Coll. Antropol. **32** (2008) 2: 375–380
Original scientific paper

Duke Treadmill Score in Prioritizing Patients for Coronary Angiography: Retrospective Study of a Croatian Regional Hospital

Krešimir Gabaldo[1], Irzal Hadžibegović[1], Đeiti Prvulović[1], Božo Vujeva[1], Pejo Samardžić[1] and Davorin Đanić[2]

[1] Cardiology Division, Internal Medicine Department, General Hospital »Dr. Josip Benčević«, Slavonski Brod, Croatia
[2] Scientific Unit, General Hospital »Dr. Josip Benčević«, Slavonski Brod, Croatia

ABSTRACT

Aim of the study was to determine the potential of Duke Treadmill Score (DTS) in prioritizing patients for coronary angiography in a transitional country clinical setting. We analyzed 114 patients with suspected stable coronary artery disease who underwent exercise treadmill testing, and coronary angiography in Slavonski Brod General Hospital. DTS was calculated from treadmill test as: exercise time – (5 × ST deviation in mm) – (4 × exercise angina). Regarding the score, patients were grouped into three groups of risk for coronary artery disease: low risk, medium risk, and high risk patients. All patients underwent coronary angiography, and were grouped in accordance to the severity of the coronary artery disease into three groups: insignificant, significant, or severe coronary artery disease. All patients scored as high risk DTS had significant or severe coronary artery disease. Medium and low risk DTS patients had insignificant coronary artery disease in 50%, and 90% of cases, respectively. Medium risk patients with significant or severe coronary artery disease were significantly older, and had more frequent history of typical chest pain with higher number of episodes per week ($P<0.05$), whereas there were no differences regarding gender or presence of risk factors. There were no significant differences among medium risk patients regarding the severity of coronary artery disease in exercise time or ST deviation. However, the presence of limiting exercise angina in medium risk patients was significantly more related with significant and severe coronary artery disease ($P<0.05$). High risk DTS result showed great potential in stratifying patients for immediate coronary angiography. This scoring system may be used in prioritizing patients for coronary angiography in a transitional clinical setting.

Key words: *coronary artery disease, exercise test, treadmill test score, coronary angiography*

Introduction

Predicting coronary artery disease in growing number of patients with chest pain or at risk for coronary artery disease using economical non-invasive techniques represents a challenge to the transition countries' clinicians in this cost conscious era. The exercise treadmill test remains a useful tool in diagnosing coronary artery disease[1], and the maximization of the test diagnostic value with the addition of clinical information is encouraged[2]. Several treadmill scores that incorporate clinical and test variables were proposed as useful tools in managing patents with suspected coronary artery disease[3].

The DTS, traditionally a prognostic score[4], was also tested as a diagnostic score, and shown to predict coronary artery disease better than the ST response alone[5]. Other studies showed that DTS remained useful for diagnosing coronary artery disease and stratifying for the likelihood of coronary artery disease, although it was less accurate than other treadmill scores[6]. However, it presented very high specificity for the detection of three-vessel disease, two-vessel disease including proximal left anterior descending artery, or left main disease[7]. Although the American College of Cardiology/American Heart Association guidelines on exercise testing suggested using complicated computer assisted statistical techniques to enhance the interpretation of the treadmill test[8], transition countries' clinicians are often constrained to the

Received for publication July 11, 2006

simplified scores because of the low cost, lesser time-consuming process. Several simple treadmill scores designed for diagnosing coronary artery disease have been recently proposed for everyday practice[9], but there are still insufficient data from prospective studies on their usefulness. Nevertheless, DTS can be easily applied without a calculator, and had been already tested successfully as a reliable prognostic tool in patients with suspected coronary artery disease.

An objective numerical scoring system that would help prioritizing patients and secure fast procedure for patients in need of coronary angiography has not been proposed in transitional country's cardiology centers. We conducted this retrospective study to determine the ability of DTS to prioritize patients for coronary angiography.

Patients and Methods

Patients

In all, 114 patients with suspected stable coronary artery disease, referred to outpatient clinic of the Internal Medicine Department of Slavonski Brod General Hospital for treadmill testing between December 2003 and December 2004, were included in the study. Patients with previous history of ST elevation or non-ST elevation myocardial infarction, revascularization procedures, paced rhythms and pre-excitation syndromes, or left bundle-branch block, were not included.

All 114 patients underwent coronary angiography within 4 months of the exercise treadmill test. A complete clinical history was taken at the ward, prior to coronary angiography. All clinical data were collected retrospectively, by analyzing patients' history forms (Table 1).

