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# Pharmaco-Invasive Therapy is a Critical Option in Nigerian Stemi Treatment: A Review

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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***Review Article***

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## ABSTRACT

Primary percutaneous coronary intervention (PCI) is the recommended reperfusion approach in patients with ST-segment elevation myocardial infarction (STEMI), When conducted in a timely and by skilled operators. This technique, however, has proven to have limitations in areas without PCI facilities and with long wait times between the initial medical contact and balloon because to logistical issues and a lack of skilled operators. In STEMI patients, pre-treatment with a fibrinolytic prior to PCI has the potential to give early pharmacologic reperfusion before definitive PCI. According to current evidence, assisted PCI has no advantage over main PCI. The role for pharmaco-invasive reperfusion, defined as pharmacological re-perfusion followed by rapid transfer for routine delayed coronary angiography and PCI may still be considered in centers without on-site PCI capability.

Patients presenting with STEMI in Nigeria have a lot of challenges which include delay in decision making, cost of revascularization, religious believes, ignorance and availability of cardiac catheterization and the skillful personnel for the operation. To meet with the demand and

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challenges of Myocardial infarction in Nigeria, we need the mode of treatment that is beneficial, cost effective and lifesaving. Hence, pharmaco-invasive is the way for Nigeria and other low-income countries of sub-Saharan Africa.

*Keywords: Pharmacoinvasive; percutaneous coronary intervention; myocardial infarction; facilitated.*

## 1. INTRODUCTION

"Coronary artery disease [CAD] is rising in Nigeria" [1-5]. "CAD may present as asymptomatic and symptomatic. The symptomatic coronary artery disease could present as stable angina, unstable angina, non-ST-segment myocardial infarction [NSTEMI] and ST-segment myocardial Infarction [STEMI]" [6]. The urgency of treatment depend on the presenting phenotype of CAD [7,8]. Also, STEMI is the only phenotype that require the use of fibrinolytic drugs. The examples of these drugs include streptokinase, alteplase and tenecteplase [9-11].

**Nigerian population:** "The total population in Nigeria was estimated at 211.4 million people in 2021, according to the latest census figures and projections from Trading Economics". [12] below is the map of Nigeria with the 36 states and the federal capital territory, Abuja.Fig. 1 showed Nigerian map with the 36 states and the federal capital territory, Abuja.

**Definitions:** "Pharmaco-invasive therapy refers to administration of fibrinolytic agent, then systematically performing an angiography (and PCI if needed) within 3 to 24 hours after the start of fibrinolytic therapy; regardless of whether fibrinolysis results is successful or not" [13]. "In the event of fibrinolytic failure, then rescue PCI should be performed immediately and the initial 3-hours window should not be taken into account" [13,14].


**Fig. 1. Nigeria map**

**Acute MI trial proved the usefulness of pharmaco-invasive therapy:**

Time to treat < 90 minutes
Time to fibrinolytic < 30 minutes

These are illustrated in Fig. 2 and Fig. 3. The diagnosis of STEMI is from the time 0 clock. The decision for choosing reperfusion strategy in patients presenting via Emergency room form out-of-hospital setting or in a non-PCI center is based on the estimated time from STEMI diagnosis represent the maximum time to perform specific interventions.

A STEMI patient should have PIC with stent within 90 minutes of the onset of symptoms. If patient cannot get to the Cath lab within 120 minutes, then fibrinolytic agents such streptokinase, Alteplase, tenecteplase should be given, and move patient to the cath lab for coronary angiogram with or without PCI + stent within 3-24 hours [13,14].

