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ST segment elevation following coronary artery bypass surgery

Jing Liu, MD *, Yochai Birnbaum, MD

Section of Cardiology, Baylor College of Medicine, MS: BCM620, One Baylor Plaza, Houston, TX 77030, United States of America

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ABSTRACT

ST elevation on ECGs immediately after cardiac surgery is usually considered to be non-specific. However, these ST changes can be the first clues to serious condition such as graft occlusion and myocardial infarction. We present two patients with ST elevation on ECGs immediately following coronary artery bypass surgery to illustrate that ST changes early after surgery can represent significant pathology and true ischemia after cardiac surgery, which warrants prompt investigation. More studies are needed to see if different thresholds for ST elevation should be used for detecting STEMI after heart surgery.

Introduction

While ST elevation in non-cardiac surgery patients with associated symptoms of angina is highly diagnostic of acute myocardial infarction, such ST changes on ECG immediately after cardiac surgery is usually considered to be non-specific and difficult to discern due to pericardial and myocardial inflammation. Further complicating the diagnosis of myocardial infarction in the immediate post cardiac surgery period is the fact that most patients are intubated and sedated. We present two patients with ST elevation immediately following bypass surgery to illustrate this diagnostic challenge.

Case 1

A 59-year-old male with a history of thyroid cancer status post thyroidectomy and radiation presented with chest pain. On presentation, patient's vital signs were stable. His cardiac examination was unremarkable. Initial electrocardiogram (ECG) showed T wave inversions in V4–V5, biphasic T wave in V6 (Fig. 1a). Troponin-I peaked at 0.11 ng/ml (normal range <0.03 ng/ml), then decreased to normal level. Coronary angiography showed severe multi-vessel disease: Distal left main coronary artery (LM) with 50% calcified stenosis extending into the left anterior descending artery (LAD), 80% ostial left circumflex (LCX) stenosis, proximal 70% right coronary artery (RCA) stenosis. Because the patient had significant fibrosis in the airway from previous radiation therapy, he was deemed too high risk for conventional coronary artery bypass surgery (CABG). Ultimately, patient underwent a hybrid approach of percutaneous coronary intervention (PCI) with stenting to the RCA, followed by robotic assisted minimally invasive bypass of left internal mammary artery (LIMA) to LAD. Following transfer to the cardiovascular recovery room, while still being sedated and ventilated, ST elevation was noted on the telemetry monitor and ECG was performed (Fig. 1b), showing new Q waves in III and aVF, a significant decrease in the R wave amplitude in V3–V6, ST elevation in II, III, AVF and V3–V6 and ST depression in I and aVL, which were new compared to his prior ECG (Fig. 1a). Troponin was 1.65 ng/mL. Transthoracic echocardiogram despite the use of contrast, was technically limited due to poor acoustic windows. The left ventricular endocardium was incompletely visualized and left ventricular systolic function was unable to be reliably assessed. *Trans*-esophageal echocardiogram was contraindicated due to his post-radiation esophageal stricture. Subsequent ECGs showed persistent ST elevation. Repeat troponin-I increased to 17.45 ng/ml. Patient underwent coronary angiogram which revealed a new LAD occlusion distal to the LIMA-LAD anastomosis. Patient underwent PCI to the LAD. Post intervention ECG showed resolution of ST elevation with new Q waves in V2–5. The Q waves in the inferior leads persisted (Fig. 1c). Troponin-I peaked at 70 ng/ml post intervention. Patient recovered from the procedure without significant cardiovascular adverse events.

Case 2

A 68-year-old male with coronary artery disease, status post 4-vessel CABG and PCI with two stents to the grafts was admitted to the cardiac intensive care unit after a routine surveillance CT scan revealed an intrathoracic aortic aneurysm measuring 6.5 cm, with intramural

* Corresponding author at: Section of Cardiology, Baylor College of Medicine, One Baylor Plaza, Houston, TX 77030, United States of America
E-mail addresses: jing.liu@bcm.edu (J. Liu), ybirnbau@bcm.edu (Y. Birnbaum).

