THE ASSOCIATION OF TYPE B VENTRICULAR PRE-EXCITATION AND RIGHT BUNDLE-BRANCH BLOCK

BY

P. G. C. ROBERTSON,* D. EMSLIE-SMITH, K. G. LOWE, AND HAMISH WATSON

From the Department of Medicine, University of St. Andrews, Queen's College, Dundee

Received March 22, 1963

The syndrome of a short P–R interval and "bundle-branch block" occurring in healthy young people prone to paroxysmal tachycardia was described by Wolff, Parkinson, and White in 1930. Since then it has been suggested that the short P–R interval is due to ventricular pre-excitation (Öhnell, 1944) and that a delta wave (Segers, Lequime, and Denolin, 1944) is responsible for the prolonged QRS complex. Rosenbaum *et al.* (1945) gave an electrocardiographic classification into two types according to the polarity of the delta wave in the præcordial unipolar scalar leads. In type A, the delta wave is upright in both right and left præcordial unipolar leads, as illustrated in Fig. 1, while in the vectorcardiogram, the delta vector or the delta plus QRS $\widehat{sE}$

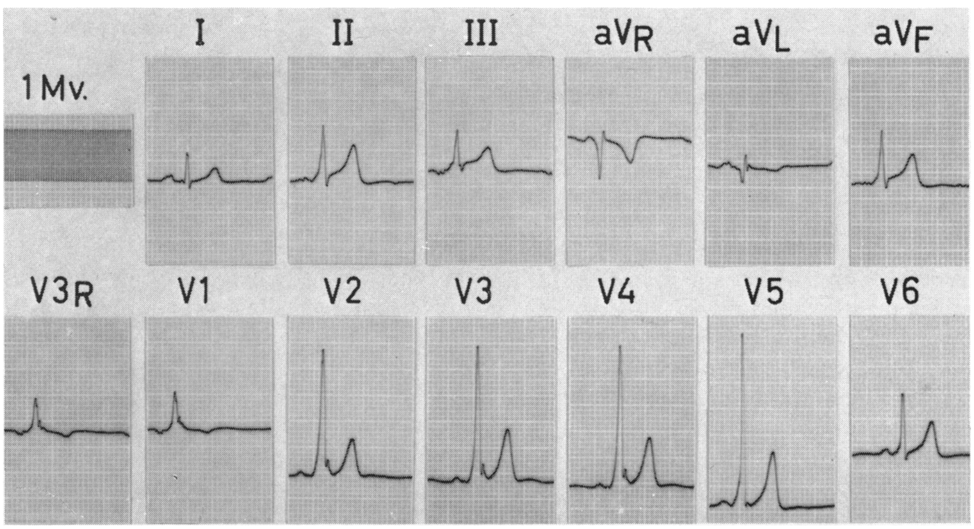

FIG. 1.—Scalar electrocardiogram of type A ventricular pre-excitation showing positive delta waves in all the unipolar chest leads.

loop is orientated anteriorly between +30 and +120 degrees in the horizontal plane (Bleifer *et al.*, 1959) (Fig. 2). In type B, the delta wave is negative in the right præcordial leads (Fig. 3) and, in the horizontal plane vectorcardiogram, the delta vector or the delta plus QRS $\widehat{sE}$ loop is orientated between +30 and −60 degrees (Bleifer *et al.*, 1959) (Fig. 4). It should be noted that, in both types, subtraction of the delta wave leaves QRS of normal duration, there being no true bundle-branch block.

* In receipt of a grant from the Scottish Hospitals Endowment Research Trust.