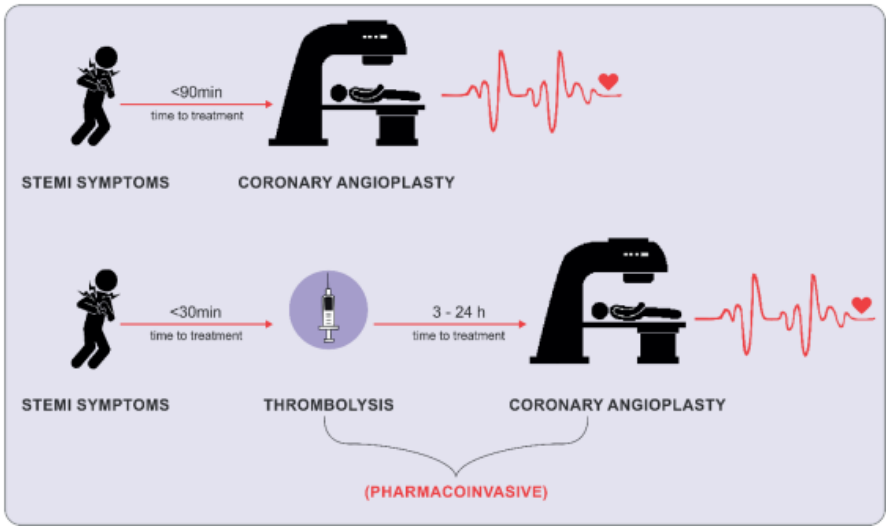


**Fig. 2. Pharmaco-invasive approach of STEMI care (adapted from [14])**

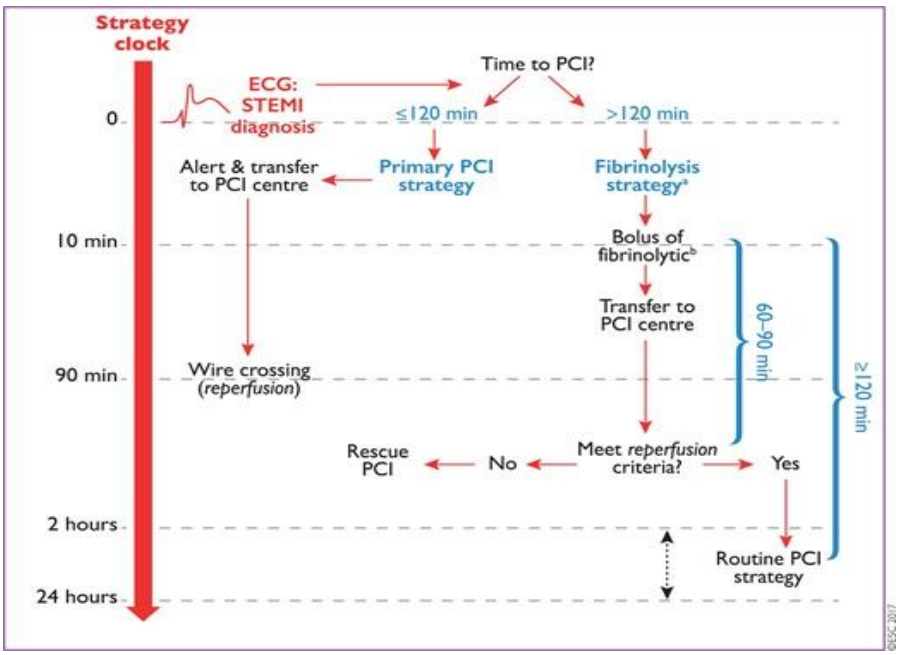


**Fig. 3. Target times according to reperfusion strategy selection in patients presenting via Emergency room or in a non-PCI center**

*ECG = electrocardiogram; PCI = Percutaneous Coronary Intervention; STEMI = ST-segment elevation myocardial infarction. [15] Adapted from ESC 2017 guideline [15]*

## 2. PCI CENTERS IN NIGERIA

The PCI centers are in some cities in Nigeria. These include Lagos, Yenegoa, Port Harcourt, Abuja, Enugu, Ekiti, etc. There are many cities in Nigerian 6 geopolitical regions. Most of these cities have no functional cardiac catheterization laboratory. Also, many of the hospitals with cath labs cannot perform coronary artery by-bass surgery hence they are stand alone PCI centers without surgical back up.

**Challenges of STEMI Management in Nigeria:** Re-perfusion therapy is the pillar of STEMI management. Among the various approach to re-perfusion, primary PCI is preferred if it can be done timely. If that is not available [within 120minutes from onset of symptoms] then fibrinolytic drugs should be given and followed with urgent PCI within 24 hours in PIC-capable center, for re-perfusion therapy [12]. In Nigeria it is not readily accessible due to many challenges which may include the following:

1. **Accessibility:** This is not limited to geographies with no access to PCI facilities, but also in regions where cardiac catheterization laboratories are available. Among those that will be available for PCI, the distance of the PCI capable center from the city where the patient lives may take several hours to get there.

