ORIGINAL ARTICLE

ST Segment Depression in the Inferior Leads in Brugada Pattern: A New Sign

Pasquale Crea, M.D., Giuseppe Picciolo, M.D., Francesco Luzzo, M.D.,
and Giuseppe Oreto, M.D.

From the Department of Clinical and Experimental Medicine, University Hospital of Messina, Messina, Italy

Background: Brugada pattern (BP) is characterized by J wave and elevated ST segment in the right precordial leads. At times the ECG signs are present only with the electrodes displaced 1 or 2 intercostal spaces above.

Methods: We analyzed the electrocardiograms of 87 subjects with type 1 BP looking for ST segment depression (≥ 0.1 mV with duration ≥ 0.08 s) in the inferior leads. In 21 subjects, BP pattern was evident only with V_1 – V_2 electrodes at the 3rd or 2nd space.

Results: ST segment depression was present in 41 cases (47%). In the 21 patients with BP recognizable only at the 2nd or 3rd intercostal space, 10 (48%) presented a significant ST depression in the inferior leads.

Conclusions: ST segment analysis in the inferior leads has never been considered for BP diagnosis. When accurately searched for, however, ST segment depression can be observed in those leads in BP, suggesting the need for further investigation.

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Brugada pattern; ST segment

Brugada pattern (BP) is characterized by definite ECG abnormalities (J wave, elevated ST segment) in precordial leads V_1 to V_3 .^{1–5} In several subjects, however, the typical ECG signs are only present when the right precordial leads are recorded with the electrodes placed 1 or 2 intercostal spaces above the conventional site.^{6–12} Analysis of limb leads, in contrast, is usually considered not useful in BP diagnosis. In the present study, we have analyzed, in a population of subjects with BP, the configuration of inferior leads in order to point out possible abnormalities that could facilitate BP recognition.

MATERIALS AND METHODS

We analyzed the electrocardiograms of 87 patients (78 males, 9 females) with a mean age of 41 ± 12 years (range 18–63). In any case, a type 1 BP was present, according to the diagnostic criteria

recently proposed by an international Consensus Conference. Patients with structural heart disease were excluded. In 66 cases, BP was recognizable with the recording electrodes of leads V_1 and V_2 at the 4th intercostal space (is), whereas in 21 subjects BP recognition was possible only with the electrodes at the 3rd or 2nd is.

Inferior Leads Analysis

The inferior leads were analyzed first, and subsequently leads aVR and aVL; lead I was not taken into account. Any lead was magnified on the computer screen, and a horizontal line was drawn (Fig. 1) in correspondence of last section of the T-P segment. This permitted to easily identify the moment in which the ST segment crossed the isoelectric line; this point corresponded roughly to both the end of ST segment and the T wave beginning. Whenever an ST depression with a voltage ≥ 0.1 mV (1 mm) was present, we measured

Address for correspondence: Giuseppe Oreto, Via Terranova, 9, 98122 Messina, Italy. Tel: +39 0902213520; Fax: +39 090223845; E-mail: goreto@unime.it

Figure 1. Evaluation of ST segment depression in the inferior leads. ST segment depression assessment in the inferior leads in Brugada pattern. The horizontal line drawn in correspondence of the last section of the T-P segment identifies the moment in which the ST segment crosses the isoelectric line. The ST segment depression lasts more than 0.08 s in all the leads, with a maximal voltage >0.1 mV.

Figure 2. Additional recordings of the right precordial leads in Brugada pattern. A case of BP not immediately evident in the conventionally recorded ECG. The 12-lead electrocardiogram (upper section of the figure) does not show a typical BP, but a definite ST segment (J point) elevation in lead V_2 is present. Displacing the V_1 and V_2 electrodes at the 3rd or 2nd is, BP appears. The inferior leads, in addition, show a clear ST segment depression, that is more easily recognized in aVF (as an ST segment elevation) when the inverted mirror image is analyzed.

the duration of ST segment depression: a duration of 0.08 s was considered significant. An ECG was classified as positive, namely, suggestive of BP, whenever at least 2 of the inferior leads showed ST segment depression ≥ 0.1 mV with duration ≥ 0.08 s.

In addition, for each ECG the QRS axis was calculated, and a possible relationship was searched between ST segment depression in inferior leads and QRS axis. Patients were divided into two groups: (1) normal axis (between 0° and $+90^\circ$); (2) abnormal axis (any value outside the above range).