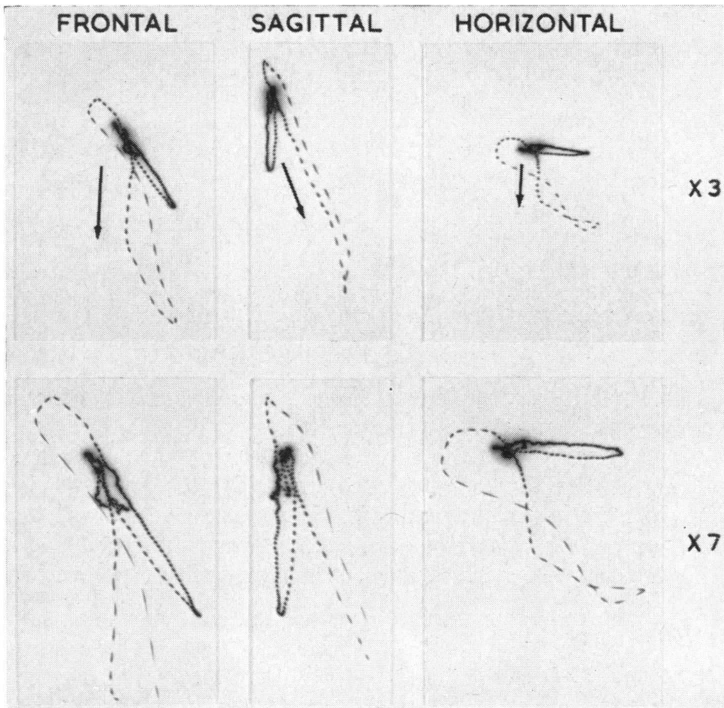

FIG. 2.—Vectorcardiogram of type A ventricular pre-excitation. The delta vector is inscribed slowly and directed forward at an angle of +80° in the horizontal plane. The Cube system of electrode placement (Grishman, Borun, and Jaffe, 1951) is used throughout. The sagittal plane is viewed from the right. Time marking is at 0·0025 sec. intervals.

The sites of ventricular pre-excitation in the two types are not known. Some authors consider that, in both, pre-excitation starts on the right side of the interventricular septum, higher for type A and lower for type B (Sodi-Pallares, 1956), while others believe that it starts in the left ventricle in type A and in the right ventricle in type B (Hecht, 1957; Latour and Puech, 1957). It has also been thought that the association of bundle-branch block and ventricular pre-excitation would help to identify these sites, since it may at first seem likely that pre-excitation of one ventricle could be associated with bundle-branch block only when the bundle-branch of the opposite ventricle is blocked (Gamboa *et al.*, 1962). Temporary right bundle-branch block has been produced experimentally in man by looping a cardiac catheter in the right ventricle (Peñaloza, Gamboa, and Sime, 1961). Three patients with ventricular pre-excitation were studied in this way by Gamboa *et al.* (1962). The simultaneous features of pre-excitation and an advanced degree of right bundle-branch block in scalar and vector electrocardiograms were studied in 2 patients with type A ventricular pre-excitation: they suggested that the prematurely activated muscular segment was located in the left ventricle and that the induced right bundle-branch block delayed right ventricular activation. In their third patient, who had intermittent type B pre-excitation, right bundle-branch block could be produced only when there was no pre-excitation. The authors argued that frank right bundle-branch block could not be produced in association with type B ventricular pre-excitation on the basis that in this type pre-excitation takes place in the right ventricle, the depolarization of which would depend mainly on the pre-excitation.

Pick and Fisch (1958) could find only five published cases in which pre-excitation occurred

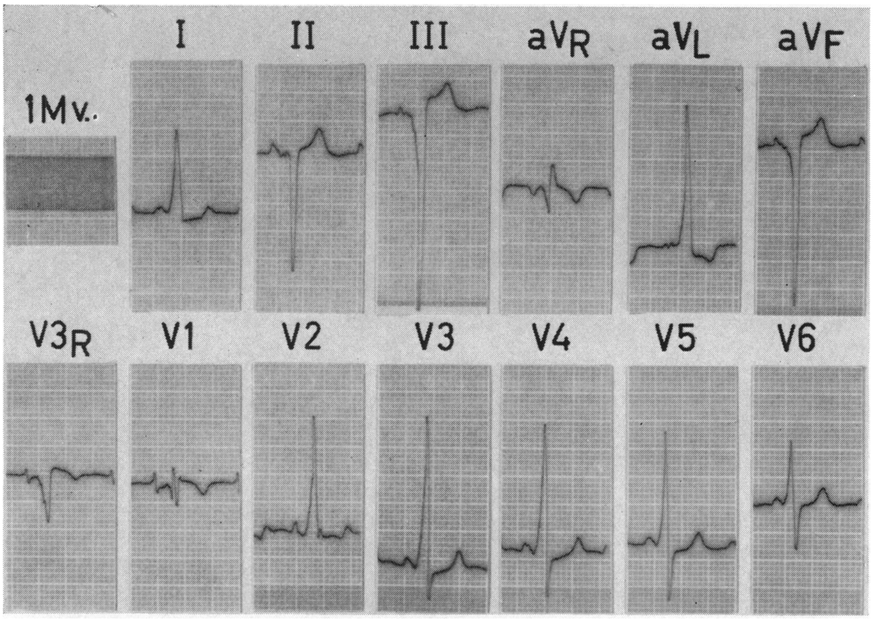

FIG. 3.—Scalar electrocardiogram of type B ventricular pre-excitation showing negative delta waves in V3R and V1 and positive delta waves in the remaining chest leads.

