST prior to 640-slide CCTA or invasive coronary angiography. The uninterpretable results of coronary imaging were excluded from this study. Baseline characteristics and medical history including age, gender, Body Mass Index and underlying disease were collected. This protocol was approved by the Institutional Review Board Royal Thai Army Medical Committee.

Exercise Stress Test

Exercise Stress Tests were done with standard BRUCE protocol and interpreted by cardiology fellows and cardiologists. Positive-type Exercise Stress Test result included systolic blood pressure < 90 mmHg or diastolic blood pressure < 60 mmHg or decreasing of systolic blood pressure more than 30 mmHg from baseline blood pressure, ST segment elevation, horizontal ST segment depression, upsloping ST segment depression and down sloping ST segment depression.

Coronary Computed Tomographic Angiography (CCTA) assessment

All CCTA were performed with ECG-gated by 640-slice MDCT scanner (Toshiba, Aquilion One vision edition). The standard protocol for coronary artery scanning was used with 0.25 mm slice thickness reconstruction. Cardiologist who specialized in cardiac imaging interpreted CCTA by visual assessment technique. Significant coronary artery stenosis was defined as more than 70% luminal stenosis. Collected CCTA data were Agatston's coronary calcium score, percent of luminal stenosis in each coronary arteries and number of significant coronary artery stenosis as single vessel, double vessel and triple vessel disease.

Invasive Coronary Angiography (CAG)

Invasive coronary angiography was performed by Philips, Allura Xper FD10 model with standard protocol.

Interventional cardiologists interpreted by visual assessment technique. Significant coronary artery stenosis was defined as more than 70% luminal stenosis. Collected invasive coronary angiographic data were percent of luminal stenosis in each coronary arteries and number of significant coronary artery stenosis as single vessel, double vessel and triple vessel disease.

Endpoints

Primary endpoint of this study was to evaluate the accuracy of positive EST result compared with 640-Slice CCTA or invasive coronary angiography for significant coronary artery stenosis detection. The secondary endpoint was to evaluate the correlation between the positive-type exercise stress test and significant coronary artery stenosis in each coronary artery.

Statistical analysis

Continuous variables were expressed as mean with standard deviation and percent. Correlation between morphological changed criteria for positive EST and significant coronary artery stenosis detection from CCTA or invasive coronary angiography was calculated by Chi-square test with significant *p-value* less than 0.05. Sensitivity and Specificity were calculated.

Results

Between March 2012 to July 2015, total 2,450 patients underwent exercise stress tests at Phramongkutklao Hospital and 458 patients were positive exercise stress test results. Among positive exercise stress test result, there were 348 patients were male and 110 patients were female. The average age was 61 years. Heart rate and blood pressure appropriate response during exercise stress test was 96% and 95%, respectively. The mean metabolic equivalent at peak exercise was 9.99 METs. Baseline characteristics data as shown in Table 1.

Among patients who had positive exercise stress test, one patient had positive at low workload, 11 patients met criteria for positive exercise stress test as blood pressure drop, 6 patients had ST segment elevation, 273 patients had horizontal ST segment depression, 104 patients had upsloping ST segment depression and 63 patients had downsloping ST segment depression which were 2.4%, 1.3%, 59.6%, 22.7% and 13.8%, respectively. Total 348 patients of positive exercise stress test underwent invasive coronary angiography or CCTA, 212 patients were sent for invasive coronary angiography and 136 patients underwent CCTA, as shown in Table 1. Results of invasive coronary angiogram and Coronary Computed Tomographic Angiography as shown in Table 2.

Considering 348 patients who underwent invasive coronary angiography or CCTA, 210 patients had significant coronary artery stenosis while 103 patients had non-significant coronary artery stenosis and 35 patients had normal coronary artery.

Among 210 patients who had significant coronary artery stenosis, 81 patients had single vessel disease, 67 patients had double vessel disease and 62 patients had triple vessel disease. Segment stenosis from invasive coronary angiography or CCTA showed that 3.5% had significant left main coronary artery stenosis, 47.9% had significant left anterior descending artery stenosis, 34% had significant left circumflex artery stenosis, 29.6% had significant right coronary artery stenosis and 10% had significant posterior descending artery stenosis.

The correlation between positive-type exercise stress test and significant coronary artery stenosis per vessel was analyzed as shown in Table 3. The test result did not demonstrate the statistically significant correlation. This study also analyzed the accuracy of exercise stress test as a diagnostic method for significant coronary artery stenosis detection compared with invasive coronary angiography or CCTA, the result showed sensitivity 62%, specificity 72%, positive predictive value 75% and negative predictive value 58%.

Table 1 Baseline charcteristics of patients who had positive exercise stress test

Baseline characteristics		Number	Percent	Means	SD
Gender	Male	348	75.98		
	Female	110	24.02		
Age				61	
HR response	Appropriate	439	95.85		
	Inappropriate	19	4.15		
BP response	Appropriate	434	94.76		
	Inappropriate	24	5.24		
Total exercise time (mins)				7.86	2.58
Pulse (bpm)				87.72	13.77
METs				9.99	4.43
Symptoms	None	374	81.66		
	Chest pain	15	3.28		
	Syncope	5	1.09		
	Dyspnea	64	13.97		
Arrhythmia	AF	4	0.87		
	AV block	1	0.22		
	Junctional	1	0.22		
	Normal sinus	404	88.2		
	PAC	3	0.65		
	PVC	36	7.86		
	RBBB	3	0.66		
	RVOT VT	1	0.22		
	SVT	2	0.44		
	VT	3	0.66		
Positive-type EST	BP drop	11	2.40		
	ST Elevation	6	1.31		
	Horizontal ST depression	273	59.61		
	Upsloping ST depression	104	22.71		
	Downsloping ST depression	63	13.76		
Investigation	Medication	110	24.01		
	CAG	212	46.29		
	CCTA	136	29.69		