2. **Finance:** This is one of the key challenges in STEMI treatment in Nigeria. The cost of the treatment is expensive and the most patients pay from their pockets. Once patients are informed of the cost, some will give off hope, others will tell you that they will look for the money first. Only few will proceed for the therapy to meet with timing of PCI.

3. Delay within the PCI capable hospital may result from patient or Health-care system delay. Patient delay is the time from symptom onset to the first medical contact. The common cause of patient delay include finance, denial of diagnosis, wrong advise from relatives or friends, religion and ignorance and lack of awareness.

4. Health-care system delay is the time from medical contact to reperfusion. This may result from lack of transfer facilities or inaccessibility of hospital with PCI capabilities. Other causes of health system delay include factors such as traffic congestion, delay in shifting the patient.

5. **Delayed presentation:** This is one of the major problems in accessing early reperfusion therapy. Lack of public education and awareness in recognizing early signs and symptoms of myocardial infarction is a significant challenge in Nigeria. This is due to low rates of literacy and diverse society. Delay in transportation time is another major problem. For example, majority of hospitals ambulances are not equipped with paramedics. The services of paramedics in Nigeria is still far from optimal. Our roads are bad with multiple potholes that slow than vehicle movement

While in this delay, imminent myocardial damage has occurred, and the timing of primary PCI has elapsed. This can be prevented by using fibrinolytic therapy. Therefore, in the Nigerian context, pharmaco-invasive approach is a golden opportunity for the management of STEMI patients. This help in prolonging the prolongs the window of opportunity to 24 hours and provide breathing space to overcome some of the challenges listed above.

These points above highlighted the critical need of pharmaco-invasive therapy in Nigeria. This approach may cover many cities, suburban and villages in Nigeria where PCI is not readily available.

**The geography and logistics of transport and cost of the procedure:** The advantage of pharmaco-invasive system and any long term follow up are dependent on factors like the type of fibrinolytic agent used. In Nigeria, we must give room for pharmaco-invasive therapy. This can prove a wide time window for PCI if pharmaco-invasion is followed.

**Pharmaco-invasive Reperfusion Therapy:** Initial fibrinolysis followed by the start of angiography/PCI revealed prospective benefits in a number of clinical investigations. A overview of trials comparing routine early PCI following fibrinolysis to conventional treatment in STEMI patients is shown in Table 1. The meta-analyses that contrasted routine early coronary angioplasty with ischemia-guided angioplasty after thrombolysis have also supported the idea of pharmaco-invasive treatment.

**Table 1. Trials comparing fibrinolysis plus PCI versus Primary PCI**

| Study (year) | Inclusion criteria | Lytic agent (type) | Strategy | Symptoms to lytic therapy/early PCI (min) | Primary endpoint |
|---|---|---|---|---|---|
| SIAM-III (2003) [14] | STEMI patients presenting <12 h from symptom onset. | Reteplase | Standard therapy (81 patients) (rescue PCI in 12%)<br>Early PCI < 6 h from lysis (82 patients) (PCI in 100%) | 216<br>192 | Combined death, reinfarction, recurrent ischaemia, target lesion revascularization at 6 months |
| CARESS-IN-AMI (2008) [17] | High-risk STEMI patients presenting <12 h from symptom onset | Reteplase (HALF dose) | Standard therapy (301 patients) (rescue PCI in 31%)<br>Immediate PCI after lysis (299 patients) (PCI in 86%) | 165<br>161 | Combined death, Reinfarction and recurrent ischaemia at 30 days |
| GRACIA-1 (2004) [18] | STEMI patients presenting <12 h from symptom onset | Alteplase (accelerated) | Early PCI <3 h from lysis (86 patients) (PCI in 89%)<br>Standard therapy (251 patients) (rescue PCI in 12%) | 120<br>187 | Combined death, reinfarction, ischaemic induced revascularization at 12 months |
| CAPITAL-AMI (2005) [19] | 1 High-risk STEMI patients presenting < 6 h from symptom onset | Tenecteplase | Early PCI < 24 h from lysis (104 patients)d (PCI in 86%)<br>Standard therapy (84 patients) (rescue PCI in 9.5%) | 120<br>120 | Combined death, reinfarction, ischaemic events or stroke at 6 months |
| WEST (2006) [20] | STEMI patients presenting < 6 h from symptom onset | Tenecteplase | Early PCI <6 h from lysis (537 patients) (PCI in 85%)<br>Standard therapy (100 patients) (rescue PCI in 14%) | 113<br>113 | Combined death, reinfarction, recurrent ischaemia, new CHF, cardiogenic shock, and major ventricular arrhythmia at 30 days |

