Various 12-Lead Electrocardiographic Findings of Diffuse Three Vessel Coronary Artery Spasm

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광범위한 삼혈관 관상동맥 경련 환자의 12-유도 심전도 소견

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KEY WORDS: 12-lead electrocardiographic findings • Diffuse three vessel coronary artery spasm.

Introduction

During coronary spasm documented changes in the ECG include ST-segment and T wave changes, R and S wave voltage changes, appearance of Q waves, change in QT interval, and develop-
ment of arrhythmias\textsuperscript{11}. Although angiographic and ECG changes may occur frequently without angina, coronary spasm may be associated with no important ECG changes, especially in patients with diffuse narrowing of the left and right coronary arteries during ischemia because they may have prevented an electrical gradient from developing between the anterior and inferior regions because of global ischemia\textsuperscript{2,3}.

I have observed four separate diffuse three vessel coronary spasm and my experience suggests that electrocardiographic changes may show various findings as well as no ST segment changes according to a difference of an electrical gradient from developing between the anterior and inferior regions because of global ischemia.

**Case Reports**

**Case 1**

A 47-year-old man visited our hospital on 3rd December in 1990 for evaluation of frequent chest pain, first noted twenty days previously. He had severe substernal oppression during washing face at 7AM with several minute duration with one attack every two to three day.

Angina was relieved by rest or sublingual nitroglycerin. There was no chest pain on exercise. He had no previous history of hypertension, diabetes mellitus, hyperlipidemia except cigarette smoking. He admitted to a coronary care unit

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**Fig. 1-A, B. A.** On 3rd December, there was no chest pain and ECG was normal at 3PM.

B. On 3rd December, the patient had severe chest pain at 9:55PM and ECG demonstrated 1 to 3mm ST segment elevation in lead II, III, aVF and Reciprocal changes in lead I, aVL, V\textsubscript{2-4}. The ECGs were recorded at a sensitivity of 10mm/mV and at a paper speed of 25mm/sec.
and ECG monitoring was done. He never took isosorbide and calcium channel blocker except sublingual nitroglycerin until ergonovine test was done. He completed 16 Mets of an exercise test (Bruce protocol) with no chest pain.

ECG findings

On 3rd December in 1990, there was no chest pain and ECG was normal at 3PM (Fig. 1-A).

On 3rd December, he had severe chest pain at 9:55PM and ECG showed 1 to 3mm ST segment elevation in lead II, III, aVF and reciprocal changes in lead I, aVL, V2-4 (Fig. 1-B). Pain was relieved with sublingual nitroglycerin.

On 10th December, he had again severe chest pain at 10:50PM but ECG was normal. Pain was relieved with 0.6mg sublingual nitroglycerin 2 times (Fig. 1-C).

On 13th December, coronary angiography revealed normal findings (Fig. 2-A,B) and ECG showed normal findings (Fig. 1-D). Following single bolus ergonovine 0.4mg intravenously, he complained of severe chest pain in two minutes but ECG showed no changes (Fig. 1-E).

At that time, right and left coronary angiography showed severe diffuse vasoconstriction (Fig. 2-C,D). Following nitroglycerin 200µg intracoronary injection two times, chest pain was relieved and ECG showed no differences compared to a basal ECG.

![Fig. 1-C. D. C. On 10th December, the patient had severe chest pain but ECG was normal. D. ECG showed normal findings during a coronary angiography before an administration of ergonovine maleate. The ECGs were recorded at a sensitivity of 10mm/mV and at a paper speed of 25mm/sec.](image-url)
ECG findings

Left coronary angiography showed spontaneous diffuse spasm (Fig. 3-A,B). Patient complained of chest pain but ECG showed no differences (Fig. 4-B) compared to a basal ECG (Fig. 4-A).

Right coronary angiography revealed severe spontaneous diffuse spasm (Fig. 3-C,D) and patient complained of chest pain and ECG showed 2mm horizontal ST segment elevation in lead II, III, aVF and reciprocal changes in lead I, aVL, V2-4 (Fig. 4-C).

Intracoronary nitroglycerin 200µg was injected into the left, right coronary artery. Pain was relieved and ST segment elevation returned to an isoelectric line (Fig. 4-D). The patient was discharged with a diagnosis of coronary artery spasm. Isosorbide dinitrate and peridipine were prescribed.

Case 3

A 53-year-old man visited our hospital on 21th August in 1990 of frequent chest pain. He had complained of episodes of chest pain and left arm pain that were relieved by nitroglycerin between 5AM and 7AM. He had no previous history of hypertension, diabetes mellitus, hyperlipidemia except smoking.

There was no chest pain on exercise.

ECG findings

Basal ECG was normal

Left coronary angiography showed spontaneous diffuse spasm (Fig. 5-A) and patient complained of chest pain but ECG showed no differences compared to a basal ECG.

