The Electrocardiogram In Interatrial Septal Defect

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Strictly speaking, it seems unlikely that the mere presence of an interatrial septal defect, unless it were very large or located in such a position as to involve the atrio-ventricular conduction system, could of itself be productive of any specific electrocardiographic pattern. Rather it would seem that any electrocardiographic abnormalities observed in the presence of this defect are more likely the result of changes in cardiac chamber work, and therefore size, coincident to changes in pressure and the direction (and volume) of blood flow across the defect in the interatrial septum. The primary diagnostic contribution of the electrocardiogram is therefore dependent on the accuracy with which it provides evidence not only of the presence and degree of single or combined cardiac chamber enlargement but also of the underlying hemodynamics and therefore the type of chamber enlargement observed.

Since mean pressures are normally higher on the left or systemic than in comparable positions on the right or pulmonary side of the central circulation, the direction of blood flow through an uncomplicated interatrial septal defect is from left to right. As a result the characteristic features are:

1. Increase volume flow of blood through the right atrium, right ventricle, and pulmonary circulation.
2. Increased work, without significant changes in pressure, and therefore increased size of the right atrium and right ventricle—in other words, those chambers receiving the increased volume due to the shunt.
3. Absence of systemic arterial oxygen unsaturation.

The characteristic electrocardiogram in uncomplicated defects of the interatrial septum is accordingly one representative of right atrial and right ventricular enlargement, the latter of the type designated as predominantly dilatation or diastolic-overloading (increased volume flow-work) enlargement in contrast to systolic-overloading (increased pressure-work) hypertrophy of this chamber. The typical pattern of this type of right ventricular strain and enlargement appears to be one of some degree of right bundle branch block. (Figures 1, 2 and 3). This immediately calls to mind several basic problems relative to the interpretation of bundle branch block patterns, which can be listed but not discussed within the time limits of this paper:

1. The importance of the factors of age and changing relative right ventricular mass in the genesis of various “typical” patterns of incomplete and complete (uncomplicated) right bundle branch block.
2. Electrocardiographic criteria for the determination of the degree of right ventricular enlargement in the presence of otherwise uncomplicated right bundle branch block.
3. The differentiation of patterns of right bundle branch block with and those without associated or complicating increased pressure-work hypertrophy of the right ventricle.
4. The recognition, in the presence of right bundle branch block (with or without right ventricular enlargement) of associated strain and enlargement of the left ventricle.
5. The determination of right ventricular enlargement in the presence of left bundle branch block. (Figure 4)
Figure 1
A typical electrocardiogram in an infant with a large uncomplicated interauricular septal defect. The precordial leads are characteristic of probable right bundle branch block and right ventricular hypertrophy. In this case there was fairly marked pulmonary artery and right ventricular hypertension.

Figure 2
A typical electrocardiogram in an infant with an interatrial septal defect but no significant pulmonary artery or right ventricular hypertension. These precordial leads show uncomplicated right bundle branch block.
Another typical electrocardiogram in uncomplicated interauricular septal defect. T wave inversion across the precordium through lead V5 is suggestive of marked right ventricular dilatation.

In this case there was an uncomplicated interauricular septal defect, proved surgically and by pre and post-operative cardiac catheterization. This is one of the extremely rare circumstances in which such a defect is associated with left instead of right bundle branch block.
The electrocardiogram may or may not help in identifying the anatomic position of the interauricular septal defect. In this case, for example, there is no "typical" left axis deviation, nor definite evidence of associated left sided enlargement as seen with complicating mitral insufficiency. In other words, the electrocardiogram by itself does not necessarily exclude the possibility of a primum type of defect.

This is a more typical electrocardiogram in a primum type of interauricular septal defect— with left axis deviation in the extremity leads, and combined right bundle branch block and left ventricular hypertrophy in the precordial leads.
This is a typical electrocardiogram, especially the precordial leads, for combined right and left ventricular enlargement, of a type not observed in uncomplicated interauricular septal defect. This is much more characteristic of a high pressure communication and shunt, or a combined high and low pressure communication and shunt such as common A-V ostium.

