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Contribution of Stress Testing to the Management of Ischemic Heart Disease in Mali

Youssouf Camara[1], Hamidou Oumar Ba[2], Ibrahima Sangaré[2], Boubacar Sonfo[1], Coumba Adiaratou Thiam[1], Mahamadou Sékou Diakité[1], Koniba Diarra[1], Karamba Touré[1], Massama Konaté[3], Ichaka Menta[2]

[1]Cardiology Department, University Hospital Professeur Bocar Sidi Sall Kati, Kati, Mali
[2]Cardiology Department, University Hospital Gabriel Touré, Bamako, Mali
[3]Cardiology Department, Mali Hospital, Bamako, Mali
Email: cestoto29@yahoo.fr

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Abstract

Introduction: Exercise stress testing (on a treadmill or ergometer bicycle) is an important test in cardiology for diagnosing myocardial ischemia. This test in Mali is still in its beginning compared to other countries in the sub-region. The lack of data in Mali prompted this study, which aimed to evaluate the indications of this activity and its diagnostic contribution to cardiology in Mali. **Materials and Methods:** This was a retrospective, descriptive study. The study was conducted at the "TOUCAM" medical clinic in Kati based on the analysis of stress test reports between January 2016 and August 2022. **Result:** During the study period, we documented 73 patients who underwent exercise testing on a bicycle ergometer for suspected coronary heart disease. The mean age of our patients was 47.5 ± 13.8 years (14 and 79 years). Males accounted for the majority (78.1%). The sex ratio is 3.5. More than half of our patients were overweight or obese (77.1%). Hypertension and diabetes affected 52.1% and 25.8% of patients, respectively. 20.8% of patients had coronary artery disease. renin-angiotensin-aldosterone system blockers (56.8%) and beta-blockers (51.3%). The main indications were chest pain (63.0%) and ischemia detection (15.1%). A modified STEEP protocol was used. The majority of our patients (71.2%) achieved at least 85% of their maximum theoretical heart rate. The main reason for the termination of the study was fatigue (57.3%). The average duration was 11.3 ± 4.2 minutes. 24.7% thought the stress tests were positive and 17.8% thought they were controversial. **Conclusion:** This study demonstrates the importance of stress testing in the diagnosis and treatment of ischemic heart disease, especially in settings where we have very limited access to coronary angiography.

Keywords

Stress Test, Ischemic Heart Disease, Mali

1. Introduction

Coronary heart disease is the leading cause of death in the Western world, causing 7.4 million deaths [1]. It commonly presents as angina, with an annual incidence of 2 percent in the general population [2] [3] [4]. Exercise testing (ET) has been and continues to be the reference test for the diagnosis and treatment of coronary artery disease.

With ET, the electrical activity of the heart is recorded during exercise on a treadmill or stationary bike. This is the main non-invasive test most often used when angina is suspected and can also be used to assess the effectiveness of treatment.

It is cheaper and easier to perform than coronary angiography (which is invasive and still not readily available in our resource-limited country). Sensitivity is estimated to be 45% - 50% [5].

Despite these advantages, in developed countries we see a decrease in their use in favor of coronary angiography and, in some cases, stress ultrasound.

In Africa, it has been going on for several years in sub-Saharan regions, so:

- In Senegal, Mboup [6] found that 33.9% of 59 patients admitted with acute coronary syndrome (ACS) had preexisting stable angina and therefore could be detected by ET. Of 40 stress tests performed for precordial pain, 27 (67.50%) were also positive for Aw [7]. Of these positive cases, 20 patients underwent coronary angiography, of whom 9 (45%) had significant coronary artery disease, corresponding to a sensitivity of 45% [7].
- In Burkina Faso, 60 patients underwent a stress test to treat ischemic heart disease. Ten percent of these patients have a positive stress test and an additional 10% have inconclusive stress test results [8].
- In our country, unlike other countries in the sub-region, this trial was conducted only recently, making it necessary to evaluate its contribution to the treatment of ischemic heart disease (IHD) in our country.