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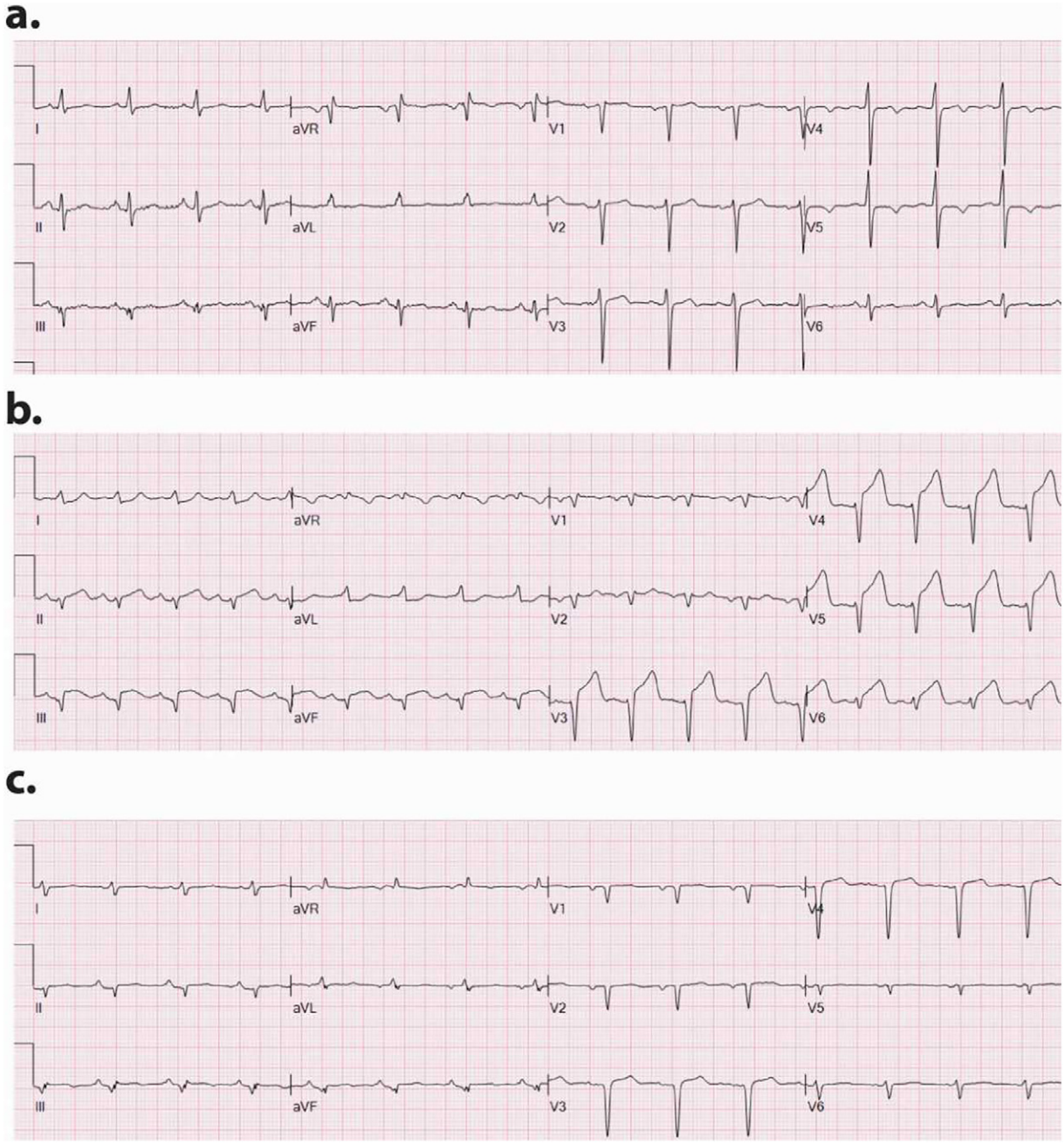