| Study (year) | Inclusion criteria | Lytic agent (type) | Strategy | Symptoms to lytic therapy/early PCI (min) | Primary endpoint |
|---|---|---|---|---|---|
| TRANSFER-AMI (2009) [21] | High-risk STEMI patients presenting <12 h from symptom onset | Tenecteplase | Immediate PCI after lysis (134 patients) (PCI in 86%)<br>Standard therapy (522 patients) (rescue PCI in 25%) | 117<br>115 | Combined death, reinfarction, recurrent ischaemia, new CHF, cardiogenic shock at 30 days |
| NORDISTEMI (2010) [22] | STEMI patients presenting <6 h from symptom onset | Tenecteplase | Primary PCI (948 patients)<br>Standard therapy (132 patients) (rescue PCI in 27%) | 178<br>126 | Combined death, reinfarction, recurrent ischaemia, or stroke at 12 months |
| STREAM (2010) [23] | STEMI patients presenting <3 h from symptom onset | Tenecteplase (only in age>75yrs, HALF dose) | Primary PCI (155 patients)<br>Early fibrinolysis (<3h symptom) followed by PCI (6-24h) (944 patients) (rescue PCI in 36%) | 260<br>100 | 30-day composite of death from any cause, shock, congestive heart failure, or reinfarction |
| STEPP AMI (2016) [24] | STEMI patients presenting <12 h from symptom onse | Tenecteplase | Fibrinolysis + PCI (<12h symptom) (rescue PCI 12%)<br>Primary PCI (155 patients) | 245<br>260 | Composite of death, reinfarction, repeat revascularization, CHF |

*Note: STEMI, ST elevation myocardial infarction; PCI, percutaneous coronary intervention; CHF, congestive heart failure*

**Table 2. Characteristic features of fibrinolytic agents [16,25-28]**

| characteristics | Streptokinase | Alteplase | Reteplase | Tenecteplase |
|---|---|---|---|---|
| Plasminogen activation | Indirect | Direct | Direct | Direct |
| Allergic reactions | Yes | No | No | No |
| Fibrin specificity | No | Yes | Yes | Yes |
| Dose /administration | 1.5M | 15 mg bolus plus 90-min infusion up to 85mg | 10 + 10 units double bolus given over 2 min with 30 minutes apart | < 60 kg - 30 mg (6 mL)<br>60 to 69 kg - 35 mg (7 mL)<br>70 to 79 kg - 40 mg (8 mL)<br>80 to 89 kg - 45 mg (9 mL)<br>≥90 kg - 50 mg (10 mL) |
| Plasma half life | 18mins [fast half]<br>83mins [slow half life] | 5 mins | 18 mins | 20 mins |
| Activity on platelet rich clot | + | ++ | + | +++ |
| Patency at 90 min | + | +++ | +++ | +++ |
| TIMI grade 3 flow (%) | 32 | 54 | 60 | 63 |
| Systemic fibrinogen depletion | Marked | mild | Moderate | Minimal |
| Cost | + | ++++ | ++++ | ++++ |

*Note: TIMI, thrombolysis in myocardial infarction; PAI-1, plasminogen activator inhibitor-1 Reteplase*

**Fibrinolytic Options for Pharmaco-Invasive Therapy:** Fibrinolytic agent lyses thrombotic occlusion associated with STEMI and restores the coronary flow. These drugs reduce infarct size and improves myocardial function and survival over the short-term and long-term. These drugs work by converting plasminogen to plasmin, the active enzyme. Plasmin is a serine protease that works by dissolving fibrin blood clots. A range of fibrinolytic agents are present in Nigeria.

These include the first generation Streptokinase to newer fibrinolytic agents such as the second generation Alteplase, and third generation Reteplase and Tenecteplase. The Table 2 detail the characteristics of the commonly used fibrinolytic agents.