Figure 3. Four examples of BP with ST segment depression in the inferior leads. In case D, the conventional lead V₁ is nondiagnostic, but a typical BP appears when the electrode is placed at the 2nd is. Inverted mirror image of lead aVF is suggestive of BP in all cases.

Leads aVR and aVL Analysis

These leads have been analyzed searching for ST segment elevation ≥ 1 mm. All tracings were analyzed by two independent observers; the interobserver agreement (ST depression vs non-ST depression in the inferior leads and ST elevation vs non-ST elevation in leads aVR and aVL) was calculated.

RESULTS

QRS Axis

The QRS axis was normal in 67 patients (77%), whereas 16 patients (18%) had left axis deviation, 3 patients undetermined axis, and only 1 patient right axis deviation ($\hat{A}QRS -120^\circ$).

Inferior Leads ST Segment

ST segment depression (≥ 0.1 mV in voltage, ≥ 0.08 s in duration) was present in 41 cases (47%). This sign was observed in 31 patients (36%), 29 patients (33%), and 41 patients (47%) in lead II, III, and aVF, respectively. In the 21 patients with

BP diagnosis possible only at high (2nd or 3rd) intercostal spaces, 10 (48%) presented a significant ST depression in the inferior leads. This sign was present in 41/67 (61%) of patients with normal QRS axis and in none of the patients with abnormal QRS axis. None of the patients showed ST elevation in the inferior leads.

aVR and aVL ST Segment

ST elevation in aVR (≥ 1 mm) was observed in 4/87 (5%) subjects, whereas in aVL 17 patients (20%) showed ST segment elevation.

Interobserver agreement concerning ST depression in inferior leads/ST elevation in leads aVR and aVL was 84% (Cohen K 0.68).

DISCUSSION

The present study points out that in type 1 BP slightly less than one half of patients show a definite ST segment depression in the inferior leads. This has been recently reported in a study on Brugada Syndrome mainly aimed at determining the clinical importance of ST segment elevation in

Figure 4. The inverted mirror image of inferior leads. Same case of Figure 1. The inverted mirror image of inferior leads is immediately obtained by flipping the tracing.

the limb leads. In that research, 22% of patients had ST segment depression in the limb leads.¹³

Type 1 BP is often immediately revealed by a typical ST segment elevation in leads V_1 and V_2 ; in such a circumstance, inferior leads analysis does not add anything to the diagnosis. Contrariwise, in cases with no clear BP evidence in the conventional right precordial leads, ST depression in the inferior leads can be helpful in suspecting BP, suggesting the need for precordial electrodes displacement 1 or 2 spaces above. This holds true particularly in patients whose ECG is almost normal in leads V_1 and V_2 recorded at the 4th is. In our population, 21 patients had a BP diagnosis possible only with recordings obtained at the "high" intercostal spaces; 10 out of these, however, showed a clear ST segment depression in the inferior leads, pointing out the usefulness of analyzing the latter leads (Fig. 2; Fig. 3D).

ST segment depression in the inferior leads can be often not immediately evident unless a detailed analysis is performed, since cardiologists are not accustomed to search for such a sign. This is, however, very easy to be discovered if an inverted mirror image of inferior leads is obtained. Figure 3, as well as Figure 2, shows the striking analogy between inverted mirror image inferior lead and leads V_1 and V_2 in BP.

This is because in both situations an upward convex ST segment elevation followed by a negative T wave is present. Nowadays, cardiologists grasp immediately the typical BP configuration in the right precordial leads; at times, however, the only pointer to BP can be a mild ST depression in the inferior leads. This is more easily recognized in inverted mirror image tracings. To obtain quickly an inverted mirror image (Fig. 4), the tracing must be "flipped" (rotated upside down) and analyzed backlight (the observer should not see the electrocardiogram, but the opposite side of the electrocardiographic paper). In this condition, the inferior leads appear very similar to leads V_1 and V_2 in the "normally" analyzed ECG, since the inferior leads show a mainly negative QRS complex followed by ST segment elevation and negative T wave. This holds true whenever the QRS axis is normal, resulting in mainly positive QRS complexes in the inferior leads. Whenever there is a left axis deviation, in contrast, the inferior leads show mainly negative QRS complexes and positive T waves; this hampers the recognition of BP in inverted mirror image tracings, since the abnormal ST vector is "concordant" with the terminal deflection of the QRS complex

Leads aVR and aVL

Analysis of ST segment elevation in leads aVR and aVL, observed in 5% and 20% of cases, respectively, did not add anything to the information provided by the precordial and the inferior leads; for this reason, a detailed study of such leads aimed at BP recognition cannot be recommended, on the basis of the present data.