Fig. 1. A. Baseline ECG shows T wave inversion in V4–V5, and biphasic T wave in V6. **B**. ECG after CABG shows new Q waves in III and aVF, decrease in the R wave amplitude in V2–V6, ST elevation in the inferior leads + V3–V6 and reciprocal ST depression in I and aVL. **C**. ECG following PCI to the LAD distal to the anastomotic site shows resolution of ST segment elevation on the inferior and anterior leads, and new Q waves in V3–5. The Q waves in the inferior leads persisted.

hematoma. On presentation, patient's vital signs were unremarkable except for mildly elevated blood pressure. ECG showed Q waves in the inferior leads suggesting prior inferior infarct, high R/S ratio in V2 with ST depression in V1–V2, and incomplete right bungle branch block (Fig. 2a). Troponin-I was <0.01 ng/ml. Trans thoracic echocardiogram pre-procedure showed normal wall contractility with LVEF 55–60%. Coronary angiogram showed 70% distal LM stenosis. Native RCA was occluded with distal right posterior descending artery (PDA) and posterolateral (PL) branch filled by left to right collaterals. LCX had mild plaques, obtuse marginal branch-1 (OM1) was occluded. The LIMA was atretic, filled retrogradely by flow from the LAD. Saphenous vein graft (SVG) to the RCA was occluded, and SVG to OM1 was patent. Patient underwent ascending aorta and hemi-arch 28MM graft placement, and redo SVG to RCA and SVG to LAD. The first ECG 1 h after the operation showed a wide QRS rhythm without distinct P waves (Junctional rhythm? Accelerated idioventricular rhythm?). There was new ST elevation in the inferior and anterior leads, and ST depression in I and AVL (Fig. 2b). Patient remained intubated, sedated at this time. However, no further work up, including cardiac markers were checked. Patient had a prolonged course in the cardiac intensive care unit and was subsequently extubated and transferred to the floor. He had a transthoracic echocardiogram two days after surgery showing grossly normal LVEF; however, despite contrast it was difficult to assess regional wall motion abnormalities. Repeat ECG 6 days post-operatively showed atrial fibrillation with narrowing of the QRS complexes compared to the prior ECG, as well as loss of R wave height in the precordial leads (Compared to ECG 2a) and resolution of ST elevation in the inferior and anterior leads (Compared to ECG 2b) (Fig. 2c).