The characteristic features of different fibrinolytic agents are:

> "Reteplase is a second-generation recombinant tissue-type plasminogen activator. It works more rapidly and to have a lower bleeding risk than the first-generation agent alteplase. It is a synthensized from nonglycosylated deletion mutein of tPA that contains 355 of the 527 amino acids of native tPA. The drug is produced in Escherichia coli by means of recombinant DNA techniques" [29].
>
> "Reteplase does not bind fibrin as tightly as native Tpa. It can diffuse more freely through the clot rather than bind only to the surface as tPA does. At high concentrations, reteplase does not compete with plasminogen for fibrin-binding sites, allowing plasminogen at the site of the clot to be transformed into clot-dissolving plasmin. These characteristics help explain why clots resolve faster in patients receiving reteplase than in those receiving alteplase" [29].
>
> "The biochemical modifications also resulted in a molecule with a longer half-life (~13-16 minutes), which allows bolus administration. It is administered as two boluses of 10 U given 30 minutes apart, with each bolus administered over 2 minutes" [29]. "The result is more convenient administration and faster thrombolysis with reteplase than with alteplase, which is given in a bolus followed by intravenous (IV) infusion" [29]. Like alteplase, reteplase may be readministered as necessary; it is not antigenic and almost never is associated with any allergic manifestations.

Tenecteplase: "Tenecteplase, a variant of the t-PA. It is 527-amino-acid glycoprotein (GP) and it has modifications in amino acid molecules. These modifications included substitution of asparagine for threonine 103 and glutamine for asparagine 117, as well as a tetra-alanine substitution at amino acids 296-299 in the protease domain. It molecule is an approved agent for the treatment of STEMI" [30]. "Unlike the earlier generation lytics, Tenecteplase can be administered as a single bolus over five seconds. It has the highest fibrin specificity and resistance to inactivation by plasminogen activator inhibitor-1 (PAI-1). The weight-based dosing is the main drawback of Tenecteplase, as significant dosing errors could occur due to wrong measurements of weight during the emergency situations that are common in STEMI" [30-32].

**Streptokinase:** "Streptokinase is produced by beta-hemolytic streptococci. It is not a plasminogen activator, but when it binds with free circulating plasminogen (or with plasmin), it forms a complex that can convert additional plasminogen to plasmin" [33]. "Streptokinase activity is not enhanced in the presence of fibrin. Studies using radioactive streptokinase have documented two disappearance rates: a "fast" half-life (~18 minutes) and a "slow" half-life of (~83 minutes)" [33].

"Because streptokinase is produced from streptococcal bacteria, it often causes febrile reactions and other allergic problems" [33]. "It can also cause hypotension that appears to be dose-related. Streptokinase usually cannot be administered safely a second time within 6 months, because it is highly antigenic and results in high levels of antistreptococcal antibodies" [33].

"Streptokinase is the least expensive fibrinolytic agent, but unfortunately, its antigenicity and its high incidence of untoward reactions limit its usefulness in the clinical setting" [33].

Reperfusion strategy in STEMI: Once the diagnosis of STEMI is confirmed, the patient could be taken for primary PCI or pharmaco-invasive therapy. The Fig. 4 below explain the illustration of the steps approach to management.