2. Methodology

1) Duration and type of study:

This was a retrospective, descriptive study lasting from January 2016 to August 2022.

2) Study site:

The study was conducted at the "TOUCAM" medical clinic in Kati. This is one of the earliest institutions in my country to carry out stress testing.

3) Sample:

We comprehensively included all available reports (CR) of patients referred for ET for suspected or follow-up ischemic heart disease during the study period, regardless of symptoms.

We did not include reports that were unusable because they were missing basic information such as age, sex at examination, or stress test results.

4) Review procedure:

5) Before testing:

The patient had a consultation in the clinic before the stress test. During this consultation, a complete clinical examination, electrocardiogram, and transthoracic Doppler echocardiogram were performed to determine any contraindications to this test. Heart rate and baseline blood pressure were recorded**.** In some patients, beta-blocker therapy was interrupted for at least 48 hours (primary diagnosis of coronary artery disease). We also took the opportunity to explain the examination process to the patient to gain his cooperation.

6) Although:

The test is performed in the presence of a well-prepared, athletically-suited cardiologist and nurse.

The patient is monitored for heart rate and underwent a 12-lead electrocardiogram, while blood pressure is measured manually.

Stress testing was performed on a bicycle ergometer. The protocol used was a modified STEEP protocol with a starting load of 30 watts and a gradual increase of 30 watts every three minutes. Blood pressure was measured manually every two minutes. Patients were asked to report any symptoms that occurred during testing. The stress test was stopped if the patient showed signs of positivity, disabling functional signs or exhaustion.

3. Recovery

Recovery was either passive or active with a load of 25 Watts. During this phase, clinical and electrocardiographic monitoring was maintained. Blood pressure was taken every minute. The return to baseline parameters and the absence of complaints ended the exploration.

1) Operational definitions

- Theoretical maximum frequency (TMF) was estimated using Astrand's formula (TMF = 220 - age of subject ± 10) and Brawner's formula (TMF = 164 - 0.7 × age) for patient under heart frequency lowering treatment [9] [10].
- The level of effort achieved was defined by the percentage of TMT reached [9] [10]: sub-maximal effort if maximal HR < 85% TMT, sub-maximal effort if 85% TMT ≤ maximal HR < 100% TMT, maximal effort if maximal HR ≥ 100% TMT.
- The stress test was consiered to be "unmasked" when the anti-anginal and/or bradycardic drugs had been discontinued for 48 hours, otherwise it was said to be "masked".
- The criteria for a positive ET were:

Chest pain associated with ST-segment depression that is horizontal or downsloping ≥ 1 mm, extending 60 - 80 ms beyond the J point, horizontal or descending, Upsloping ST-segment depression ≥ 1.5 mm, extending 80 ms beyond the J point ST Upslopping in the absence of infarction, changes in the R wave, inversion of the U wave or tripling of the T wave, ST-segment elevation ≥ 1 mm, ST/HR index ≥ 1.6 V/beat·min^{-1}, exhaustion associated with exercise-induced

Ventricular Extra-Systole and abnormality of the T wave on the baseline ECG [11] [12].

- The stress test was said to be contentious if it was: a sub-maximal stress test and the target stress level was not reached; an ascending sub-shift; a sub-shift present only in the recovery phase [11].

2) Data collection:

Data were collected on an individual survey form. The studied variables were: socio-demographic data (age, sex, profession, place of residence), technical data (ergometer, protocol) and clinical and paraclinical data (patient history, cardiovascular risk factors, resting HR, exercise HR max, electrical signs at rest and during exercise, current treatment, indication, results of the exercise test and reasons for discontinuing EE).