Exercise treadmill testing

All patients underwent treadmill testing using Bruce treadmill protocol[10]. Most patients reached maximal exercise at more than 6 min. The ST response considered was the most horizontal or downsloping ST-segment depression in any lead except aVR, during exercise or recovery. An abnormal response was defined as ≥1 mm of horizontal or downsloping ST segment depression. Patients were instructed to signalize occurrence and severity of chest pain during the exercise test.

Duke treadmill score

The DTS was calculated as DTS = exercise time – (5 × ST deviation in mm) – (4 × exercise angina, with 0 = none, 1 = nonlimiting angina, and 2 = limiting angina). Occurrence of chest pain during the test was noted as nonlimiting angina, while the chest pain that caused the ending of the test was considered as limiting angina. According to the DTS, patients were stratified into three groups of likelihood for coronary artery disease: low risk (DTS ≥ 5), medium risk (DTS between +4 and –10), and high risk (DTS ≤ –11)[4].

TABLE 1
CLINICAL CHARACTERISTICS OF THE STUDY POPULATION DEFINED BY DUKE TREADMILL SCORE

Clinical characteristics	No. (%) of patients with risk*			
	Llow (n=40)	Medium (n=62)	High (n=12)	Total (n=114)
Gender:				
male	16 (40)	28 (45.2)	6 (50)	50 (43.9)
Age (X±SD)	57.6 ± 8	59.6 ± 8.3	64.2 ± 7.7***	59.5 ± 8.3
Risk factors:				
BMI >32	3 (7.5)	5 (8.1)	2 (16.7)	10 (8.8)
family history of coronary artery disease	16 (40)	20 (32.3)	5 (41.7)	41 (36)
current smoker	7 (17.5)	12 (19.4)	3 (13.6)	22 (19.3)
diabetes	5 (12.5)	16 (25.8)	2 (16.7)	23 (20.2)
hypertension	29 (72.5)	53 (85.5)	10 (83.3)	92 (80.7)
hypercholesterolemia	22 (55)	30 (48.4)	10 (83.3)**	62 (54.4)
Symptoms:				
typical angina	11 (27.5)	31 (50)	10 (83.3)**	52 (45.6)
atypical angina	26 (65)**	19 (30.6)	0 (0)	45 (39.5)
non-anginal symptoms	3 (7.5)	12 (19.4)	2 (16.7)	17 (14.9)
episodes per week (X±SD)	2.1±1.9	2.2±1.9	3.9±2.5	2.37±2
months with symptoms (X±SD)	12±15.4	9.65±14.2	11.1±9.9	10.63±14.2
progression	3 (7.5)	13 (21)	6 (50)**	22 (19.3)

* low risk: Duke treadmill score ≥5, medium risk: Duke treadmill score between +4 and –10, high risk: Duke treadmill score ≤ –11.
**χ^2, $p<0.05$.
***ANOVA, $p<0.05$.

Coronary angiography

Coronary angiography was used as a »state of the art« method in coronary artery disease diagnosis. Coronary artery narrowing was visually estimated and expressed as percent lumen diameter stenosis. Patients with a 70% narrowing in one or more of the following were considered to have significant coronary artery disease: left anterior descending, left circumflex, right coronary artery or their major branches, or a 50% narrowing in the left main or proximal left anterior descending artery.

Patients were classified into three groups regarding the severity of the coronary artery disease: insignificant (no stenosis or insignificant stenosis), significant coronary artery disease (significant single or double vessel stenosis), and severe coronary artery disease (multiple vessel disease, double vessel disease including proximal left anterior descending artery, left main disease). The classification was performed according to current treatment guidelines for stable coronary artery disease, where single or double vessel disease require medication or percutaneous coronary intervention, while multiple vessel or left main disease require coronary artery by-pass graft operation[11].

Statistics

Chi square test was used to determine the relationships between DTS and clinical data other than age, episodes of symptoms per week, and months with symptoms. ANOVA was used to determine the differences among groups of patients defined by DTS regarding age, episodes of symptoms per week, months with symptoms, and exercise time.

The relationship between DTS and the severity of coronary artery disease defined by coronary angiography was determined using chi square test.

Statistical analysis was performed for patients classified as medium risk for coronary artery disease (DTS between +4 and –10) using chi square test and ANOVA to determine the differences among patients stratified by coronary angiography regarding clinical data, and data derived by treadmill testing.

P value <0.05 was considered to be statistically significant.

SPSS software v. 11.0. (SPSS Inc, Chicago, Il, USA) was used for all statistical analyses.