Right coronary angiography showed mild spontaneous diffuse spasm (Fig. 5-B) and patient complained of mild chest pain but ECG showed no differences.

And so intracoronary acetylcholine 20µg (Fig. 5-C), 50µg were injected into the right coronary artery. Suddenly patient complained of severe
Fig. 2. Left anterior oblique(A) and right anterior oblique caudal(B) projection.
A, B. Coronary angiography(CAG) revealed normal findings before an administration of ergonovine maleate(ERG).
C, D. Following single bolus ergonovine 0.4mg intravenously, right and left coronary angiography (RCA, LCA) demonstrated severe diffuse vasoconstriction with chest pain.

Fig. 3. Lateral(A) and left anterior oblique(C) projection.
A, B. LCA demonstrated spontaneous diffuse spasm with chest pain. Following 200μg intracoronary nitroglycerin(NG) injection. LCA showed no stenosis.
C, D. RCA demonstrated severe spontaneous diffuse spasm with chest pain. Following 200μg NG, RCA showed no stenosis. Abbreviations as in Figure 2.
Fig. 4-A. B. A. Basal ECG—an electrocardiography checked before CAG.
B. During LCA, patient complained of chest pain but ECG showed no differences compared to a basal ECG. Abbreviations as in Figure 2. The ECGs were recorded at a sensitivity of 10mm/mV and at a paper speed of 25mm/sec.

Fig. 4-C. D. C. During RCA, the patient complained of chest pain and ECG showed 2mm horizontal ST segment elevation in lead II, III, aVF and reciprocal changes in lead I, aVL, V2-4. B. Following 200μg NG injection, pain was relieved and ST segment elevation returned to an isoelectric line. Abbreviations as in Figure 2. The ECGs were recorded at a sensitivity of 10mm/mV and at a paper speed of 25mm/sec.
chest pain and ECG showed ST segment elevation in lead II, III, aVF on ECG monitoring.

Patient sat up, cried and acted out because of severe chest pain and so we gave up further examination and two 0.6mg sublingual nitroglycerin tablets, nitroglycerin 200μg intracoronary injection 2 times and nifedipine 10mg sublingual were done. And then chest pain relieved, we had no time checking 12-lead ECG at that time. Follow-up 12-lead ECG showed no myocardial infarct.

The patient was discharged with a diagnosis of coronary artery spasm. Isosorbide dinitrate and peridipine were prescribed.

Case 4

A 53-year-old man was referred to our hospital on 12th March in 1991 for assessment of rest chest pain between 4AM and 6AM after presenting 1 month earlier. Episodes of chest pain were relieved by nitroglycerin.

He had no previous history of hypertension, diabetes mellitus, hyperlipidemia and smoking. He completed 14.6 mets of an exercise test (Bruce protocol) with no chest pain with taking isosorbide dinitrate and verapamil.

ECG findings

- On 12th March in 1991, there was no chest pain and ECG was normal at 3PM (Fig. 6-A).
- On 15th in 1991, he had severe chest pain at 1:30AM and ECG showed 1mm ST segment elevation in aVL, hyperacute T wave in lead V2-5, 2 to 3mm ST segment depression in lead II, III, aVF and paroxysmal atrial fibrillation (Fig. 6-B). Pain was relieved with sublingual nitroglycerin.

On 22th March, left and right coronary angiography showed spontaneous diffuse spasm (Fig. 7-A,B) and patient complained of mild chest pain but ECG showed no differences (Fig. 6-D) compared to a basal ECG (Fig. 6-C).

Intracoronary nitroglycerin 200μg was injected...
Fig. 6-A, B. A. On 12th March, there was no chest pain and ECG was normal.

B. On 15th March, the patient had severe chest pain and ECG showed 1mm ST segment elevation in aVL, hyperacute T wave in lead V2-5, 2 to 3mm ST segment depression in lead II, III, aVF and paroxysmal atrial fibrillation. The ECGs were recorded at a sensitivity of 10mm/mV and at a paper speed of 25mm/sec.

into the left, right coronary artery. Left and right coronary angiography revealed dilatation except a proximal left anterior descending artery 30% stenosis (Fig. 7-C,D). The patient was discharged with a diagnosis of coronary spasm. Isosorbide dinitrate and verapamil were prescribed.

Discussion

The incidence of diffuse three vessel coronary artery spasm among variant angina has not yet been reported. Diffuse vessel spasm may be masked in some patients by administration of nitroglycerin, nifedipine or verapamil when patients complain of severe chest pain or show hemodynamic unstartility or ventricular tachyarrhythmia because of right or left coronary artery spasm. And so, diffuse three vessel spasm after an ergonovine provocation test is rare. Moreover, ergonovine administration to patients with unrecognized multi-vessel spasm could be extremely hazardous with the risk of electromechanical dissociation and death.