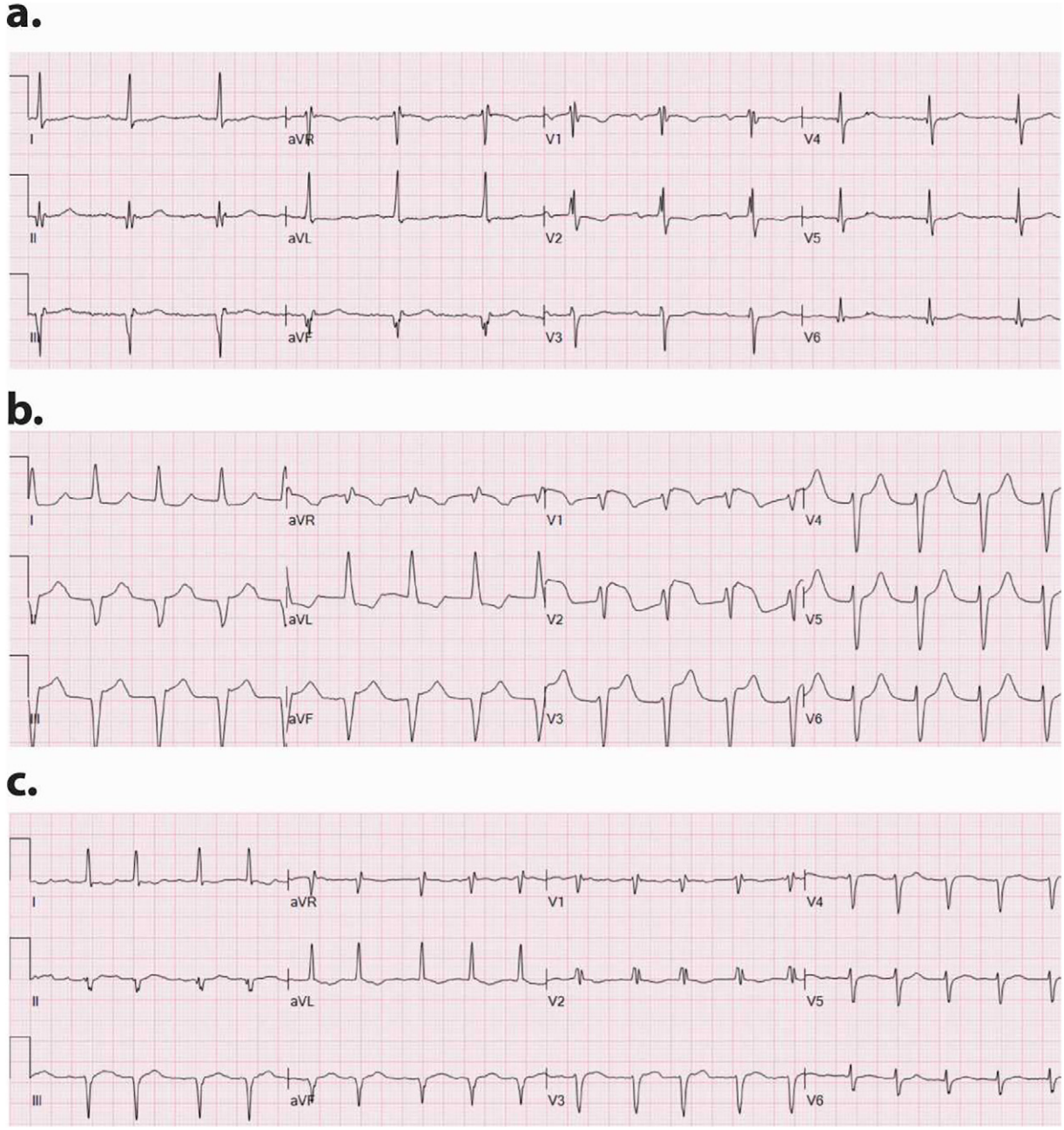

Fig. 2. A. Baseline ECG shows Q waves in the inferior leads suggesting prior MI. There is high R/S ratio in V2 and ST depression in V1–V2 as well as incomplete RBBB. There is T wave inversion in V1–V2. **B**. ECG following CABG shows wide QRS rhythm. P waves are not seen. There is significant ST elevation in the inferior and anterior leads, and ST depression in the lateral leads (I and aVL). **C**. Repeat ECG 6 h after CABG shows atrial fibrillation with narrowing of the QRS complexes compared to the prior ECG, loss of R wave height in precordial leads, and resolution of the ST elevation.

Discussion

The significance of ST-T wave changes after CABG surgery may be difficult to discern, as their presence may be non-specific. The differential diagnoses for these changes are broad, including expected post-operative inflammatory changes, myocarditis, pericarditis, or acute ischemia. Post pericardiotomy syndrome (PPS), a medical syndrome triggered by inflammatory response following damage to the pericardium, occurs commonly with an incidence of 10–40% after cardiac operations. It usually occurs days and up to weeks following cardiac surgery. ECG can provide evidence of typical changes associated with pericarditis, such as diffuse concave ST-elevation and PR depression [1]. However, at other times, patients with pericarditis following cardiac surgery can also have atypical ECG findings, as the pericardial inflammation might be focal, and the ECG changes might be confounded by concomitant myocardial ischemia and infarction.