3) Data analysis:

Data were analyzed using IBM SPSS 25 software. Qualitative variables were expressed as a proportion and were compared using the chi 2 test or Fisher's exact test. Quantitative variables were presented as mean ± standard deviation, and compared using Student's t test. The significance threshold was set at $p < 0.05$.

4. Results

During the study period, 97 stress tests were performed, of which 73 (75.3%) met our inclusion criteria.

1) Socio-demographic characteristics

The modal age group in the sample was 45 - 59 years, accounting for 45.2% of cases. The mean age was 47.5 ± 13.8 years. The mean age for men (48.3 ± 13.8 years) was higher than for women (45.7 ± 14.3 years), but there was no significant difference ($p = 0.52$).

The study population was composed of 78.1% male and 21.9% femal, giving a sex ratio of 3.5. Table 1 shows the distribution by age and sex.

At least one history or cardio-vasculare risk factor was found 65.7% of our paients, principally obesity (77.1%), High blood pressure (52.1%) and diabetes (25.0%). Furthermore 20.8% of patients have a past history of coronaropathy. Table 2 gives the detail in distribution of patients according to cardiovasculare

Table 1. Age group distribution according to sex.

Age groups (years)	Sex		Total N (%)
	Male N (%)	Female N (%)	
14 - 29	06 (75.0)	02 (25.0)	08 (11.0)
30 - 44	14 (82.4)	03 (17.6)	17 (23.3)
45 - 59	25 (75.8)	08 (24.2)	33 (45.2)
≥60	12 (80.0)	03 (21.4)	15 (20.5)
Total	56 (78.1)	16 (21.9)	73 (100.0)

Table 2. Distribution of past medical history and cardiovascular risk factors.

History/risk factors	Number (N = 48)	Percentage (%)
Obesity	37	77.1
High blood pressure	25	52.1
Diabetes	12	25.0
Ischaemic heart disease	10	20.8
Other	06	12.5

Other: dyslipidaemia, hyperthyroïdism, smoking, gastritis.

history of risk factor.

Thirty-seven of our patients (50.7%) were currently receiving cardiovascular treatment. Inhibitors of the renin angiotensin aldosterone system (56.8%) were the most commonly used therapeutic class, followed by beta-blockers (51.3%) and calcium channel blockers (29.7%). **Table 3** shows the distribution of patients according to current treatment.

Cardiologists were the only prescribers, as EE is a recent development in our country and therefore little known to other practitioners. Chest pain (63.0%), detection of ischaemia (15.1%) and palpitations (12.3%) were the main indications in our series. **Figure 1** shows the distribution of the sample according to the reason for EE.

2) Exercise test

The test was performed without bradycardic treatment (stopped at least 48 hours before) in 47.6% of our patients undergoing slowing treatment. The mean duration of the exercise test was 11.3 ± 4.2 minutes. The mean maximum systolic blood pressure was 185.6 ± 26.5 mmHg with extremes of 110 and 260 mmHg and the mean maximum diastolic blood pressure was 94 ± 10.9 mmHg with extremes of 70 - 120 mmHg.

Thirty point one percent of our patients had reached a load of 120 Watts corresponding to a level 4, in 24.7% of cases a load of 150 Watts, level 5, had been reached and a load of 90 Watts (level 3) in 19.2%. The average load was 132.1 ± 43.4 Watts and the average number of stages reached was 4.4 ± 1.5. **Figure 2** shows the distribution of patients according to the load achieved.

Effort was submaximal in 21 patients (28.8%), submaximal and maximal in 35 (47.9%) and 17 (23.3%) patients respectively. **Table 4** shows the distribution of patients according to the proportion of theoretic maximum frequency.

Our main discontinuation criteria were exhaustion, leg pain and dyspnoea (57.3%, 28.3% and 5.4% respectively). Chest pain accounted for only 2.7% of discontinuation criteria. **Figure 3** shows the distribution of patients according to discontinuation criteria.

The average recovery time was 6.1 ± 1.4 min, with extremes of 1 and 9 min.