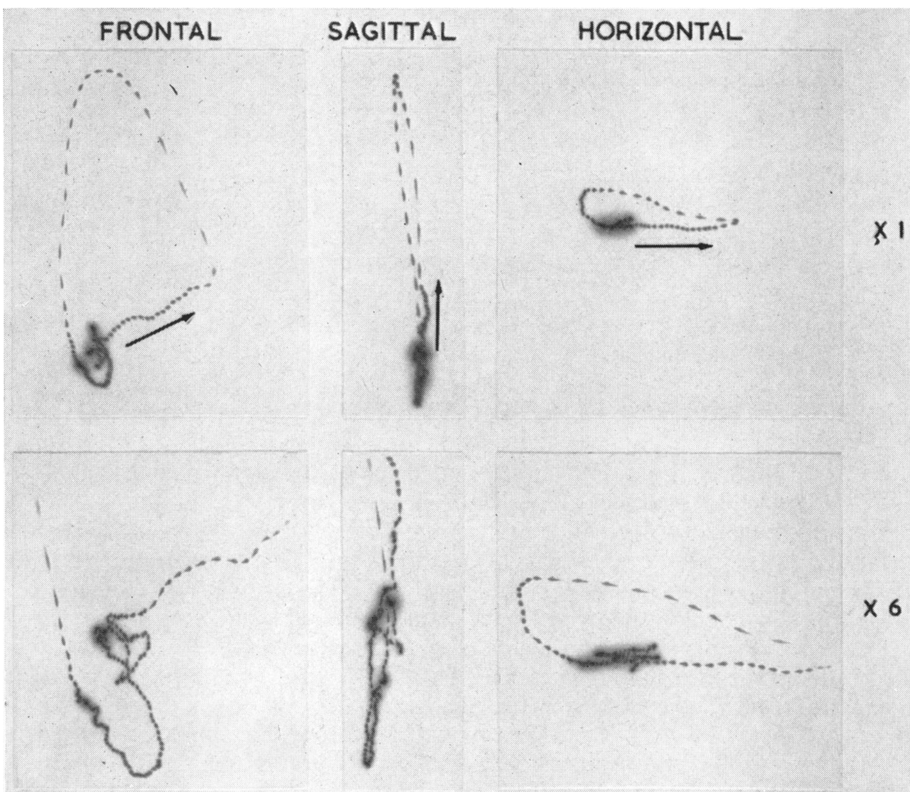

FIG. 4.—Vectorcardiogram of type B ventricular pre-excitation. The delta vector is inscribed slowly and runs along the 0° axis in the horizontal plane.

intermittently in patients with right bundle-branch block (Duthie, 1946; Ask-Upmark, 1942; Wolff and Richman, 1953), and 'in at least 2, the presence of the right bundle-branch block was obscured by the appearance of ventricular pre-excitation'. They described three patients with type A ventricular pre-excitation of whom two had associated left bundle-branch block and one had associated right bundle-branch block. Castellanos, Mayer, and Lemberg (1962) were able to record scalar and vector electrocardiograms from 5 patients with type A pre-excitation: this was associated in 3 cases with right bundle-branch block and in 2 with left bundle-branch block. They called attention to several probable instances of ventricular pre-excitation with left bundle-branch block that had been considered as examples of pre-excitation only (Bleifer *et al.*, 1959; Averill, Fosmoe, and Lamb, 1960; Burch and DePasquale, 1961). Type B pre-excitation with left bundle-branch block pattern, as well as type A pre-excitation with right bundle-branch block pattern