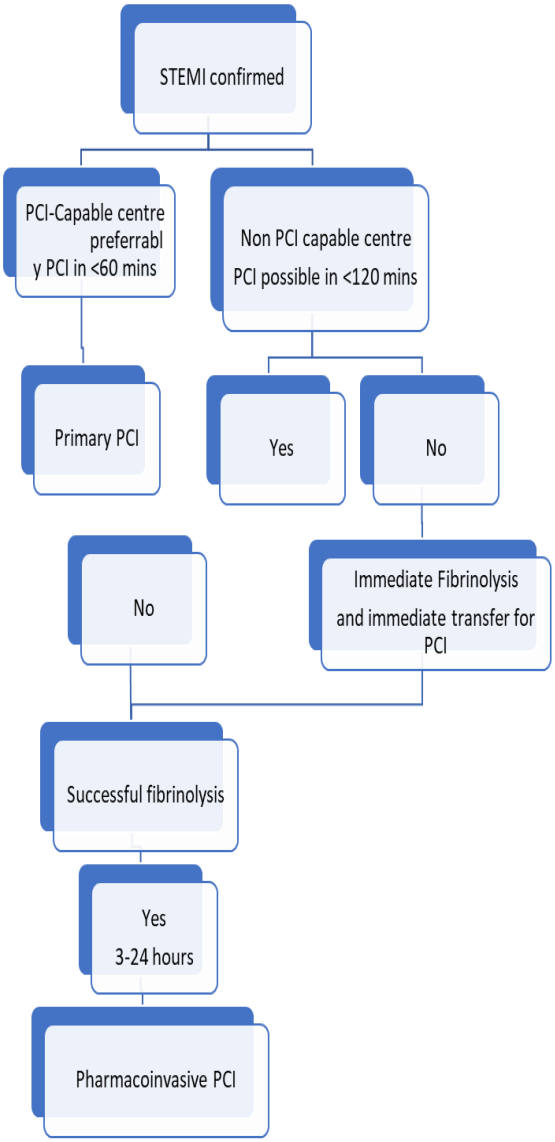


**Fig. 4. Reperfusion strategy in STEMI**

## 3. TYPES OF PHARMACO-INVASIVE THERAPY [34,35]

Four types of pharmaco invasive therapies are being utilized currently:

1. Facilitated PCI: PCI done following thrombolysis for all patients with STEMI who do not have absolute contraindication to thrombolysis.
2. Consolidating PCI: PCI early after thrombolysis that can establish recanalization when lysis has failed, and bolster benefit when it has succeeded.
3. RESCUE PCI: PCI following thrombolysis in patients in whom thrombolysis has failed.
4. DELAYED PCI: This is late PCI post thrombolysis, if needed to improve recurrent ischemia before discharge from the hospital

## 4. NEED FOR PHARMACO INVASIVE THERAPY [12-14]

The outcome of STEMI is influence by the time from symptomatic onset to successful reperfusion. Time is critical factor in STEMI care. Every 30 minutes delay in treatment present an increase of 75% mortality per year. Early fibrinolytic therapy saves life. The Table 3 showed the various time target to save the myocardium.

**Import targets:**

**Table 3. Imported targets in treatment of STEMI [5-6, 12-14]**

| S/N | INTERVALS | TIME TARGET |
|---|---|---|
| 1. | Maximum time from FMC to ECG and diagnosis | ≤10minutes |
| 2. | Maximum delay from STEMI diagnosis to primary PCI (wire Crossing) to choose primary PCI one fibrinolytic agent | ≤120 minutes |
| 3. | Maximum time from STEMI diagnosis to wire crossing in patients presenting as primary PCI hospital | ≤60 minutes |
| 4. | Maximum time from STEMI diagnosis to wire crossing in transferring patients | ≤90 minutes |
| 5 | Maximum time from STEMI diagnosis to bolus or infusion of fibrinolyte | ≤10 minutes |
| 6. | Time delay from start of fibrinolyte to evaluation of its efficacy (success or failure | 60 – 90minutes |
| 7. | Time delay from start of fibrinolytic to angiogram (if fibrinolytic is successful | 3 -24 hours |

**Contraindication of thrombolysis:**

1. **Absolute CI:**
   - Previous ICH or stroke of unknown origin
   - Ischemic stroke in the past 6 months
   - Recent major trauma/surgery/head injury (within the preceding 3 weeks)
   - GI bleeding within the past month
   - Known bleeding within past month
   - Known bleeding disorder
   - Aortic dissection
   - Non compressible puncture in the past 24 hours ( e.g lung biopsy, lumber puncture)
2. **Relative CI:**
   - Transient ischemic attack in the last 6 months
   - Oral anti-coagulant therapy
   - Pregnancy or within one week post-partum
   - Refractory hypertension > 180/100 mmHg
   - Advanced lung disease
   - Infective endocarditis
   - Acute peptic ulcer
   - Prolong traumatic resuscitation

## 5. CONCLUSION

To meet with the demand and challenges of Myocardial infarction in Nigeria, we need the mode of treatment that is beneficial, cost effective and life saving. Hence, pharmaco-invasive is the way for Nigeria and other low income countries of Africa.

