



## Pseudonormalization of T Waves after Coronary Angioplasty: A Medical Emergency

Abhijeet Shelke B\*, Ramesh Kawade and Chintha Sriram

Department of Cardiology, Krishna Institute of Medical Sciences "Deemed University", Karad, India

### Abstract

The changes in the Electrocardiography (ECG) are known to occur during and after coronary angioplasty. T waves may be inverted in patients with chronically ischemic myocardial cells due to abnormal transmural action potential gradient. Such patient when develop acute ischemia, may present with upright T waves in the ECG as an early sign which is called as pseudonormalization. However the importance of pseudo normalization of T waves after angioplasty is not described in the literature. Pseudonormalization may be the only ECG change seen during acute vascular occlusion immediate after angioplasty. It requires early diagnosis and emergency vascular intervention. This case report highlights the usefulness and value of old ECG sign in the management of patient with chest pain post angioplasty. Also we discuss electrophysiological mechanism in detail.

**Keywords:** Pseudonormalization; Post-angioplasty; ECG; Acute coronary occlusion

### Learning Objectives

ECG changes may be noticed during and immediately after angioplasty. Pseudonormalization of T waves after angioplasty indicates acute transmural ischemia and urgent coronary intervention is required. Early recognition of Subtle ECG signs is important in the management patients with acute cardiac ischemia who have baseline ECG abnormality.

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#### \*Correspondence:

Abhijeet Shelke B, Department of Cardiology, Krishna Institute of Medical Sciences "Deemed University", Malakapur, Karad (Dist: Satara), 415110, Maharashtra, India, Tel: +91-2164-241555; E-mail: panacea2005.abhijeet@gmail.com

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### Introduction

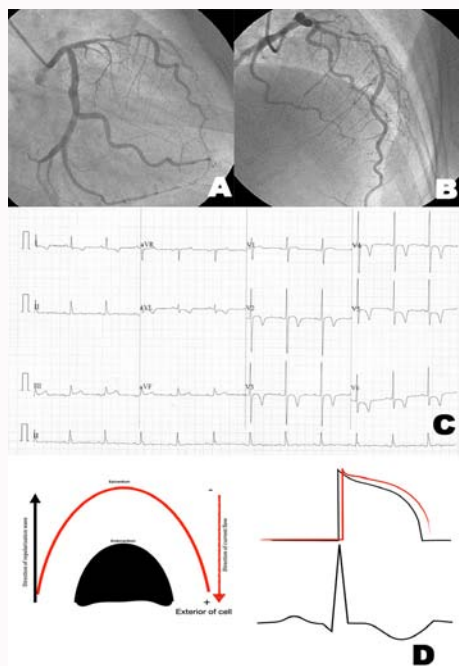
Physiologically; T waves are upright in all the ECG leads except lead aVR & V1. T waves may be inverted in patients with chronically ischemic myocardial cells due to abnormal transmural action potential gradient. Shawl et al. [1] observed that symmetric T wave inversion in chest leads is commonly present in patients with severe stenosis of the proximal left anterior descending coronary artery. The study also revealed that; these T inversions may persist for more than 28 weeks after successful revascularization with angioplasty and only half patients had complete normalization of T waves within 14 weeks.

T wave normalization immediately after angioplasty; especially with symptoms of ischemia may indicate acute vascular occlusion. This phenomenon is called as Pseudonormalization. In this report we present a case of pseudonormalization post angioplasty; due to acute vascular occlusion. Also we discuss the mechanism of pseudonormalization in detail.

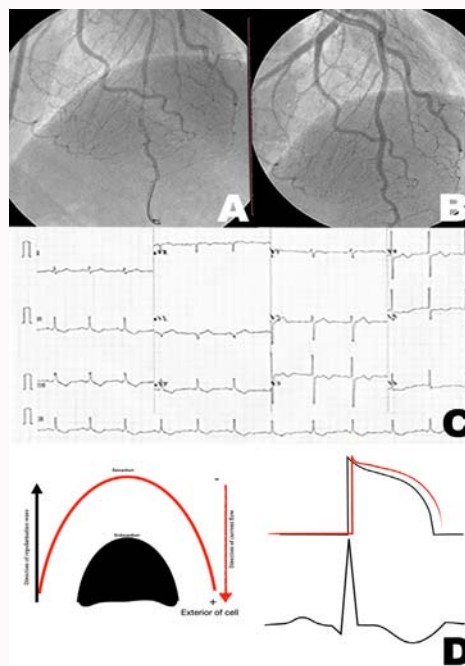
### Case Presentation

A 50-year-old female presented with angina on exertion. Baseline ECG showed symmetrical deep T wave inversion in leads I, aVL, and V2-V6 (Figures 1A-1C). LV systolic function was normal on 2D Echocardiography. She underwent coronary angiography which revealed 90% stenosis of mid-segment of the Left Anterior Descending artery (LAD). Subsequently coronary angioplasty to LAD was performed with drug-eluting stent (PROMUS ELEMENT, Boston scientific). Four hours after the angioplasty; she developed the chest pain. ECG was recorded immediately (Figure 2C). ECG recorded during pain showed upright T waves in the limb leads (I and aVL), and the chest leads (V2 to V6).