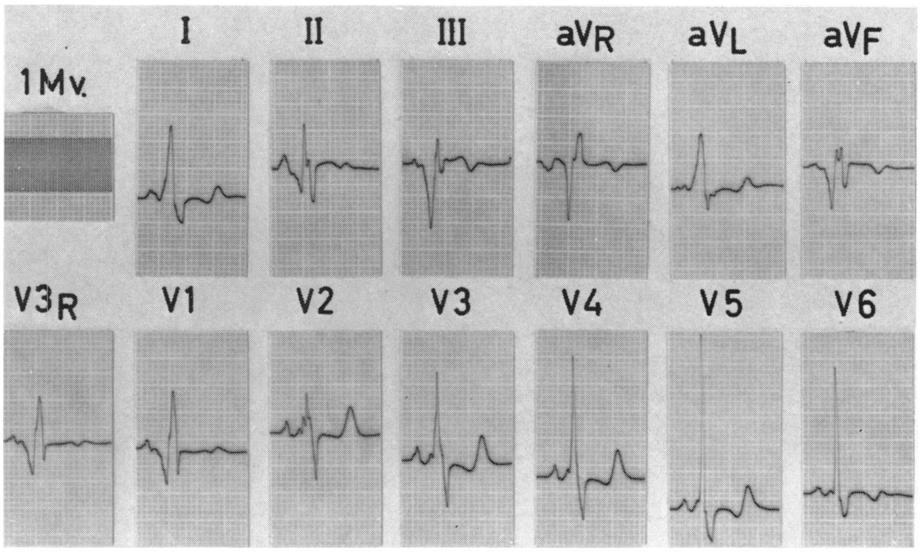

FIG. 5.—Scalar electrocardiogram of type B ventricular pre-excitation with right bundle-branch block from a case of Ebstein's anomaly of the tricuspid valve. The delta wave is the initial negative deflection in V3R and V1 and the initial positive deflection in V2 to V6 as in Fig. 3. Right bundle-branch block is characterized by the slurred S in lead I, V5, and V6 and the slurred R in aVR

have been depicted by Burch and DePasquale (1961) although they do not specifically describe the electrocardiograms in that way. It seems, therefore, that the association of type A ventricular pre-excitation with both right and left bundle-branch block and type B ventricular pre-excitation with left bundle-branch block has been described.

No clear-cut and constant association of type B pre-excitation with right bundle-branch block has been published and the experimental work of Gamboa *et al.* (1962) suggests that it is not likely to occur. However, type A pre-excitation, considered by some authorities to be due to left ventricular pre-excitation, has been shown to be associated with ipsilateral bundle-branch block. We see no reason, therefore, why type B pre-excitation, considered by all authorities to be due to pre-excitation of the right ventricle, could not also be associated with ipsilateral bundle-branch block, particularly if there were an abnormality or disease of the right ventricle. Burch and DePasquale (1961) point out that in ventricular pre-excitation the 'various forms of the QRS complex are determined by the temporal relationships of these two major phases of depolarisation, i.e. the delay in penetration of the normal impulse and the site of origin of the pre-excitation activation wave in the ventricle'.

Type B Ventricular Pre-excitation and Right Bundle-branch Block

In reviewing our cases of type B pre-excitation we have found an example in which the scalar and vector electrocardiograms show right bundle-branch block. The patient was a boy, aged 15 years, with Ebstein's anomaly and supraventricular paroxysmal tachycardia. The scalar electrocardiogram (Fig. 5) shows sinus rhythm with a P–R interval of 0·10 sec. The P wave in standard lead II is positive, 3 mm. tall and of normal duration. The delta wave is positive in standard lead I and in præcordial leads V2 to V6, and is negative in standard leads II and III and in præcordial leads V3R and V1. The duration of the total QRS, including the delta wave complex, is 0·18 sec. The duration of the delta wave in lead I is 0·05 sec. and the remainder, 0·13 sec., suggests delay in the ventricular conduction tissue. The broad late R wave in lead aVR and the broad late S waves in standard lead I and the left præcordial leads are characteristic of right bundle-branch block. The horizontal plane vectorcardiogram shows the slow inscription of the first part of the efferent limb of the QRS $\widehat{sE}$ loop characteristic of ventricular pre-excitation. This slowly-inscribed delta wave vector (duration 0·05 sec.) runs to the left along the 0 degrees axis—the direction typical of type B ventricular pre-excitation. Right bundle-branch block is indicated by the terminal appendage with its slow run-in from the right (Fig. 6).

