Original article

Reliability and validity of a 2-minute walk test in coronary artery bypass graft patients

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Abstract:

Background: *The 2-minute walk test (2MWT) has been studied to demonstrate its relationship and sensitivity to physical functions in coronary artery bypass graft (CABG) patients, however, the data on its reliability and validity in this group of patients compared to a 6-minute walk test (6MWT) are limited.* ***Objective:*** *This study aimed to determine the reliability and validity of the 2MWT compared with the 6MWT in CABG patients.* ***Methods:*** *This analytical study was conducted in 15 CABG patients at the outpatient cardiac rehabilitation clinic, Phramongkutklao Hospital. The patients were divided into two groups to participate in both the 2MWT and the 6MWT trials. The first group started with a trial of 2 times of 2MWT, then 1 time of 6MWT. The second group began with a trial of 1 time of 6MWT, then 2 times of 2MWT. The measurement of walking distance and maximum heart rate was recorded.* ***Results:*** *The reliability of two trials of 2MWT was 149.43±30.96 meters and 148.12±28.55 meters, respectively, with the intraclass correlation coefficient equal to 0.985 (p <0.001). Whereas, the validity of the first and second trials plus an average of 2MWT in both trials had a significant correlation with the 6MWT (r = 0.957, 0.931, and 0.951, respectively; p <0.001). The exercise intensity of 2MWT and 6MWT was 32.37 and 39.41 percent, respectively.* ***Conclusion:*** *The 2-minute walk test yields a high reliability and validity among CABG patients in outpatient cardiac rehabilitation clinic.*

Keywords: ● *Coronary artery bypass graft* ● *2-minute walk test* ● *6-minute walk test* ● *Outpatient cardiac rehabilitation*

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นิพนธ์ต้นฉบับ

ความน่าเชื่อถือและความเที่ยงตรงของการทดสอบการเดิน 2 นาที ในผู้ป่วยที่ได้รับการผ่าตัดบายพาสหัวใจ

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บทคัดย่อ

บทนำ *การทดสอบการเดิน 2 นาที (2MWT) พบว่ามีความสัมพันธ์และความไวต่อสมรรถภาพทางกายของผู้ป่วยที่ได้รับการผ่าตัดบายพาสหัวใจ (CABG) แต่ข้อมูลการศึกษาความเที่ยงและความตรงในผู้ป่วยกลุ่มนี้เมื่อเทียบกับการทดสอบการเดิน 6 นาที (6MWT) ยังมีจำกัด* ***วัตถุประสงค์*** *เพื่อหาความน่าเชื่อถือและความเที่ยงตรงของ 2MWT เทียบกับ 6MWT ในผู้ป่วย CABG* ***วิธีการศึกษา*** *ผู้ป่วยหลังเข้ารับการผ่าตัด CABG จำนวนทั้งหมด 15 ราย ซึ่งแบ่งลำดับของการเดินทดสอบออกเป็นสองกลุ่ม กลุ่มแรกจะเริ่มทำการทดสอบ 2MWT ก่อน จำนวน 2 ครั้ง จากนั้นทำการทดสอบ 6MWT 1 ครั้ง โดยกลุ่มที่สองจะเริ่มต้นทำ 6MWT ก่อน จากนั้นทำ 2MWT จำนวน 2 ครั้ง ข้อมูลที่ได้จากการทดสอบคือระยะทางที่เดินได้ และ อัตราการเต้นของหัวใจสูงสุด* ***ผลการวิจัย*** *การทดสอบความน่าเชื่อถือ ใช้ค่าระยะทางที่เดินได้ใน 2MWT จำนวนสองครั้งมาคำนวณ ได้แก่ 149.43±30.96 เมตรและ 148.12±28.55 เมตร ตามลำดับ พบว่าในการเดิน 2MWT ทั้งสองครั้งมีค่าสัมประสิทธิ์สหสัมพันธ์ภายในชั้น (Intraclass correlation coefficient) เท่ากับ 0.985 ($p < 0.001$) ในส่วนของการศึกษาความเที่ยงตรงได้ทำการหาความสัมพันธ์กันระหว่าง 2MWT และ 6MWT พบว่าทั้งในส่วนของการทดสอบ 2MWT ครั้งที่ 1, 2 และ ค่าเฉลี่ยของการทดสอบทั้งสองครั้งนั้น มีความสัมพันธ์กันอย่างมีนัยสำคัญกับการทดสอบ 6MWT r= 0.957, 0.931 และ0.951 ตามลำดับ ($p < 0.001$)). ความหนักของการออกกำลังกายของ 2MWTและ 6MWT เป็นร้อยละ 32.37 and 39.41 ตามลำดับ* ***สรุป*** *การทดสอบการเดิน 2 นาที เป็นการทดสอบที่มีความน่าเชื่อถือและความเที่ยงตรงสูงเมื่อนำมาใช้กับผู้ป่วยหลังผ่าตัดบายพาสหัวใจในคลินิกฟื้นฟูหัวใจแบบผู้ป่วยนอก*