ECG changes have become a principal and almost necessary prerequisite in selection patients with chest pain who are considered highly likely to have coronary spasm. Although coronary spasm may be associated with no important ST
changes. Fuchs et al reported that presence of Q waves, ST segment elevation and T wave inversion in leads I, aVL and V1-V4 were all highly correlated with the presence of left anterior descending coronary artery disease ($P<0.001$), and the same ECG findings in leads II, III and aVF were associated with right or circumflex coronary artery narrowings ($P<0.001$).

And so ST segment changes in the 12-lead ECG checked when patients complained of chest pain give an important clue in deciding whether first selective left coronary artery is injected or right coronary artery during an ergonovine provocation test.

Bell et al\(^3\) described three patients with spontaneous diffuse three vessel spasm and no ST segment changes were noted during episodes of chest pain\(^3\).

Feldman et al\(^2\) described that in eight of 79 patients with coronary artery spasm ECG changes usually didn’t accompany episodes of rest angina and three patients with diffuse three vessel spasm included among them. He suggested that with respect to the eight patients who did not usually have important ECG changes, reasons were the following:
Fig. 7. Right anterior oblique cranial(A) and left anterior oblique(C) projection.

A, B. LCA and RCA showed spontaneous diffuse spasm and the patient complained of mild chest pain.

C, D. Following 200μg intracoronary NG, LCA and RCA revealed dilatation except a proximal left anterior descending artery 30% stenosis. Abbreviations as Figure 2.

1) Collateral flow may have reduced the mass of ischemic myocardium and limited important ECG changes detectable by surface ECG recordings.

2) Preexisting right bundle branch block may have masked ST segment changes related to transient myocardial ischemia.

3) Left ventricular wall motion abnormalities during an angina free interval.

4) Diffuse narrowing of the left and right coronary arteries during ischemia may have prevented an electrical gradient from developing between the anterior and inferior regions because of global ischemia.

5) Physiologically important atherosclerotic narrowings involved regions that would electrically oppose each other.

Catheterization and angiography of my four patients with variant angina showed only further reason diffuse narrowing of the left and right coronary arteries. In view of the lack of important ST-T wave changes during typical angina in my four patients, I think that the absence of ECG changes in patients with diffuse three vessel spasm is that global ischemia may prevent the development of an electrical gradient between different myocardial regions.

However, from these four cases the most impor-
tant observation is that 12-lead ECG with diffuse three vessel coronary artery spasm show not only no important ST segment changes but also important ST segment changes ST segment elevation, depression, hyperacute T wave or paroxysmal atrial fibrillation and so on according to a difference of an electrical gradient from developing between the anterior and inferior regions during episodes of chest pain.

Clinical Implications

I think that ST segment shifts occurring with variant angina may give more information in understanding the electrophysiologic basis for ST segment shifts occurring with ischemia.

In patients with strongly suspected variant angina when 12-lead ECG show no important ST segment changes even episodes of angina and diffuse artery spasm during an ergonovine provocation test, diffuse three vessel coronary artery spasm may be present. And so, if patients’ conditions are stable another coronary arteriography should be before injecting intracoronary vasodilator and ruled out diffuse three vessel spasm and the incidence of diffuse three vessel coronary spasm may be higher than previously reported. In a study of selective intracoronary injection of acetylcholine in patients with variant angina, multivessel spasm was found in 76%, particularly those with normal or near normal coronary arteries.

However, an important implication of my results is that ergonovine or acetylcholine administration to patients with unrecognized multivessel spasm could be extremely hazardous with the risk of electromechanical dissociation and death. Cardiologists should always pay attention to. The importance of administration of nitroglycerin or verapamil to reverse any spasm is emphasized.

But it is not easy to foresee diffuse three vessel coronary artery spasm before an ergonovine provocation test because various 12-lead ECG findings may be shown. However, when there are no important ST segment changes in 12-lead ECG checked during episodes of typical rest angina, the possibility of diffuse three vessel coronary artery spasm may be present and more attention must be paid during an ergonovine provocation test.

Conclusions

Electrocardiographic findings of diffuse three vessel coronary artery spasm may show various findings including no ST segment changes according to a difference of an electrical gradient from developing between the anterior and inferior regions because of global ischemia.

I suggest that diffuse three vessel coronary artery spasm must be considered when 12-lead ECG show no important ST segment changes even episodes of angina and diffuse coronary artery spasm during an ergonovine provocation test in patients with strongly suspected variant angina.

Acknowledgement

I am grateful for the medical advice of Park Young Bae, M.D., and for the secretarial assistance of Lee Min Joo and Jeong Young Sin and for technical assistance of Jeon Byung Sook and Ham Dong Hoon and Kim Sung Hee R.N.

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