## CONSENT AND ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Oyati AI, Danbauchi SS, Alhassan MA, Isa MS: Is the incidence of acute myocardial infarction in Nigerians increasing?. Annals of African Medicine. 2005;4(3):132-135.
2. Akinboboye A, Idris O, Akinboboye O, Akinkugbe O: Trends in coronary artery disease and associated risk factors in sub-Saharan Africans. J Hum Hypertens. 2003,17:381-387. DOI:10.1038/sj.jhh.1001562.
3. Nwaneli CU: Changing trend in Coronary Heart Disease in Nigeria. Afrimedic Journal. 2010;1 (1):1-4.
4. Mensah GA: Ischaemic Heart Disease in Africa. Heart. 2008;94:836-843.
5. Mocumbi AO, Ferreira MB: Neglected Cardiovascular Diseases in Africa; challenges and opportunities. J Am Coll Cardiol. 2010;55:680-687.
6. Kumar M, Cannon CP, Acute Coronary Syndromes: Diagnosis and Management Mayo Clin Proc. 2009 Oct;84(10):917-938.
7. Martin U, Sponer G, Strein K. Evaluation of thrombolytic and systemic effects of the novel recombinant plasminogen activator BM 06.022 compared with alteplase, anistreplase, streptokinase and urokinase

in a canine model of coronary artery thrombosis. JACC. 1992;19:433-440.
8. Kohnert U, Rudolph R, Verheijen JH. Biochemical properties of the kringle 2 and protease domains are maintained in the refolded t-PA deletion variant BM 06.022. Protein Engineering. 1992;5:93-100.
9. Bode C, Smalling R, Gunther B, et al. Randomized comparison of coronary thrombolysis achieved with double bolus reteplase (recombinant plasminogen activator) and front-loaded, accelerated alteplase (recombinant tissue plasminogen activator) in patients with acute myocardial infarction. Circulation. 1996;94:891-898.
10. INJECT Study Group. Randomised, double-blind comparison of reteplase double-bolus administration with streptokinase in acute myocardial infarction (INJECT): trial to investigate equivalence. Lancet. 1995;346:329-336.
11. Martin U, Gärtner D, Markl HJ, et al. D-PHE-PRO-ARGCHLOROMETHYLKETONE prevents in vitro fibrinogen reduction by the novel recombinant plasminogen activator BM 06.022. Ann Hematol. 1992;64(suppl)A47.
12. Nigerian population by World Bank estimate; 2021.
13. Alexander T, Juvale NJ, Dasbiswas A, Kubba S, Singh RK, Raja V. Pharmaco-invasive Therapy with fibrinolytic agents: A potent lifesaving reperfusion strategy in STEMI Patients in Metro/Tier-I Cities in India. Journal of The Association of Physicians of India. 2018;66:1-7.
14. Alexander T. STEMI in India. A newly developed system towards a practical and equitable ST-segment elevation myocardial infarction (STEMI) system of care connecting rural India. Eur Heart J. 2016;37:2449-2453.
15. Borja Ibanez, Stefan James, Stefan Agewall, Manuel J Antunes, Chiara Bucciarelli-Ducci, Héctor Bueno, Alida L P Caforio, Filippo Crea, John A Goudevenos, Sigrun Halvorsen, Gerhard Hindricks, Adnan Kastrati, Mattie J Lenzen, Eva Prescott, Marco Roffi, Marco Valgimigli, Christoph Varenhorst, Pascal Vranckx, Petr Widimský, ESC Scientific Document Group, 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC), European Heart Journal. 07 January 2018;39(2):119–177.
16. Scheller B, Hennen B, Hammer B, Walle J, Hofer C, Hilpert V, et al; SIAM III Study Group. Beneficial effects of immediate stenting after thrombolysis in acute myocardial infarction. J Am Coll Cardiol. 2003;42:634-41.
17. Di Mario C, Dudek D, Piscione F, Mielecki W, Savonitto S, Murena E, et al; CARESS-in-AMI (Combined Abciximab RE-teplase Stent Study in Acute Myocardial Infarction) Investigators. Immediate angioplasty versus standard therapy with rescue angioplasty after thrombolysis in the Combined Abciximab REteplase Stent Study in Acute Myocardial Infarction (CARESS-in-AMI): an open, prospective, randomised, multicentre trial. Lance.t 2008;371:559-68.
18. Fernandez-Avilés F, Alonso JJ, Castro-Beiras A, Vázquez N, Blanco J, Alonso-Briales J, et al; GRACIA (Grupo de Análisis de la Cardiopatía Isquémica Aguda) Group. Routine invasive strategy within 24 hours of thrombolysis versus ischaemia-guided conservative approach for acute myocardial infarction with ST-segment elevation (GRACIA1): A randomised controlled trial. Lancet. 2004;364:1045-53.
19. Le May MR, Wells GA, Labinaz M, Davies RF, Turek M, Leddy D, et al. Combined angioplasty and pharmacological intervention versus thrombolysis alone in acute myocardial infarction (CAPITAL AMI study). J Am Coll Cardiol. 2005;46:417-24.
20. Armstrong PW; WEST Steering Committee. A comparison of pharmacologic therapy with/without timely coronary intervention vs. primary percutaneous intervention early after ST-elevation myocardial infarction: the WEST (Which Early ST-elevation myocardial infarction Therapy) study. Eur Heart J. 2006;27:1530-8.
21. Cantor WJ, Fitchett D, Borgundvaag B, Ducas J, Heffernan M, Cohen EA, et al; TRANSFER-AMI Trial Investigators. Routine early angioplasty after fibrinolysis for acute myocardial infarction. N Engl J Med. 2009;360:2705-18.
22. Bøhmer E, Hoffmann P, Abdelnoor M, Arnesen H, Halvorsen S. Efficacy and safety of immediate angioplasty versus ischemia-guided management after