คำสำคัญ: ● *การผ่าตัดบายพาสหัวใจ* ● *การทดสอบการเดิน 2 นาที* ● *การทดสอบการเดิน 6 นาที* ● *การฟื้นฟูหัวใจระยะผู้ป่วยนอก*

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ต้องการสำเนาต้นฉบับติดต่อ นพ.พศวีร์ ขวัญช่วย ภาควิชาเวชศาสตร์ฟื้นฟู คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์ ปทุมธานี 12120

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Introduction

A cardiac rehabilitation program is an integrated rehabilitating process for patients with cardiovascular problems that provides care with a suitable and safe exercise program to reduce mental anxiety and risk factors of cardiovascular diseases through consultation and advice on behavioral modifications to health. The goal is to increase an appropriate level of functional capacity in specific patients, so they can return to their careers and have a good quality of life with lower disease recurrence, morbidity, and mortality[1]. The American College of Cardiology (ACC) and the European Society of Cardiology (ESC) have suggested that all cases of patients with cardiac diseases from various causes should receive a cardiac rehabilitation program (Class I recommendation)[2,3]. Exercise training is a critical component of the cardiac rehabilitation program. Before starting the exercise training in Phase 2 or outpatient cardiac rehabilitation program, all patients are suggested to perform an exercise stress test at the symptom-limited level for their risk classification, together with the appropriate exercise prescription[4]. By performing the cardiopulmonary exercise test (CPET) or the electrocardiogram exercise stress test, it can yield useful and beneficial information. However, those methods are not commonly used due to the requirement of expensive tools and specialists with expertise to test and interpret results.

The walk test is a measurement that can be used to evaluate the effectiveness of performance, overall treatment efficiency, and readiness before hospital discharge[5]. The 6-minute walk test (6MWT) is a popular functional test below the highest level that patients can do the highest in the submaximal test, especially those with cardiac and lung diseases, as well as other chronic diseases due to its convenience, no need of complicated equipment, less time consuming, no requirement of specialists for testing, and more related results to the capability of performing daily activities than other tests[5]. Thus, the 6MWT is used for both inpatient and outpatient cardiac rehabilitation[6].

Another walk test with a shorter distance, the 2-minute walk test (2MWT), was first used in COPD patients. It possesses a good level of reliability and validity when compared to the 6MWT. It is very useful for patients with low functional capacity, not being strong, and having walking problems. The 2MWT is practical when used in clinics with a large number of patients and limited length of service[7,8].

Following a literature review, there have been limited studies on the 2MWT in patients with cardiac rehabilitation[9]. A study in a group of coronary artery bypass graft patients showed that the 2MWT was moderately associated with the ability to perform physical function when compared to daily activities and the quality of life. However, it has sensitivity but lacks reliability and validity when compared to the 6MWT, which is widely used in the cardiac rehabilitation clinic.

Hence, the primary objective of this study was to determine the reliability and validity of the 2MWT in coronary artery bypass graft patients. The secondary objective was to compare the intensity of the 2MWT and the 6MWT in coronary artery bypass graft patients. It was hypothesized that the 2MWT had a good level of reliability and validity when compared to the 6MWT in coronary artery bypass graft patients. The results of this study should be adapted to provide services to cardiovascular artery bypass graft patients who attended outpatient cardiac rehabilitation.

