THE ELECTROCARDIOGRAM IN RESPIRATORY DISTRESS SYNDROME*

THE PRAECORDIAL P WAVE AS AN AID TO ASSESSMENT

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Although the respiratory distress syndrome (RDS) has been the subject of extensive study and review, the clinical and prognostic evaluation, and the therapy, still present considerable difficulties. This report concerns a progressive change in the electrocardiogram, which was found to be of value in assessing severity and prognosis. Attention was drawn to these variations in pattern in a recent brief communication to the *Lancet* (Sutin and Heese, 1964).

Material and Methods

Electrocardiographic tracings were routinely obtained on infants as soon as possible after admission into a special unit for the intensive investigation and treatment of RDS. This unit is in Groote Schuur Hospital, associated with the University of Cape Town, and staffed by members of the Department of Child Health. All the tracings were recorded on a Sanborn direct-writing Visocardiette, conventionally standardized, and run at paper speed of 25 mm. per second. Attempts were made to obtain the 6 standard limb leads and the praecordial leads V1 to V6 in every instance.

This is a retrospective study on these initial tracings, and concerns the 34 graphs in which the behaviour of the P wave and the QRS deflection in V1 and V2 could be clearly interpreted.

All these tracings were taken within the first 48 hours of life. Of these infants, 27 belonged to the White, 6 to the Coloured, and 1 to the Bantu racial group.

During analysis of the tracings, special emphasis was placed on the pattern of the P wave in the right praecordial leads. This wave was considered to be notched when there was a second peak irrespective of the width or depth of the intermediate phase. Attention was also paid to the Index of Macruz (Macruz, Perloff, and Case, 1958), namely, the ratio of the width of the P wave to the corres-

ponding P-R segment. Constant correlation of a specific electrocardiographic pattern with single factors such as blood pH, potassium, and total plasma carbon dioxide, could not be obtained. Attention was then directed at seeing whether any pattern could be related to the over-all clinical condition at the time, and/or the possible outcome.

Results

Our findings in leads V1 and V2 are shown in the Table. When R was clearly greater than S in the right praecordial leads (Group 1), clear-cut right ventricular dominance was generally present. When R was either equal to, or less than, S in V1 or V2 or both (Group 2), R was usually dominant in V6, indicating a more balanced ventricular pattern or left ventricular preponderance. The P wave is shown as being either peaked, biphasic, notched, or inverted. The average and the range of weights of infants with a specific pattern in V1 and V2 are also shown, as well as the number of survivors and deaths among these particular infants.

From the Table it can be seen that there were 2 deaths in Group 1. One was associated with notching of the P wave in both praecordial leads, and the other with notching in V1 and inversion in V2. In Group 2 there were 11 deaths, i.e. a 50% mortality rate. Of these deaths, 10 occurred in infants showing notching present in V2, and 7 of these had notching present in V1 as well. There were no survivors in Group 2 when notching was present in both praecordial leads.

From the weights it can be seen that the smaller infants tended to fall within Group 2. Two of the smallest infants weighing 2 lb. 12 oz. (1,247 g.) and 2 lb. 15 oz. (1,332 g.) survived. In both these, the P wave was either peaked or biphasic in the right praecordial leads.

Fig. 1 illustrates some of the patterns described.

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TABLE
ELECTROCARDIOGRAPHIC FINDINGS (LEADS V1 AND V2) IN 34 CASES

P Wave		Weight (g.)		Survivors	Deceased
V1	V2	Mean	Range		
Group I: R > S in V1 and V2 (12 cases)					
Peaked or biphasic	Peaked or biphasic	1,956	1,247-3,117	4	0
Peaked or biphasic	Notched	2,607	2,323-2,834	2	0
Normal	Notched	2,295	1,814-2,721	3	1
Normal or inverted	Inverted	2,210	2,041-2,352	1	1
Group II: R < S or R = S in V1 and/or V2 (22 cases)					
Peaked or biphasic	Peaked or biphasic	2,182	1,332-3,061	3	1
Peaked or biphasic	Notched	2,069	1,587-2,891	8	2
Normal	Notched	1,558	1,275-2,295	0	7
Inverted	Notched	1,473	—	0	1

Discussion

Previous studies (Usher, 1959, 1961; Keith, Rose, Braudo, and Rowe, 1961) have shown that left ventricular preponderance tends to occur in the more severe forms of the RDS. This is borne out in our series of predominantly White infants. This electrocardiographic finding may be of lesser significance in our Coloured and Bantu, as an interracial difference in normal full-term newborn infants has recently been shown (Sutin and Schrire, 1964). This interracial factor is being considered in establishing normal standards for premature infants. Right ventricular dominance, noted in those less severely involved, is less suggestive of abnormality in the early neonatal period.