Table 2 Results of invasive coronary angiography and Coronary Computed Tomographic Angiography (CCTA)

Coronary arteries		Number	Percent
Left main stenosis	Free of stenosis	255	81.99
	Minimal (1-25%)	15	4.82
	Mild (25-50%)	23	7.40
	Moderate (50-70%)	7	2.25
	Severe (>70%)	11	3.54
	Total (100%)	0	0.00
LAD stenosis	Free of stenosis	78	25.08
	Minimal (1-25%)	22	7.07
	Mild (25-50%)	39	12.54
	Moderate (50-70%)	23	7.40
	Severe (>70%)	138	44.37
	Total (100%)	11	3.54
LCX stenosis	Free of stenosis	121	38.91
	Minimal (1-25%)	30	9.65
	Mild (25-50%)	28	9.00
	Moderate (50-70%)	26	8.36
	Severe (>70%)	94	30.23
	Total (100%)	12	3.86
RCA stenosis	Free of stenosis	129	41.48
	Minimal (1-25%)	22	7.07
	Mild (25-50%)	48	15.43
	Moderate (50-70%)	20	6.43
	Severe (>70%)	68	21.86
	Total (100%)	24	7.72
PDA stenosis	Free of stenosis	266	85.53
	Minimal (1-25%)	10	3.22
	Mild (25-50%)	3	0.96
	Moderate (50-70%)	1	0.32
	Severe (>70%)	31	9.97
	Total (100%)	0	0.00

Table 3 Correlation between positive-type exercise stress test and significant coronary artery stenosis per vessel

Type		BP drop		STElevation		Horizontal		Upsloping		Downsloping		*p-value*
Vessel	Stenosis	n	%	n	%	n	%	n	%	n	%	
LM	>70%	1	*12.5*	0	*0.0*	7	*3.7*	2	*2.9*	1	*2.3*	0.692
	<70%	7	*87.5*	2	*100.0*	182	*96.3*	67	*97.1*	42	*97.7*	
LAD	>70%	4	*50.0*	1	*50.0*	96	*50.8*	30	*43.5*	18	*41.9*	0.769
	<70%	4	*50.0*	1	*50.0*	93	*49.2*	39	*56.5*	25	*58.1*	
LCX	>70%	3	*37.5*	1	*50.0*	67	*35.4*	23	*33.3*	12	*27.9*	0.883
	<70%	5	*62.5*	1	*50.0*	122	*64.6*	46	*66.7*	31	*72.1*	
RCA	>70%	1	*12.5*	0	*0.0*	55	*29.1*	20	*29.0*	16	*37.2*	0.526
	<70%	7	*87.5*	2	*100.0*	134	*70.9*	49	*71.0*	27	*62.8*	
PDA	>70%	0	*0.0*	0	*0.0*	13	*6.9*	13	*18.8*	5	*11.6*	0.054
	<70%	8	*100.0*	2	*100.0*	176	*93.1*	56	*81.2*	38	*88.4*	

Discussion

Exercise stress test is a convenient, non-invasive and inexpensive method for detection of significant coronary artery stenosis which caused myocardial ischemia during exertion. According to previous studies, the accuracy of the exercise treadmill test for detecting obstructive coronary arteries compared with invasive coronary angiography which is the gold standard for coronary artery disease diagnosis resulted in 65-70% sensitivity and 75-80% specificity.[1,5] Coronary CTA is an emerging non-invasive technique that use instead of invasive coronary angiography in low to intermediate risk chest pain patients. The mostly used 64-slice CCTA showed high sensitivity and specificity to detect obstructive coronary artery disease when compared with invasive coronary angiography[6-8], but the data from 640-slice CCTA was limit.

According to latest guideline recommendation, non-invasive functional imaging or CCTA is recommended as the initial test to diagnose CAD in patients presenting with chest pain.[9] CCTA is recommended in patients with low clinical likelihood because of the extremely high negative predictive value of the test while imaging stress testing is preferred in patients with high clinical likelihood. The role of EST is limited as the guideline mentions that EST may be considered as an alternative test to rule-in and rule-out CAD when non-invasive imaging is not available.[9]

Our institute is the first use 640-slice CCTA in the country and our study showed sensitivity 62% and specificity 77% of exercise stress test to detect significant coronary artery stenosis confirmed by 640-slice CCTA or invasive coronary angiography, these results were not difference from the previous data. The sensitivity and specificity of EST from our study can be implied that EST might be the good screening test for obstructive CAD detection in suspected patients when concern about the expense and availability of the test in our country. Nevertheless, our data did not study about the cost effectiveness of the EST.

Our study did not show the correlation of positive-type exercise stress test and significant coronary artery stenosis detected from 640-slice CCTA or invasive coronary angiography

The main limitation of this study was data from negative exercise stress test patients were not included

due to these patients were not transferred for CCTA or invasive coronary angiography. Including these patients with negative exercise stress test may generate more precise data. However, we used the most accurate and affordable data to conduct the study.

In conclusion, this study found that the sensitivity of exercise stress test as a simple diagnostic method for significantly obstructive coronary artery disease detection was close to previous studies.

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