Why is evaluation of the childhood ECG difficult?

The brief physiologic *devolution of the ECG* requires knowledge of the normal values for each age group. However, the normal range varies greatly.

The *configuration* of ECG tracings *peculiar* to children may be unfamiliar to a doctor predominantly working in adult cardiology.

*Extracardiac factors* play a much greater part in children than in adults; they vary from age group to age group and are often difficult to differentiate.

Recording of faultless tracings meets with purely *technical difficulties*, especially in young children: artifacts due to restlessness, crying, slipping of electrodes, etc., must be taken account of in interpretation.

### 14.1 Normal Development of ECG as a Whole

#### 14.1.1 Newborns

The fetal heart resembles a “double pump” interpolated into the systemic circulation. The aorta is supplied with blood from the left – via the physiologic shunts through the foramen ovale and ductus arteriosus – and from the right heart in approximately equal proportions. This “dynamic equilibrium” results anatomically in the characteristic *balance of mass* of the two halves of the heart of a newborn. The muscle mass ratio right to left is approximately 1:1 in the newborn, in the adult 1:2.6. In the newborn, the right ventricle is thus more than twice as heavy as the left when compared with the left ventricle of the adult. Hence, it is justifiable to speak of a “*physiologic right hypertrophy*” of neonates.

Thus, the ECG of the newborn reveals right axis deviation (up to +180°), deep S in leads I and aVL, tall R in leads III, aVF, and usually also in aVR. In the chest leads there are tall positive deflections over the right (R in V3r, V1, V2), deep negative waves over the left precordium (S in V5, V6).

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The preponderance of the right ventricle is especially impressive in the vectorcardiogram (Fig. 98). The vector loop of the newborn lies almost completely to the right of the vector origin, both in the frontal and horizontal projections, and thus represents almost the mirror image of that commonly seen in adults. The vector loop reveals at first glance that most vectors run toward the right leads (V1, V2, III, aVR). This explains the tall R waves in these leads as well as the deep S waves in all leads over the left of the heart (V5, V6, I, aVL).

During the first weeks of life the vector loop in the horizontal projection is inscribed in a direction (clockwise) opposite to that of the later normal one (anticlockwise) (see arrow in Fig. 98). As a result of this different vector rotation there is normally in the newborn a relative prolongation of the QR interval over the right chest with simultaneous shortening over the left. The positive difference QR in V6–QR in V1 of the older child is thus negative in the majority of neonates.

14.1.2 Infants

A transition from a few hours to days is required for the fetal circulation to adapt to postfetal conditions. This process varies considerably in time but is basically quite regular on ECG and continues into adulthood. Due to altered hemodynamic conditions in the first few months of life the structure of the heart is transformed. The left ventricle increasingly dominates in supplying the systemic circulation, whereas the right ventricle undergoes a kind of "physiologic atrophy."

The strengthening of the left ventricle is reflected mainly in the left chest leads. The small neonatal R in V5, V6 rapidly becomes larger, the S wave correspondingly smaller. After a few months the QRS complexes in the left chest leads hardly differ from those seen at a later age. In the right chest leads (V1, V2), the signs of right preponderance also regress distinctly (R becomes smaller, S deeper), but not as fast as in the left leads. An R in V1 and V2, relatively tall as compared with the adult norm, persists throughout childhood (Fig. 98).

14.1.3 Young Children

At the end of the first year of life the structural change in the heart is usually completed, and the normal mass relation of the ventricles has been almost attained. Growth-induced change in the position of the heart within the thorax now occurs and is affected by different factors in the different age groups.

The anatomic transverse position of the heart in the first few years is due to the relatively large transverse and small vertical diameter of the thorax together with the physiologically raised diaphragm. Contrary to adult conditions, the right ventricle occupies a far greater proportion of the anterior surface of the heart, which appears to be rotated clockwise on its longitudinal axis. Whereas the horizontal position of the infant heart is electrically fully compensated by the vector projection resulting from muscle-mass relationships and cannot be seen in the ECG, rotation on the longitudinal axis is manifest by an extremely deep Q wave in lead III which is typical of early childhood. A depth of Q in excess of the accepted adult threshold of 25% of the height of the R wave is almost the