Nearly one-quarter of the tests in our series were positive and 17.8% were contentious. In addition, test positivity was not statistically related to age ($p = 0.21$), gender ($p = 0.74$) or indication ($p = 0.893$).

Table 3. Distribution of patients according to current treatment.

Drug class	Number (N = 37)	Percentage
ACEI*/ARB** II	21	56.8
Beta blockers	19	31.3
Non-bradycardic calcium blockers	11	29.7
ASA	6	16.2
Statins	6	16.2
Calcium blockers with bradycardia activity	2	05.4
Other	2	05.4

*Angiotensine converting enzyme inhibitors, **Angiotensine receptors inhibitors.

Table 4. Distribution of reached theoretical maximum frequency.

Theoretic maximum frequency (%)	Number	Percentage
<85	21	28.8
85 - 99	35	47.9
≥100	17	23.3
Total	73	100

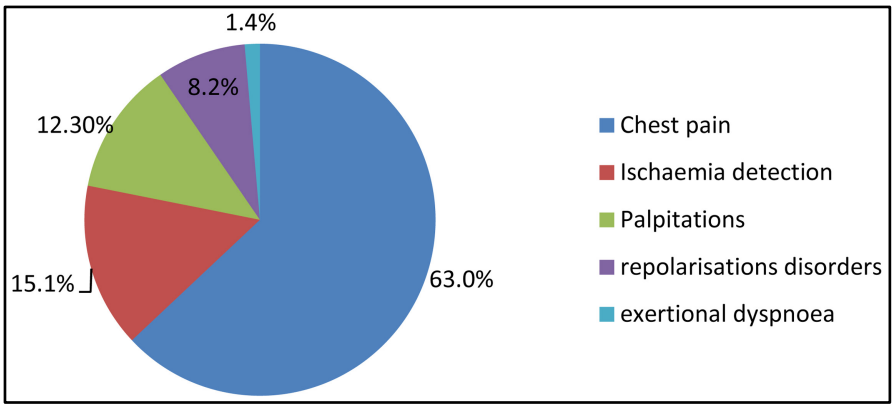

Figure 1. Distribution of reason for ET termination.

Only 4 of our positive cases had undergone coronary angiography, including 3 with significant lesions and one case of suspected coronary spasm. We found a 3-vessels disease in one case and single vessel in two. The 3 patients with significant lesions all underwent successful angioplasty. **Figure 4** shows the distribution of the sample according to the outcome of the ET.

5. Discussion

During the study period, 97 stress tests were performed, of which 73 (75.3%) met our inclusion criteria.

The mean age in our series was 47.5 ± 13.8 years, in line with other African

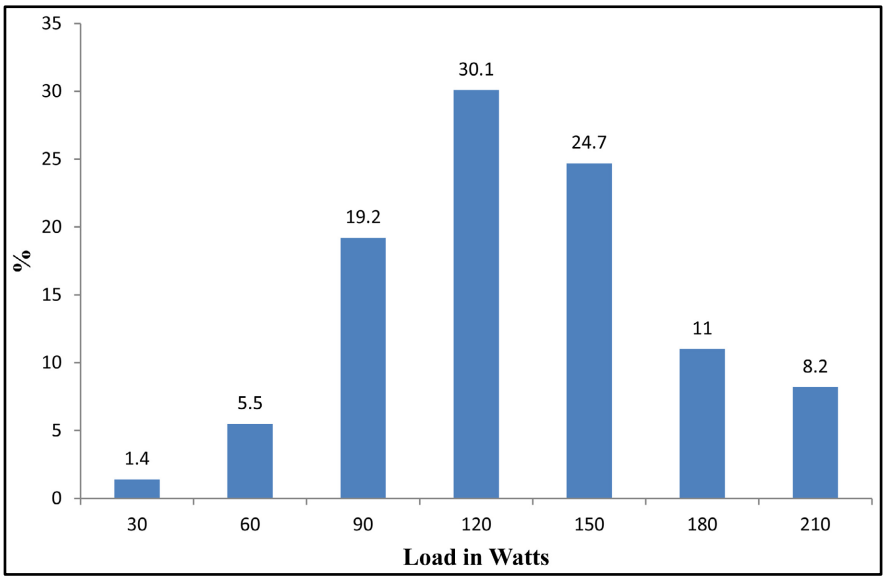

Figure 2. Distribution of maximum load (Watts).