Usher (1959) also drew attention to the 'broadening and flattening' of the P wave, and the absence of the P wave sometimes encountered in this syndrome. He related changes to serum potassium

levels. In this study the character of the P wave is reported in greater detail and, as already stated, no constant correlation with serum potassium levels was found. A definite sequence did exist, indicating a progressively more serious prognosis when the P wave was interpreted with due regard to the associated QRS deflection.

The P wave pattern was found to be variable when the R to S ratio was greater than 1 in V1 and V2. This variability is a well-recognized phenomenon in the normal full-term infant, and has recently been documented by DePasquale and Burch (1963). Walsh (1963) stated that the P wave in the premature infant differed from that in the full-term in voltage rather than contour except that the P waves in the former tended to be more peaked. Essentially, therefore, the P and QRS patterns encountered in Group 1, i.e. those infants usually mildly involved, might well be variations of the normal.

In those infants in Group 2, who were clinically more severely involved, the P wave behaved in a definite manner. When the P wave was peaked or biphasic in V1 and V2, the prognosis proved to be good. The outlook progressively worsened with the appearance of notching, and there was no survivor in Group 2 when notching was present in both the praecordial leads. From our current experience it appears that progression is from notching, through notching associated with an Index of Macruz greater than 1.6, to complete absence of the P wave which is a terminal event.

The value of interpretation of the electrocardiogram relative to the clinical condition at the time is illustrated in Figs. 2 and 3. The successive tracings in Fig. 2 are from a White infant in whom some dispute existed as to the severity of the clinical status on admission. From the initial graph a serious prognosis could be anticipated. The P wave was inverted in V1 and clearly notched in V2, with R less than S in V2 and a dominant R in V6. Within hours

FIG. 1.—Examples of the P wave patterns encountered. (a) Peaked P in V1 and V2. (b) Biphasic P in V1, peaked P in V2. (c) Biphasic P in V1, notched P in V2. (d) Notched P in V1 and V2 (note short P-R segment).

FIG. 2.—Tracings from an infant with severe RDS who succumbed. For discussion see text.

this infant was on intermittent positive-pressure assisted respiration, with considerable improvement in circulatory status. This was associated with marked peaking of the P wave as shown on the second tracing. Subsequent deterioration was heralded by the reappearance of notching in V2, and the infant died soon after this third electrocardiogram.

The tracings in Fig. 3 are from an infant who survived a very stormy clinical course. Initially, with S clearly dominant over R in V1 and V2, the P wave was peaked. This peaking was more obvious in the next tracing. With deterioration, the P wave became inverted in V1, and subsequently biphasic in V2 (tracings 3 and 4). When recovery began, peaking again occurred while R was still clearly less than S in V1 and V2 (tracing No. 5). With progressive recovery, the P wave remained peaked, while R and S tended to equalize (tracing No. 6). It must be noted that notching was never manifest, and this infant never required mechanical respiratory assistance.

In our present state of knowledge the explanation of the patterns encountered can only be speculative. Nadas (1963) states that accentuation of the negative

FIG. 3.—Tracings from an infant with severe RDS who survived. For discussion see text.

component of a biphasic P wave in V1 and V2 may be compatible with left atrial hypertrophy. Left atrial hypertrophy is further indicated by a P wave of prolonged duration and two notches of at least 0.05 second apart. Macruz *et al.* (1958) consider left atrial enlargement to be present when their index exceeds 1.6 in lead II regardless of age. Katz (1946) mentions the variations in P wave contour that may occur with respiration and also states that the 'mitral' P wave need not necessarily be notched in the chest leads, but can be biphasic. It is felt that, even if our tracings in the more severely involved do not fulfil the accepted criteria for left atrial hypertrophy, they indicate at least left atrial dominance. This dominance in the presence of left ventricular dominance may indicate a further stage in left-sided overload, and a much more serious disturbance of the haemodynamic status than reflected by the QRS alone. The combined pattern might be a reflection of the size of the left-to-right shunt shown to be present by Rudolph, Drorbaugh, Auld, Rudolph, Nadas, Smith, and Hubbell (1961) in those more severely involved. This shunt would in turn be inversely related to the pulmonary vascular resistance and changes in the

latter might well be the primary factor. Left atrial dominance *per se* could indicate that functional closure of the foramen ovale has occurred.

Summary and Conclusions

The praecordial P and QRS patterns in V1 and V2 in the electrocardiographic tracings on admission on 34 infants with the respiratory distress syndrome are presented. In this retrospective study emphasis is placed on the characteristics of the P wave.

Interpretation of the P wave contour with due regard to the concomitant QRS deflection reveals changes of pattern associated with progressive worsening in prognosis. The evolution is from a variable P wave associated with an R to S ratio greater than 1 in both V1 and V2, through a peaked or biphasic P wave, subsequently becoming notched and finally absent, with an R less than or equal to S in V1 or V2 or both. These changes are sufficiently constant to warrant the routine use of the electrocardiogram as an additional parameter in assessment of severity and prognosis. The possible mechanism by which these patterns could be produced is discussed.

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