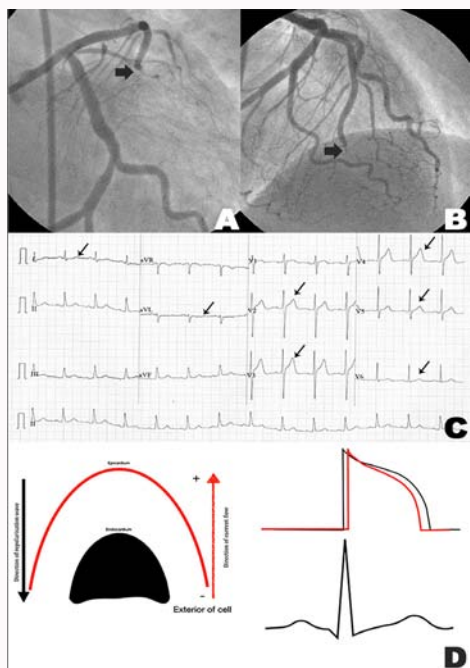
The patient was immediately shifted to the Cath-lab to perform a recheck coronary angiogram. It showed patent stent with distal LAD total occlusion (Figure 2A, 2B). The distal TIMI III flow was established with balloon dilatation and stent implantation (Figure 3A, 3B). ECG recorded (Figure 3C) after procedure showed inverted T waves similar to baseline ECG.



**Figure 1:** 1A (caudal view) and 1B (cranial view) are angiographic pictures showing mid LAD 90% lesion. 1C - shows baseline ECG with T inversions in I, aVL and chest leads. 1D - explain the electrophysiological basis of baseline T inversions.



**Figure 3:** 3A and 3B (Both cranial view) are angiographic pictures showing revascularization of distal LAD. (Black thick black arrows). 3C - ECG shows inverted T waves after revascularization. 3D - explain the electrophysiological basis of T wave morphology.



**Figure 2:** 2A (caudal view) and 2B (cranial view) are angiographic pictures showing distal LAD total occlusion (Black thick black arrows). 2C - ECG shows pseudo normalization of T waves due to acute transmural ischemia (thin black arrows). 2D - explain the electrophysiological basis of pseudo normalization of the T wave.

### Discussion

The term pseudonormalization of T-waves indicates that inverted T waves become positive similar to normal T waves. This phenomenon may indicate the re-occlusion of the re-perfused artery. It was first described in the 1970s when continuous ECG monitoring

was available [2]. The exact mechanism of pseudonormalization of T waves is not known. Under the normal circumstances, repolarization always begins in the sub-epicardium and travels to the sub-endocardium. When repolarization occurs in subepicardial cells, the interior of the cell becomes negatively charged and the exterior of the cell becomes positively charged. While at the same time the sub-endocardium is in state of depolarization with a positive intracellular charge and a negative extracellular charge. The direction of the current flow is from the negatively charged external surface to the positively charged external surface. Hence current will flow from the sub-endocardium to the sub-epicardium resulting upright T wave in the surface 12-lead ECG [3].

The baseline ECG in our patient had T wave inversions in limb leads and chest leads. In patients with chronically ischemic myocardial cells, the action potential duration in the sub-epicardial tissue is delayed and prolonged compared to the sub-endocardium. Hence there will be a negative intracellular and positive external charge on subendocardial tissues. Therefore the direction of current flow is from the sub-epicardium to the sub-endocardium resulting in an inverted T wave in surface 12- lead ECG (Figure 1D).

Distal total occlusion of LAD caused upright T waves in the limb and chest leads (Figure 2C). When the event of acute ischemia occurs in chronically ischemic myocardial cells, the action potential duration in ischemic subepicardial cells is shortened compared to the subendocardial tissues. Hence the repolarization in subepicardial cells happens earlier resulting in a negative internal charge in the cells and a positive external charge. At the same moment, subendocardial cells have a negative external charge causing the flow of current from subendocardium to sub-epicardium. This manifests as a positive T wave in surface 12-lead ECG (Figure 2D). These changes in transmembrane action potentials in chronic ischemic cells during acute ischemia may explain the pseudonormalization of T waves [4].

After the immediate revascularization of the distal vessel; the normalized T waves became inverted (Figure 3C). Pseudonormalization may be the only ECG change or the early sign, preceding ST-segment elevation seen during acute myocardial ischemia. It warrants further interventional strategy.

## Summary

ECG changes are known to occur post-angioplasty. Pseudonormalization of T waves after angioplasty may indicate sudden occlusion of vessel; especially when patient has ongoing ischemic symptoms. Early recognition of this sign and immediate vascular intervention may change the prognosis of the patient.

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