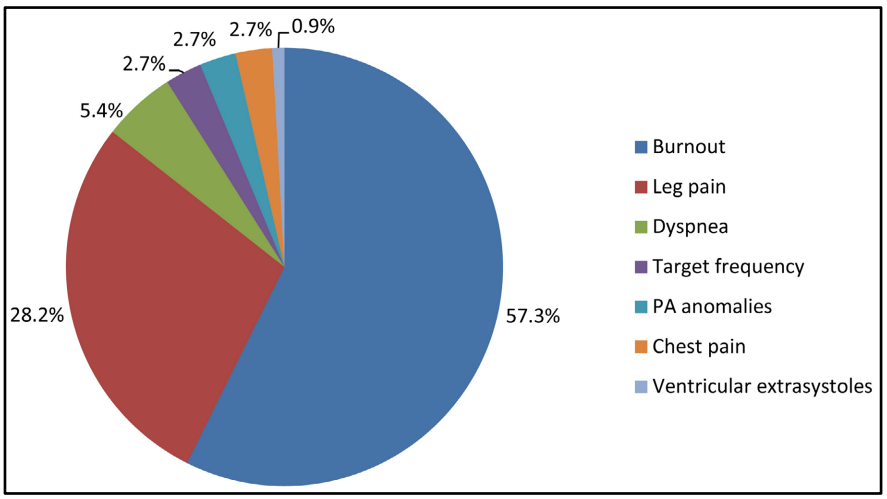

Figure 3. Distribution of discontinuation criteria.

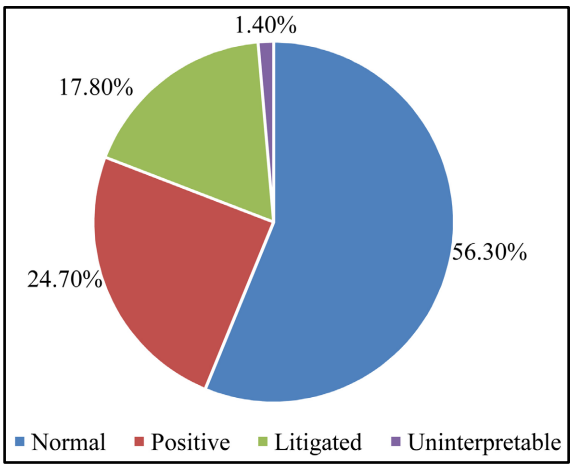

Figure 4. Distribution according to stress test result.

studies [8] [13]. The sex ratio in our study was 3.5. This male predominance was found by Coulibaly [14], Joel [8] and Tahirou [13] with 6.8, 1.3 and 1.8 respectively. This can be explained by the high incidence of coronary heart disease in men.

Medical history and risk factors were dominated by obesity and hypertension with 77.1% and 52.1% respectively. This result is generally consistent with the sub-regional literature but with different proportions [8] [13]. We noted 20.8% of our patients had known coronary artery disease, in agreement with the series by Joel [8], who found that 20% of these patients had a history of myocardial infarction. The importance of coronary artery disease in our two studies can be explained by the fact that all the recommendations indicate an ET after myocardial infarction in order to search for residual ischaemia, a rhythm disorder and to evaluate the treatment.