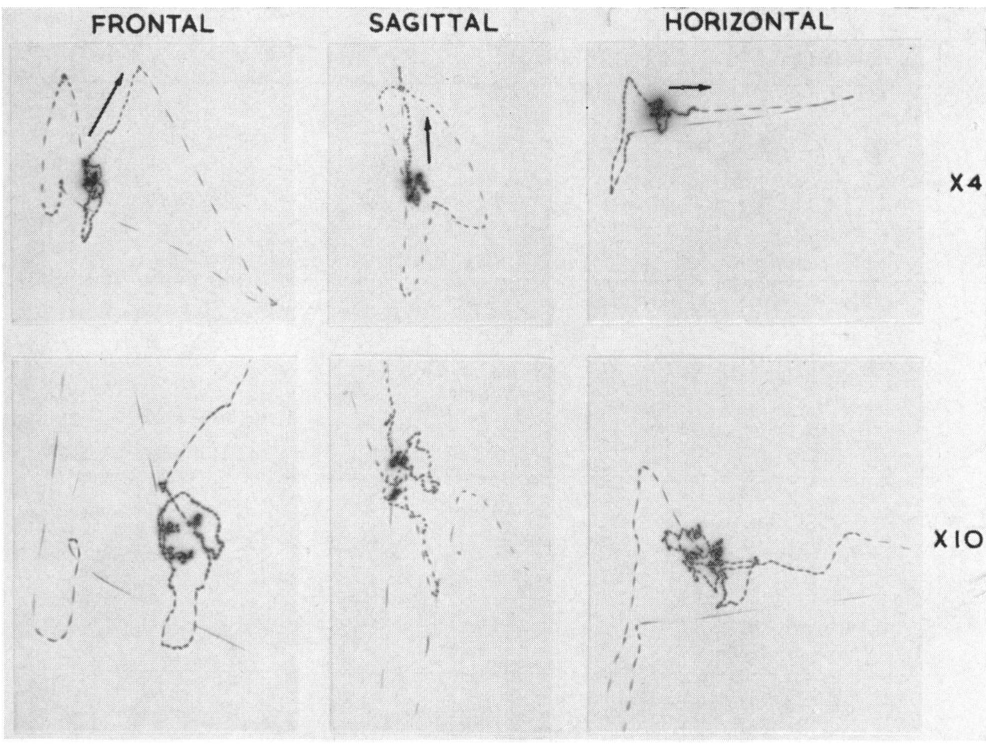

Fig. 6.—Vectorcardiogram of type B ventricular pre-excitation with right bundle-branch block. The delta vector is inscribed slowly and runs to the left along the 0° axis in the horizontal plane. Right bundle-branch block is characterized by the terminal appendage with a slow run-in from the right to J, the junction of the QRS $\widehat{sE}$ and the T$\widehat{sE}$ loops.

Discussion

With the publication of these scalar and vector electrocardiograms all possible combinations of pre-excitation and bundle-branch block have been described. The demonstration of the association of type B pre-excitation and frank right bundle-branch block pattern is opposed to the contention of Gamboa *et al.* (1962) that pre-excitation in type B ventricular pre-excitation is largely responsible for right ventricular depolarization. It may be that it holds good in patients whose hearts are normal apart from their conduction disturbances. It is possible that his theory may have to be modified in the rather exceptional case of Ebstein's anomaly where the proximal right ventricular myocardium is grossly thinned and may show histological evidence of muscle damage (Danaraj and LaBrooy, 1960). Such damage might well account for the delayed depolarization of the right ventricle as suggested by Blount, McCord, and Gelb (1957). In these circumstances it may well be that type B pre-excitation spreads so slowly through the right ventricular myocardium that the bizarre right bundle-branch block pattern, reported in at least three-quarters of cases of Ebstein's anomaly (Van Lingen and Bauersfeld, 1955; Vacca, Bussmann, and Mudd, 1958), is not necessarily abolished.

The early reported cases of type B pre-excitation in Ebstein's anomaly did not have associated right bundle-branch block (Gøtzsche and Falholt, 1954; Gotshalk, Civin, and Mills, 1954; Sodi-Pallares and Marsico, 1955; Mahaim and van Nieuwenhuizen, 1957). Kezdi and Wennemark (1958) described a patient with Ebstein's anomaly and right bundle-branch block. During cardiac catheterization she developed type B pre-excitation for a short period, the right bundle-branch block