Materials and methods

Type of study

This was an analytical study in patients who received outpatient cardiac rehabilitation at the cardiac rehabilitation clinic, Phramongkutklao Hospital from April 2018 to April 2019. Ethical approval was obtained by the Institutional Review Board, Royal Thai Army Medical Department (No.R038h/61)

Participants

The selection criteria included patients aged 18-75 years who underwent coronary artery bypass graft surgery and received outpatient cardiac rehabilitation. They agreed to participate in the study.

Those contraindicated for the 6MWT according to the American Thoracic Society (ATS) criteria[10]: 1) unstable angina within the past 1 month, 2) myocardial infarction within the past 1 month, 3) heart rate of more than 120 beats per minute at rest, 4) systolic blood pressure greater than 180 mmHg or diastolic blood pressure greater than 100 mmHg at rest, and 5) chronic lung disease or leg problems that prohibited walking, were excluded from this study.

After the coronary artery bypass graft surgery, all patients received drugs in the Beta-blockers group to help reduce the chance of arrhythmia and mortality[11]. Following the abovementioned data, all of them were given the same drugs with an effect on heart rate reduction. Thus, this should not impact the calculation of weight level of the 2MWT.

Sample size calculation

Since there have been no previous studies on the accuracy and validity of the 2MWT versus the 6MWT in cardiac rehabilitation patients, this was a pilot study in 11 cardiac rehabilitation patients, with the correlation coefficient between the 2MWT and the 6MWT of 0.734 for sample size calculation. Thus, the total number of subjects in this study were at least 15 patients.

Study methods

All participants had thorough explanations regarding their consent to participate in this study before they provided their signed informed consent. Then, they were asked to complete a questionnaire on basic information including age, sex, underlying disease, diagnosis of cardiovascular disease, history of cardiovascular surgery, cardiovascular intervention, duration of post-cardiovascular surgery or intervention, complications, data of left ventricular ejection fraction (LVEF) NYHA functional class, medications, low-density lipoprotein (LDL) blood glucose, waist circumference, body mass index (BMI), and smoking history. All obtained data were recorded in the case record form. The participants received the 2MWT and the 6MWT at the outpatient cardiac rehabilitation clinic.

Each participant was required to take both the 2MWT and the 6MWT on the same day. The sequence of tests was divided into two groups using block randomization. One group was patients who received the 2MWT first, then the 6MWT. The other was those who obtained the 6MWT first, then the 2MWT. To lower learning effects, the collected data of all participants included heart rate, oxygen saturation, blood pressure, fatigue level, and electrocardiogram, using a remote heart tracker before and after the walk tests.

To reduce factors arising from learning and gaining familiarity with the tests, all participants practiced for each walk test one time before the actual walk tests. Data analysis of the actual walk tests was divided into 2 times of the 2MWT for reliability and 1 time of the 6MWT for validity. There was a 10-minute rest between each test, waiting for all the required measurements to return to the original baseline range of all participants. Each participant started the 2MWT or the 6MWT walk according to the sequence from randomization.

In the 6MWT, participants were instructed to walk the farthest distance within 6 minutes back and forth around the straight cones of 15 meters apart. They could take a break during the test if they were unable to walk further, then resumed their walk test until the full 6 minutes, with warning reminders for the remaining time of the walk test every 1 minute, according to the standards of American Thoracic Society[10].

For the 2MWT, participants were instructed to walk the farthest distance within 2 minutes back and forth around the straight cones of 15 meters apart, with warning reminders for the remaining time of the walk test every 1 minute, which applied from the standards of the 6MWT.

The data obtained from the walk test, including the 1st and 2nd time of the 2MWD, were analyzed to determine the reliability of the 2nd time of the 2MWT. Whereas, the 6MWD was analyzed for the validity. For the intensity of the 2MWT and the 6MWT, the highest HR while walking was applied to calculate the % intensity, using the heart rate reserve (Karvonen method) according to the equation Walking HR = Resting HR +% intensity x (Max HR - Resting HR) by calculating the maximum heart rate of each patient from the formula: 208 - (0.7x age)[12].