Results

There were 40 (35.1%) patients in the low risk DTS group, whereas there were 62 (54.4%) and 12 (10.5%) patients in the medium and high risk DTS groups, respectively. Patients in the high risk group were significantly older than in other two groups, and had more cases of hypercholesterolemia (Table 1). There were no differences among groups defined by DTS regarding gender or other risk factors. Patients with typical anginal symptoms were significantly more represented in the medium and high risk groups. In addition, patients with atypical anginal symptoms had higher DTS scores, and were significantly more represented in the low risk group (Table 1). There were significantly more cases of progressive symptoms history among high score patients (Table 1).

There were no patients with normal angiogram or insignificant coronary artery disease among high risk group. Among that group, 66% of patients had severe coronary artery disease. Patients with medium risk DTS coronary artery disease were equally distributed between insignificant and significant coronary disease groups, while patients with low risk DTS were significantly more represented in the insignificant coronary disease group ($p<0.001$, Table 2).

When analyzing the medium risk DTS group alone, there were 36 (58%) patients with insignificant coronary artery disease, while 17 (27%), and 9 (15%) patients had significant and severe coronary artery disease, respectively. Medium risk patients with significant or severe coronary artery disease were significantly older, while there were no differences regarding gender or presence of risk factors (Table 3). In addition, medium risk patients with typical angina and more episodes of symptoms per week were significantly more represented in significant and severe coronary artery disease groups. There were no significant differences among medium risk patients regarding the severity of coronary artery disease in exercise time or ST deviation. However, the presence of limiting angina in patients with medium risk DTS was significantly more related with significant and severe coronary artery disease (Table 3).

Discussion

Our study showed an excellent value of a high risk DTS result in prioritizing patients for coronary angiog-

TABLE 2
DUKE TREADMILL TEST SCORES BY CORONARY ANGIOGRAPHY GROUPS FOR 114 PATIENTS

Duke treadmill score	No. (%) of patients with coronary artery disease			
	Iinsignificant (n=72)	Ssignificant (n=24)	Severe (n=18)	Total (n=114)
Low risk	36 (90) *	3 (8)	1(2)	40 (100)
Medium risk	36 (58)	17 (27)	9 (15)	62 (100)
High risk	0 (0)	4 (33)	8 (67) *	12 (100)

*χ^2, $p<0.001$.

TABLE 3
CLINICAL HISTORY FREQUENCIES AND TREADMILL TEST RESULTS BY CORONARY ANGIOGRAPHY GROUPS FOR 62 PATIENTS WITH MEDIUM RISK DUKE TREADMILL SCORE

Variables	No. patients (%) with coronary artery disease		
	Insignificant (n=36)	Significant (N=17)	Severe (N=9)
Gender:			
male	12 (33.3)	10 (58.8)	6 (66.7)
Age (X±SD)	57.6 ± 7.9	64.4 ± 7.9**	60.4 ± 7.5
Risk factors:			
BMI >32	4 (11.1)	1 (5.9)	0 (0)
family history of CAD	14 (38.9)	2 (11.8)	4 (44.4)
current smoker	7 (19.4)	2 (11.8)	3 (33.3)
diabetes	6 (16.7)	7 (41.2)	3 (33.3)
hypertension	30 (83.3)	16 (94.1)	7 (77.8)
hypercholesterolemia	15 (41.7)	9 (52.9)	6 (66.7)
Symptoms:			
typical angina	12 (33.3)	12 (70.6)*	7 (77.8)*
atypical angina	16 (44.4) *	3 (17.6)	0 (0)
non-anginal symptoms	8 (22.2)	2 (11.8)	2 (22.2)
episodes per week (X ± SD)	1.84 ± 1.8	4 ± 2**	1.5 ± 1
months with symptoms (X ± SD)	11.8 ± 16.9	4.8 ± 3.5	10.7 ± 14.6
progression	5 (13.9)	5 (29.4)	3 (33.3)
Treadmill testing:			
exercise time, minutes (X ± SD)	6.2 ± 2.1	5.3±2.1	6.1 ± 2
ST deviation:			
0	6 (19.4)	4 (25)	1 (12.5)
1mm ≥ ST<2mm	14 (45.2)	6 (37.5)	4 (50)
2mm ≥ ST<3mm	10 (32.3)	5 (31.3)	1 (12.5)
ST ≥ 3mm	1 (3.2)	1 (6.3)	2 (25)
limiting angina	3 (8.3)	7 (41.2)*	2 (22.2)

*χ^2, $p<0.05$.
**ANOVA, $p<0.05$.