thrombolysis in acute myocardial infarction in areas with very long transfer distances results of the NORDISTEMI (NORwegian study on DI strict treatment of ST-elevation myocardial infarction). J Am Coll Cardiol. 2010;55:102-10.

23. Armstrong PW, Gershlick A, Goldstein P, Wilcox R, Danays T, Bluhmki E, et al; STREAM Steering Committee. The Strategic Reperfusion Early After Myocardial Infarction (STREAM) study. Am Heart J. 2010;160:30-35.
24. Victor SM, Vijayakumar S, Alexander T, Bahuleyan CG, Srinivas A, Selvamani S, et al. Two-year follow-up data from the STEPP-AMI study: A prospective, observational, multicenter study comparing tenecteplase-facilitated PCI versus primary PCI in Indian patients with STEMI. Indian Heart J. 2016;68:169-73.
25. Vanscoy GJ, Rihn TL, Koerner PH. Tenecteplase: Innovative Fibrinolysis for ST-Segment Elevation Myocardial Infarction (STEMI). PandT Journal. 2003; 28:21-30.
26. Elliott A. ST-Segment elevation myocardial infarction: Management. In: Bonow et al., editors Braunwald's Heart Disease. 9th ed. Missouri: Saunders; 2012.
27. Wander GS, Chhabra ST. Critical analysis of various drugs used for thrombolytic therapy in acute myocardial infarction. Medicine Update 2013;23:109-16.
28. Melandri G, Vagnarelli F, Calabrese D, Semprini F, Nanni S, Branzi A. Review of tenecteplase (TNKase) in the treatment of acute myocardial infarction. Vascular Health and Risk Management. 2009;5:249.
29. Smalling R, Bode C, Kalbfleisch J, et al. More rapid, complete, and stable coronary thrombolysis with bolus administration of reteplase compared with alteplase infusion in acute myocardial infarction. Circulation. 1995;91:2725-2732
30. Dasbiswas A, Hiremath JS, Trailokya A. Overview of Reteplase, A Novel Thrombolytic Agent in Indian Context. Cardiovascular Pharmacology: Open Access; 2015 Apr 23.
31. Vanscoy GJ, Rihn TL, Koerner PH. Tenecteplase: Innovative Fibrinolysis for ST-Segment Elevation Myocardial Infarction (STEMI). PandT Journal. 2003; 28:21-30.
32. Elliott A. ST-Segment elevation myocardial infarction: Management. In: Bonow et al., editors Braunwald's Heart Disease. 9th ed. Missouri: Saunders; 2012.
33. Sikri N, Bardia A. A history of streptokinase use in acute myocardial infarction. Tex Heart Inst J. 2007;34(3):318-27.
34. Nair T, Agrawa R, Bansal S, Dutta A, Ray R, Ray S. Expert Consensus Document on Management of ST-Elevation Myocardial Infarction: Adaptation of 2012 ESC Guidelines. Indian J Crit Care Med. 2018; 22:274-82.
35. Khan S, Khan S, Hossain H, Mira AKA. Pharmaco-invasive therapy in improving outcomes for patients with ST-Elevation Myocardial Infarction (STEMI) - Expert Consensus. Haya Saudi J Life Sci. 2021; 6(10):244-248.



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