Statistical analysis

Data were verified for accuracy and recorded by the STATA / MP 12 program. Then, general data were analyzed using descriptive statistics, such as number, percentage, mean, standard deviation, and minimum and maximum values. Chi-square test or Fisher's exact test was applied to compare basic data characteristics as the grouped data. Independent t-test or Mann-Whitney U test was employed for the continuous data. The correlation coefficient r_s was used to analyze the validity for the correlation between the 2MWT and the 6MWT. The intraclass correlation coefficient was applied to analyze the reliability between the 2 times of 2MWT and described by the Bland and Altman plot. The $p \leq 0.05$ was considered as statistical significance.

Results

A total of 15 patients underwent coronary artery bypass surgery, including 14 males and 1 female, mean age 65.27 years (8.86 standard deviation), and mean body mass index 25.01 (standard deviation 3.64), with 5 cases of diabetes (33.33%). For the risk classification among heart rehabilitation patients, there were 4 high-risk (26.67%), 2 moderate-risk (13.33%), and 9 low-risk (60%), with an average left ventricular compression value of 56.57% (the standard deviation 13.27). Other baseline data are shown in Table 1.

Table 1 Demographic data and clinical characteristics of the study population (n = 15)

Variables	n	%
Sex		
Female	1	6.67
Male	14	93.33
Age (year)	15	65.27±8.86*
Underlying disease		
Hypertension	15	100
Diabetes	5	33.33
Dyslipidemia	11	73.33
Previous stroke	1	6.67
Smoking	3	20
Risk stratification in cardiac patient		
Minimal	9	60.00
Moderate	2	13.33
High	4	26.67
Left ventricular ejection fraction (%)	14	56.57±13.27*
Fasting blood sugar (mg/dL)	14	122.5±36.04*
Hemoglobin A1C (mg%)	7	6.59±1.03*
LDL-C (mg/dL)	14	84.24±18.48*
Waist circumference (cm)	15	94.27±10.83*
Body mass index (kg/m²)	15	25.01±3.64*

*Continuous data presented with mean±SD

Data for assessing the participants prior to the start of the walk test comprised an average heart rate at rest of 78.87 beats per minute (standard deviation 10.45), mean systolic / diastolic blood pressure of 127.87 / 71.27 mmHg, median oxygen saturation of 97% (lowest - highest 96-98), and median fatigue (Borg CR-10) of 0 (Table 2).

The walk test results were divided into 2 times of the 2 MWT and 1 time of the 6MWT, with measurements of walk distance, maximum heart rate, oxygen saturation, fatigue level, and blood pressure, as shown in Table 3.

For the reliability, the distances of the walk test from 2 times of the 2MWT were used twice to calculate: 149.43 m (30.96 standard deviation) and 148.12 m (28.55 standard deviation), respectively. Whereas, the 2 times of the 2MWT yielded the Intraclass correlation coefficient of 0.985 ($p < 0.001$), indicating a high level of reliability from 2 times of repeated measurement (Table 4). The difference in mean distance of the 2MWT between the 1st and the 2nd time is shown in Figure 1.

For the validity, there was a significant correlation between the 1st and the 2nd time of the 2MWT, as well as the mean of those two times, and the 6MWT, with r = 0.957, 0.931, and 0.951, respectively ($p < 0.001$). The difference in distance between the 6MWT and the mean of the 2 times of 2MWT is shown in Figure 2.

Table 2 Baseline physical assessment

Variables (n = 15)	Median(Min-Max)/Mean±SD
Oxygen saturation (%)	97 (96-98)**
Resting heart rate (bpm)	78.87±10.45*
Rate perceive exertion (RPE)	0 (0-1)**
Systolic blood pressure (mmHg)	127.87±16.91*
Diastolic blood pressure (mmHg)	71.27±9.93*