Few studies have looked at ST segment changes following CABG and their clinical significance. In the 1980s, Patel et al. aimed to study the diagnostic significance of transient ST changes following coronary artery bypass in a long term follow up study. The group studied 76 patients undergoing CABG between 1982 and 1988. All patients underwent 48 h of ambulatory ST segment monitoring at a mean of 19 weeks after surgery. A total of 21 of the 76 patients had transient ST segment changes, of which 70% were silent. During the mean 70 months follow-up period, patients with such ischemic changes were no more likely to have either an objective (myocardial infarction or cardiac death) or subjective (unstable angina or another revascularization) events than patients without such ischemic changes. Therefore, it is possible that most of these

transient episodes of ST segments changes do not represent true ischemia [2]. Similarly, Loeb et al. studied the frequency and significance of new ST elevation during the post-operative period in patients who underwent CABG. ECGs were obtained upon admission to the cardiac intensive care unit and daily thereafter. The group did not find significant difference in postoperative morbidity and mortality in patients with new ST-segment elevation (0.1 mV) and those who did not [3].

Thus, the above-mentioned studies appeared to suggest that most ST segment changes, at least when detected >24 h after CABG surgery, are benign. Indeed, the common practice is usually not to order routine ECG immediately after surgery, labeling ST-T changes as non-specific. However, the two cases presented here show that marked ST changes, especially when occurs early after surgery and they persist, should not be ignored. Type 5 MI is myocardial infarction associated with CABG [4]. The incidence of postoperative MI is 2–15% of cases [5]. MI following CABG are graft or non-graft related [6,7]. In particular, the incidence of early graft dysfunction is 3% [8]. These two cases illustrated the complexity of diagnosing peri-operative myocardial infarction following CABG, since it was difficult to distinguish true ischemia from post-operative pericardial inflammation on ECG, and cardiac enzyme elevation can occur as a result of surgical procedure. Immediately post-surgery, there are no clinical clues that can assist in decision making: patients are usually heavily sedated, ventilated, hypotensive and on inotropic agents, so we cannot assess symptoms. Echocardiographic evaluation is usually limited due to poor endocardial resolution.

In 2018, the joint task force of European Society of Cardiology (ESC), American College of Cardiology, American Heart Association (ACC/AHA) and the World Heart Federation for Redefinition of MI proposed the following definition for post-operative MI using a combination of ECG changes, cardiac markers, and imaging modalities, applied within 48 h of the index procedure: "Elevation of cardiac troponin (cTn) values >10 times the 99th percentile upper limit of normal in patients with normal baseline cTn values. In patients with elevated pre-procedure cTn in whom cTn levels are stable (≤20% variation) or falling, the post-procedure cTn must rise by >20%. However, the absolute post-procedural value still must be >10 times the 99th percentile upper limit of normal." In addition, patient must also have development of new pathological *q* waves, angiographic documented new graft or new native coronary artery occlusion, or imaging evidence of new loss of viable myocardium or regional wall motion abnormalities [4]. However, this document does not address the significance of ST deviation and whether different thresholds should be used to diagnosed true STEMI post CABG surgery.

In conclusion, although most ST changes on ECG following CABG are considered non-specific and benign, these cases demonstrate that these changes can also represent significant pathology and true ischemia, especially when detected soon after surgery. Because of the diagnostic difficulty of post CABG MI and the non-specificity of the ECG changes, clinicians should maintain a high degree of vigilance and suspicion. If the clinical suspicion is high for true ischemia, prompt intervention with either emergency angiography with stenting or surgery should be pursued following a Heart Team discussion in complex cases. Lastly, a prospective study is warranted to see if different thresholds for ST elevation should be used for detecting STEMI at different time points after heart surgery, as the troponin cutoffs following surgery are higher than for other types of MI.

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Declaration of competing interest

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