STUDY LIMITATIONS

Our data suggest that search of ST depression in inferior leads aimed at recognizing BP can be useful only in the presence of normal QRS axis, namely, when those leads (or at least leads II and aVF) show a mainly positive QRS complex. The presence of left axis deviation appears to hamper the appreciation of ST segment abnormalities suggestive of BP in the inferior leads.

CONCLUSION

Although the diagnosis of BP is often immediate, some cases are underscored since the ECG changes are scarcely evident. This is particularly true in the not rare cases (24% in our series) showing the typical ST segment elevation in the right precordial leads only when the V₁ and V₂ electrodes are displaced superiorly. ST segment analysis in the inferior leads has been up to now not taken into account for BP diagnosis. However, when accurately searched for, ST segment depression (≥ 0.1 mV in voltage, ≥ 0.08 s in duration) can be observed in those leads, pinpointing the need for further investigation, including the displacement of V₁ and V₂ electrodes 1 or 2 intercostal spaces above.

REFERENCES

1. Brugada P, Brugada J. Right bundle branch block, persistent ST segment elevation and sudden cardiac death: A distinct clinical and electrocardiographic syndrome. *J Am Coll Cardiol* 1992;20:1391-1396.
2. Antzelevitch C, Brugada P, Borggrefe M, et al. Brugada syndrome. Report of the second consensus conference. *Circulation* 2005;111:659-670.
3. Wilde AAM, Antzelevitch C, Borggrefe M, et al. Proposed diagnostic criteria for the Brugada syndrome. *Eur Heart J* 2002;23:1648-1654.
4. Oreto G, Corrado D, Delise P, et al. Doubts of the cardiologist regarding an electrocardiogram presenting QRS V1-V2 complexes with positive terminal wave and ST segment elevation. Consensus Conference promoted by the Italian Cardiology Society. *G Ital Cardiol* 2010;11(Suppl 2):3S-22S.
5. Bayés de Luna A, Brugada J, Baranchuk A, et al. Current electrocardiographic criteria for diagnosis of Brugada pattern: A consensus report. *J Electrocardiol* 2012;45:433-442.
6. Sangwatanaroj S, Prechawat S, Sunsaneewitayakul B, et al. New electrocardiographic leads and the procainamide test for the detection of the Brugada sign in sudden unexplained death syndrome survivors and their relatives. *Eur Heart J* 2001;22:2290-2296.
7. Shimizu W, Matsuo K, Takagi M, et al. Body surface distribution and response to drugs of ST segment elevation in Brugada syndrome: Clinical implication of eighty-seven-lead body surface potential mapping and its application to twelve-lead electrocardiograms. *J Cardiovasc Electrophysiol* 2000;11:396-404.
8. Shin SC, Ryu HM, Lee JH, et al. Prevalence of the Brugada-type ECG recorded from higher intercostal spaces in healthy Korean males. *Circ J* 2005;69:1064-1067.
9. Takagi M, Toda I, Takeuchi K. Utility of right precordial leads at higher intercostal space positions to diagnose Brugada syndrome. *Pacing Clin Electrophysiol* 2002;25:241-242.
10. Hisamatsu K, Morita H, Fukushima Kusano K, et al. Evaluation of the usefulness of recording the ECG in the 3rd intercostal space and prevalence of Brugada-type ECG in accordance with recently established electrocardiographic criteria. *Circ J* 2004;68:135-138.
11. Nakazawa K, Sakurai T, Takagi A, et al. Clinical significance of electrocardiography recordings from a higher intercostal space for detection of the Brugada sign. *Circ J* 2004;68:1018-1022.
12. Rollin A, Sacher F, Gourraud JB, et al. Prevalence, characteristics, and prognosis role of type 1 ST elevation in the peripheral ECG leads in patients with Brugada syndrome. *Heart Rhythm* 2013;10:1012-1018.
13. Chinushi M, Tagawa M, Izumi D, et al. Pilsicainide-induced ST segment elevation and ST segment depression in two patients with variant forms of Brugada-type electrocardiographic abnormalities. *Pacing Clin Electrophysiol* 2009;32:811-815.