*Mean(SD) for continuous data; **Median(Q25-Q75) for interval data

Table 3 Exercise test results

Variables (n = 15)	Mean (SD)
2MWT	
Distance (m)	
Trial 1	149.43(30.96)
Trial 2	148.12(28.55)
Peak heart rate (bpm)	
Trial 1	106.73(15.95)
Trial 2	105.87(16.19)
Oxygen saturation (%)	
Trial 1	95.40 (1.35)
Trial 2	95.47(1.64)
Rate perceive exertion (RPE)	
Trial 1	1.06 (0.75)
Trial 2	1.1 (0.82)
Systolic blood pressure (mmHg)	
Trial 1	159.53 (19.56)
Trial 2	156.73 (19.24)
Diastolic blood pressure (mmHg)	
Trial 1	83.93 (11.08)
Trial 2	80.93 (10.00)
6MWT	
Distance (m)	423.55(88.49)
Peak heart rate (bpm)	110.87 (16.63)
Oxygen saturation (%)	95.27 (1.75)
Rate perceive exertion (RPE)	1.73 (1.08)
Systolic blood pressure (mmHg)	160.47 (24.54)
Diastolic blood pressure (mmHg)	80.27 (11.74)

Continuous data presented with mean±SD

Table 4 Intraclass Correlation Coefficient of the 2MWT (n = 15)

	ICC	95%CI	*p*-value
2MWT trial 1 and 2	0.985	0.913-0.990	< 0.001

ICC = Intraclass Correlation Coefficient

Significant if $p \leq 0.05$

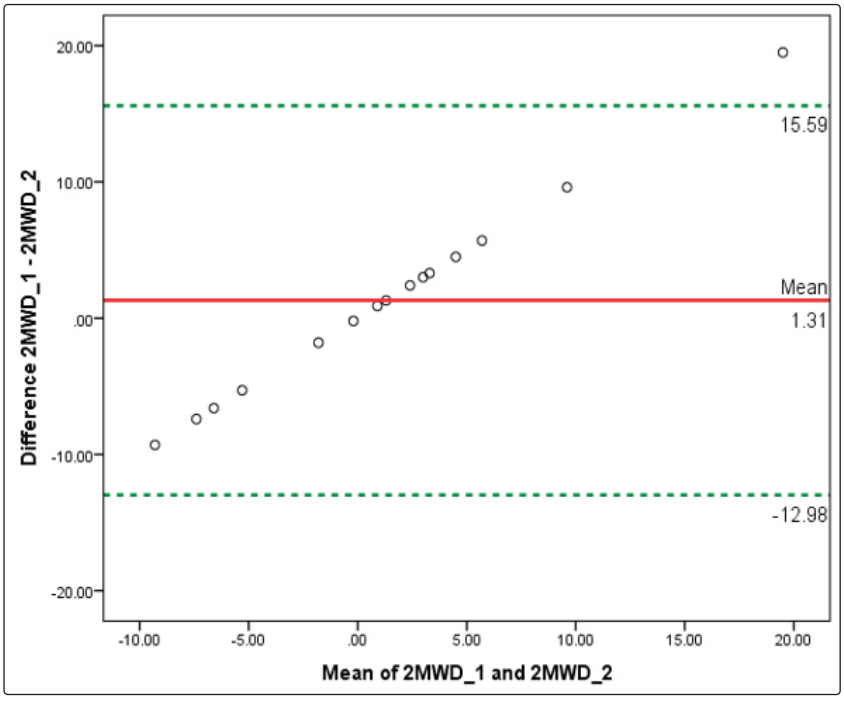

Figure 1 Differences in 2MWT results between trials 1 and 2.