raphy, whereas all patients with suspected stable coronary artery disease classified as high risk had significant or severe coronary artery disease. Low risk DTS also contributes to coronary angiography decision making since 90% of patient with low risk DTS had insignificant coronary artery disease. However, the ability of DTS to stratify all patients for the likelihood of the coronary artery disease was less accurate. More than half of studied patients had medium risk DTS, and almost 60% of them had insignificant coronary artery disease. Other studies also showed DTS to be less accurate in diagnosing coronary artery disease than other treadmill scores that incorporate pretest clinical data in their equations[6]. The additional analysis of clinical data, and treadmill test measurements was required for patients with medium risk DTS. We found that elderly patients presented with typical chest pain, more episodes of symptoms per week, and with limiting angina during the test had significantly more cases of significant or severe coronary artery disease. In most studies, limiting angina during the exercise test was found to be a significant factor in identifying patients with coronary artery disease[8].

The use of scoring for diagnostic purposes has been proven to be helpful in making the correct clinical decision[9]. The scoring classification schemes are easily remembered and an assignment to such distinct groups certainly determines further management. Croatia, as well as other transition countries, has a growing problem of long waiting lists for coronary angiography. Introducing patient scoring can help prioritize to avoid high-risk patients waiting too long for the procedure[12]. This study showed that assignment to the high risk DTS group should result in immediate referral to coronary angiography. However, decisions for coronary angiography in medium risk DTS patients should be made after detailed history of chest pain, depending of the presence of limiting angina during the test, while low risk patients require further non-invasive monitoring[13].

Our study had several limitations, one of them being the retrospective design of the study. The clinical data were not assembled using uniformed, standardized computer forms, and the evaluation of chest pain was not made according to known classification procedures[14]. We scored all our patients using DTS, while some studies found that DTS was non-reliable when applied in elderly patients[15], or younger women with suspected stable coronary artery disease[16]. Because of the non-digital test evaluation, it was also hard to perform the analysis of other

treadmill test measurements in the Bruce protocol, such as duration of ST deviation, blood pressure, or the level of exertion at the onset of chest pain during the test. Relatively high number of patients with insignificant coronary artery disease was probably a result of the high number of patients with suspected stable coronary artery disease referred to our hospital for coronary angiography from different minor regional hospitals, since it was introduced in 2003 as the first invasive cardiology laboratory in eastern Croatian region.

It would be interesting to evaluate the treadmill test scores in a prospective study, using standardized history forms with reliable scoring of chest pain, and computerized treadmill scores with the analysis of the duration of ST deviation, blood pressure, or the level of exertion at the onset of chest pain during the test. Other non-invasive techniques such as stress echocardiography or nuclear imaging have also been proven to help in predicting coronary artery disease[17], and cost benefit studies comparing these strategies with simple treadmill test scores would be interesting if performed in this clinical setting.

In conclusion, DTS is a simple treadmill score that can be calculated easily during the treadmill test, and has showed a great value in prioritizing patients for coronary angiography in a typical transitional clinical setting.