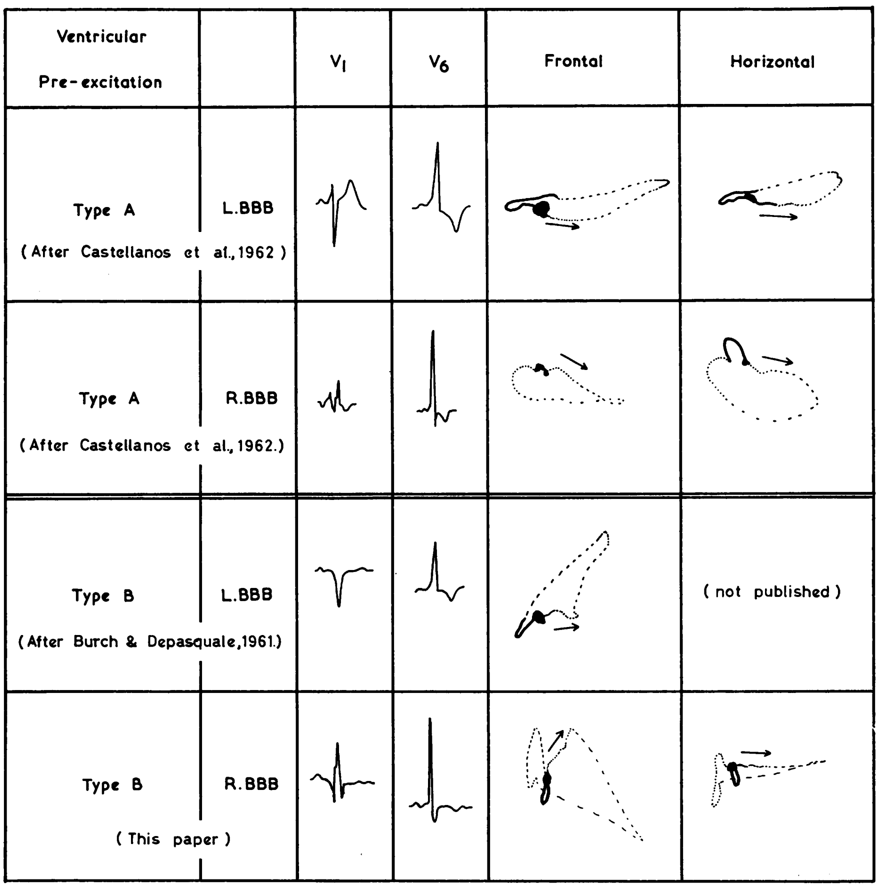

FIG. 7.—All possible combinations of ventricular pre-excitation and bundle-branch block. In each vectorcardiogram the slow initial inscription is indicated by the arrow, and is characteristic of ventricular pre-excitation. Right bundle-branch block is demonstrated by the slowly inscribed terminal portion of the loop and left bundle-branch block by the slow rate of inscription in the middle segment.

pattern being simultaneously lost or greatly diminished, and the summits of the right ventricular pressure pulses being no longer delayed. Cabrera, Feldman, and Olinto (1959) described an interesting case of Ebstein's anomaly with alternation of right bundle-branch block and type B pre-excitation in the scalar electrocardiogram. Although it is difficult to see a clear-cut association of ventricular pre-excitation and bundle-branch block in any complex in their scalar electrocardiograms, this is clearly demonstrated in the vectorcardiograms. These show QRS $\widehat{\mathrm{sE}}$ loops in all transitional stages from right bundle-branch block alone, through diminishing bundle-branch block with increasing pre-excitation, to type B pre-excitation alone. More recently Cabrera and his colleagues (1962) have extended their vectorcardiographic studies of Ebstein's anomaly and have found a high incidence of initial and terminal abnormalities of the QRS $\widehat{\mathrm{sE}}$ loops suggestive or characteristic of type B pre-excitation and right bundle-branch block respectively. The gross pattern of this constant association in both scalar and vector electrocardiograms illustrated in this paper completes the spectrum of type B ventricular pre-excitation and right bundle-branch block (Fig. 7).

SUMMARY

The scalar lead electrocardiograms and vectorcardiograms of the two common types of ventricular pre-excitation are described and illustrated. The problem of the rare association of pre-excitation and bundle-branch block is discussed. Type A pre-excitation has been reported in association with both left and right bundle-branch block. Similarly type B pre-excitation has been reported with left bundle-branch block. Whereas it had previously been argued that type B pre-excitation and right bundle-branch block were incompatible, recent studies have shown that they may alternate or be present together in varying degrees in Ebstein's anomaly.

The constant association of type B ventricular pre-excitation and complete right bundle-branch block has been demonstrated in scalar lead electrocardiograms and vectorcardiograms from a case of Ebstein's anomaly, and completes the spectrum of possible combinations of pre-excitation with bundle-branch block.

We are indebted to Professor Ian G. W. Hill for his advice and to Miss C. Anderson for technical assistance.

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