Our indications were dominated by chest pain (63%) and detection of ischaemia (15.1%) of cases. These indications are similar to those of other authors. Tahirou [13] found 73% chest pain and 14.0% detection of ischaemia. For Joel [8], chest pain and dyspnoea accounted for 83.0% and 55% respectively.

We performed a stress test on a cycle ergometer, unlike most of the studies in our sub-region [7] [8] [13], as this is the most suitable method in our context even though it is less physiological than that performed on a treadmill.

During the test, 3/4 of our patients had reached at least a load of 120 watts corresponding to a level of at least 4. The same level was reached by 78% of Joel's patients [8] and 80% of Aw's [7]. ET was sub-maximal in almost 49% and maximal in a further 22.2%. On the other hand, Joel [8] found a sub-maximal EE of 70% and AW [7] a proportion of maximal ET of 85%. This could be linked to the type of ET used in these 2 studies, *i.e.* the treadmill, which is more physiological and less tiring than ours.

Our stopping criteria, dominated by exhaustion (57.3%) and leg pain (28.2%), differed a little from those of other authors. For Joel [8] it was maximum effort (77%) and exhaustion (11%). For AW [7] it was muscle fatigue (52.5%) and anginal pain (27.5%). This may be explained by the type of test used in our various studies, since the treadmill test is more physiological and less tiring than the cycle ergometer test.

At the end of the stress test, almost 1/4 of the tests in our series were positive, whereas this proportion was 68% for Aw [7].

Only 4 of our positive cases had undergone coronary angiography, including 3 with significant lesions and one case of suspected coronary spasm. In one case the lesion was a 3-vessel disease and in two cases it was a single lesion. The 3 patients with significant lesions all underwent successful angioplasty. In the Senegalese series, 74% of positive cases were able to undergo coronary angiography, with 45% having significant lesions [7]. This difference may be explained by the difficulty our patients had in accessing coronary angiography, mainly for financial reasons.

6. Limitations of the Study

Our study has a number of limitations, including: the retrospective design of the study, which led to missing data and selection bias; the limited access of our patients to coronary angiography, making it impossible to cross-reference the results of the 2 investigations.

7. Conclusion

Despite its usefulness in terms of diagnosis and therapeutic guidance, EE remains a little-known and little-used test in our country, with only 73 cases in 79 months, hence the need to make it more widely available in our context of low-income countries where the vast majority of patients do not have access to coronary angiography.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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The Contribution of Exercise Testing in the Management of Ischaemic Heart Disease

Centre: "TOUCAM" medical practice in Kati

ID N° dossier Completion date: /___/____/____/

Identification

First name: Last name Age (years) Profession

Sex: Residence

Antécédents personnels: 1 = Yes 0 = No

High blood pressure ☐ Diabetes ☐ Dyslipidemia ☐ Tobacco ☐ Ischaemic heart disease ☐

Others ……

Prescriber ……

Indications: ……

Treatment underway: ……

Resting ECG ☐ 1 = normal 2 = pathological. if 2, specify ……

Size ……..cm. **Weight**…….Kg

Stress test

Pre-test: Basic BP……../……. mmHg. Basic heart rate ……/min. MTF……/min

Effort: maximum bearing ……. maximum load ……Watts. Maximum BP ……/……mmHg

Maximum heart rate ……../min. % MTF ……..

Stopping criteria: ……

Stress ECG: ☐ 1 = normal 2 = pathological: ST abnormalities ……

Atrial rhythm disorder …….., Ventricular rhythm disorder …….. Others ……..

Recovery: ☐ 1 = Passive 2 = Active: Load……..Watts

Recovery ECG: ☐ 1 = normal 2 = pathological: ST abnormalities …….. Atrial rhythm disorder ……. Ventricular rhythm disorder ……. BP……../……mmHg.

Heart rate at 1 minute ……/min. complaints……

Recovery time ……..min. **Total duration of stress test** …….min

Resultat: ☐ 1 = normal 2 = positive 3 = disputed 4 = uninterpretable