REFERENCES

1. FLETCHER GF, FROELICHER VF, HARTLEY LH, HASKELL WL, POLLOCK ML, Circulation, 91 (1995) 580. — 2. YAMADA H, DO D, MORISE A, ATWOOD JE, FROELICHER VF, Prog Cardiovasc Dis, 39 (1997) 457. — 3. HOLLENBERG M, ZOLTICK JM, GO M, YANEY SF, DANIELS W, DAVIS RC, BEDYNEK JL, N Eng J Med, 313 (1985) 600. — 4. MARK DB, SHAW L, MARK DB, SHAW L, HARRELL FE Jr, HLATKY MA, LEE KL, BENGTSON JR, McCANTS CB, CALIFF RM, PRYOR DB, N Engl J Med, 325 (1991) 849. — 5. SHAW LJ, PETERSON ED, SHAW LK, KESLER KL, DeLONG ER, HARRELL FE Jr, MUNLAIBER LH, MARK DB, Circulation, 98 (1998) 1622. — 6. FEARON WF, GAURI AJ, MYERS J, RAXWAL VK, ATWOOD JE, FROELICHER VF, Clin Cardiol, 25 (2002) 117. — 7. ALVAREZ TAMARGO JA, BARRIALES ALVAREZ V, SANMARTIN PENA JC, HEVIA NAVA S, VEGANZONES BAYON A, SIMARRO MARTIN-AMBROSIO E, CORTINA LLOSA A, Rev Esp Cardiol, 54 (2001) 860. — 8. GIBBONS RJ, BALADY GJ, BRICKER JT, CHAITMAN BR, FLETCHER GF, FROELICHER VF, MARK DB, MCCALLISTER BD, MOOSS AN, O'REILLY MG, WINTERS WL Jr, ACC/AHA 2002 Guideline Update for Exercise Testing, American College of Cardiology Web site., (2002), Available at: www.acc.org/clinical/guideines/ excersice/ dirIndex.htm, Accessed: 20 June 2006. — 9. RAXWAL V, SHETLER K, MORISE A, DO D, MYERS J, ATWOOD JE, FROELICHER VF, Chest, 119 (2001) 1933. — 10. MYERS J, BUCHANAN N, WALSH D, KRAEMER M, MC AULEY P, HAMILTON-WESSLER M, FROELICHER VF, J Am Coll Cardiol, 17 (1991) 1334. — 11. SILBER S, ALBERTSSON P, AVILES FF, CAMICI PG, COLOMBO A, HAMM C, JORGENSEN E, MARCO J, NORDREHAUG JE, RUZYLLO W, URBAN P, STONE GW, WIJNS W; Task Force Members, Eur Heart J, 26 (2005) 804. — 12. AZEEM T, VASSALLO M, SMITH E, MARTIN MA, Int J Clin Pract, 55 (2001) 10. — 13. POORNIMA IG, MILLER TD, CHRISTIAN TF, HODGE DO, BAILEY KR, GIBBONS RJ, J Am Coll Cardiol, 43 (2004)194. — 14. DAGENAIS GR, Can. J. Cardiol., 20 (2004) 310. — 15. KWOK JM, MILLER TD, HODGE DO, GIBBONS RJ, J Am Coll Cardiol, 39 (2002) 1475. — 16. MORISE AP, OLSON MB, MERZ CN, MANKAD S, ROGERS WJ, PEPINE CJ, REIS SE, SHARAF BL, SOPKO G, SMITH K, POHOST GM, SHAW L, Am Heart J, 147 (2004) 1085. — 17. MARWICK TH, SHAW L, CASE C, VASEY C, THOMAS JD, Eur Heart J, 24 (2003) 1153.

I. Hadžibegović

Internal Medicine Department, General Hospital »Dr. Josip Benčević«, Andrije Štampara 42, 35000 Slavonski Brod, Croatia
e-mail: irzal@vip.hr

DUKE TREADMILL SCORE U PRIORITETIZIRANJU BOLESNIKA ZA KORONAROGRAFIJU: RETROSPEKTIVNA STUDIJA JEDNE HRVATSKE ŽUPANIJSKE BOLNICE

SAŽETAK

Cilj studije bio je odrediti potencijal Duke Treadmill Scora (DTS) u prioritetiziranju bolesnika na listi čekanja za koronarografiju u županijskoj bolnici tranzicijskog okruženja. Proučili smo 114 bolesnika sa sumnjom na stabilnu koronarnu bolest kojima su učinjeni test opterećenja pokretnom trakom i koronarografija u Općoj bolnici »Dr. Josip Benčević« u Slavonskom Brodu. DTS je izračunat nakon testa opterećenja kao: vrijeme trajanja testa u minutama – (5×ST devijacija u mm) – (4×angina pektoris u opterećenju). Bolesnici su podijeljeni u tri skupine prema skoru postignutom na testu opterećenja: DTS niskog, srednjeg i visokog rizika. Svi bolesnici bili su na koronarografiji, te su prema težini koronarografskog nalaza podijeljeni u nove tri skupine: neznačajna, značajna i teška koronarna bolest. Svi bolesnici s DTS visokog rizika imali su značajnu ili tešku koronarnu bolest. Bolesnici srednjeg i niskog DTS rizika imali su neznačajnu koronarnu bolest u 50%, odnosno 90% slučajeva. Bolesnici s DTS srednjeg rizika koji su imali značajnu ili tešku koronarnu bolest bili su značajno stariji i imali su češće anamnezu tipične anginozne boli s više napadaja u jednom tjednu.

Nije bilo značajnih razlika s obzirom na spol ili uobičajene čimbenike rizika. Također, među bolesnicima sa srednjim DTS rizikom nije bilo značajnih razlika u težini koronarne bolesti s obzirom na trajanje testa ili ST devijaciju. Međutim, prisutnost limitirajuće angine pektoris češće je bila povezana sa značajnom ili teškom koronarnom bolesti među tim bolesnicima ($P<0.05$). DTS visokog rizika pokazao je visok potencijal u prioritetiziranju bolesnika za ranu koronarografiju. Ovaj skor mogao bi biti koristan u kreiranju listi čekanja u tranzicijskim zemljama.