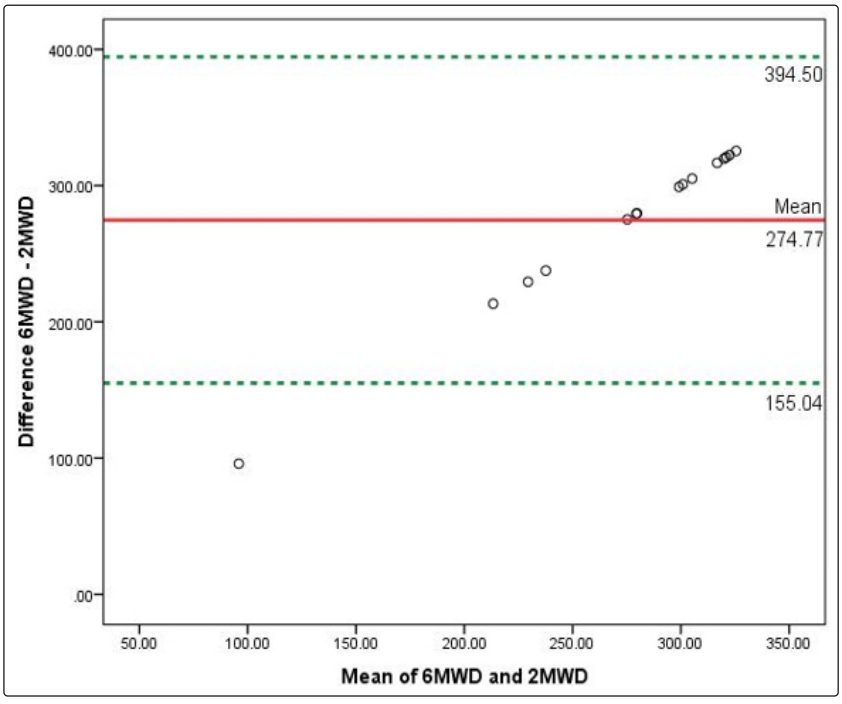

Figure 2 Differences in 6MWT and average 2MWT between trials 1 and 2

The average walking distance for two times of 2MWT was 148.78 m, therefore projecting the distance walked for 6 minutes by multiplying average 2MWD by three (3 x 148.78 = 446.34 m). The percentage error between the estimated 6MWD from 2MWT and the studied 6MWD showed 5.38 percent.

The exercise intensity of the 2MWT and the 6MWT by using the formula of % intensity), with heart rate reserve (Karvonen method), demonstrated that the average of 2 times of 2MWT had the % intensity of 32.37 (14.85 standard deviation), which was at the low level. Meanwhile, the 6MWT had the % intensity of 39.41 (14.92 standard deviation), which was also at the low level.

Discussion

This study significantly yielded similar results of the walk distances following the 2 times of 2MWT in coronary artery bypass graft patients, with a high reliability that is comparable to previous studies in those with COPD, below knee amputation surgery, cerebrovascular disease, and multiple sclerosis[8,13-15].

For the validity, our results showed that the walk distances of the 2MWT and the 6MWT tests were highly correlated following the calculation by using the mean of the 2 times of 2MWT, similar to previous studies in patients with COPD, cerebrovascular disease, and multiple sclerosis[8,14-16].

To determine the exercise intensity of 2MWT, we applied the formula for calculating the % intensity) by the heart rate reserve (Karvonen method). The light level of intensity of both the 2MWT and the 6MWT was observed (30% to < 40%), but significantly lighter in the 2MWT (32.37 and 39.41). This was in accordance with our expected primary outcome, in that the walk test with a shorter time should have lighter exercise intensity, which is considered an advantage of the 2MWT. In particular, the 2MWT in coronary artery bypass graft patients who received outpatient cardiac rehabilitation (Phase 2) and required a walk test was likely to be acceptable among those patients due to its ease and convenience to perform, especially those with a low level of fitness or walking and balance problems. Thus, it was safer with fewer complications and symptomatic abnormalities from the walk test due to lighter exercise intensity[17-28]. However, the shorter time of the walk test of the 2MWT compared to the 6MWT could cause a ceiling effect similar to the 6MWT, particularly in patients with a high functional capacity or proper walking[8,16,29-31]. In addition, the 2MWT, which consumed only a short duration of 2 minutes, may be practical for the cardiac rehabilitation services with a large number of patients.

There were several advantages from our study. Firstly, there was a reduction of factors from learning. Participants who practiced for a walk test at their first time become familiar with it as results in previous studies showed that the effects of learning factors could lead to better outcomes in subsequent tests[5]. According to the literature, our study added more information on reliability, validity, and intensity to be widely applied in coronary artery bypass graft patients.

The limitations of this study were that the results of the walk test seemed to be only the walk distance. In practice, it should depend on many factors that affect the quality of life, such as walking speed or walking safety. Additionally, our study was only performed in cardiac rehabilitation patients who underwent coronary artery bypass graft surgery. Therefore, it could not be applied to other groups of patients with cardiac diseases.

Conclusion

The 2-minute walk test yields a high reliability and validity among CABG patients in the outpatient cardiac rehabilitation clinic. This can be adapted in clinical practice to shorten the exercise test time at the cardiac rehabilitation clinic, where there are a large number of patients.

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