It should be stated at this point that electrocardiographic criteria providing a solution to several of these problems are already available, while the others are the subject of current investigation, the completion of which may be expected in the near future.

On the basis, then, that the electrocardiogram provides detailed physiologic as well as anatomic information, it may be expected to contribute significantly toward the clinical clarification of problems representing major modifications of the otherwise simple hemodynamic pattern of an uncomplicated interatrial septal defect. Three basic types of modifications might be listed to include:

1. Obstruction to right atrial or right ventricular outflow, resulting in equalization or reversal of the usual pressure gradient and direction of shunt across the interatrial defect.
   a. Pulmonary hypertension
   b. Pulmonary stenosis
   c. Tricuspid stenosis or atresia

2. Obstruction to left atrial or left ventricular outflow increasing the magnitude of the usual pressure gradient and volume of blood flow across the interatrial septal defect.
   a. Coarctation of the aorta
   b. Aortic stenosis
   c. Subendocardial fibroelastosis
   d. Mitral stenosis or atresia

3. Associated defects not necessarily affecting the usual pressure and blood flow relationships across the interatrial septal defect.
   a. Interventricular septal defect (high pressure communication and left-to-right shunt) (Figure 7)
   b. Mitral or tricuspid valve incompetence
Again, time does not permit a detailed discussion of the exact contributions of the electrocardiogram in each of the foregoing situations. On the basis of the general principles already stated, however, it would seem well to conclude these brief remarks by relating the clinical value of electrocardiography to that of other available diagnostic procedures, especially in interatrial septal defect.

In the so-called "typical" case of interatrial septal defect, with a moderate volume of left-to-right shunt but no significant elevation of pulmonary artery or right ventricular pressures, an accurate diagnosis can usually be made from a combination of physical, roentgenologic, and electrocardiographic signs:

- **Physical (Auscultatory)**
  - Basal systolic murmur of pulmonary flow or dilatation
  - Apical third heart sound
  - Prominent splitting of the pulmonary second sound

- **X-ray**
  - Increased volume of pulmonary blood flow
  - Dilatation of the pulmonary artery and right atrium
  - Right ventricular enlargement

- **Electrocardiogram**
  - Right bundle branch block
  - Right ventricular enlargement.

In the case of an interatrial septal defect in which the volume of shunt is small because of the small size of the defect rather than a decreased pressure gradient (from left to right), it is probable that the diagnosis might frequently be missed by clinical examination and made only by direct demonstration, i.e., by cardiac catheterization.

If, because of increased pressures on the right side of the heart, the volume of blood flow through an interatrial septal defect is decreased or its direction reversed, the electrocardiogram may be expected to reflect the underlying hemodynamics (and resulting cardiac anatomy) by displaying evidence of right ventricular hypertension and hypertrophy (in the case of primary or secondary pulmonary hypertension or pulmonary stenosis, or left ventricular hypertrophy in the case of a total right-to-left shunt as in tricuspid atresia). The existence of shunt reversal may, of course, be inferred from the presence of visible cyanosis (or measurable systemic arterial oxygen unsaturation); its location must be demonstrated by either cardiac catheterization or venous angiography.

In differentiating an interatrial from an interventricular septal defect, or in determining the presence of a combined interatrial and interventricular septal defect, direct measurement of the position, direction, and volume of the shunt by cardiac catheterization is generally considered essential. However, physiologic-anatomic information gained from the electrocardiogram (multiple unipolar precordial leads) may be exceedingly helpful — either serving as a guide toward determining the type of information which should be sought in other more technical diagnostic procedures, or in the clarification of physiologic data which for one of several reasons might otherwise be equivocal (ex.—interventricular septal defect with tricuspid insufficiency).

It is worthy of emphasis that electrocardiography is a procedure of absolutely no risk, requiring a minimum of technical equipment and trained personnel, yet capable of providing a wealth of physiologic and anatomic information relative to single and combined cardiac chamber work and size — much more detailed information, in fact, than has been generally appreciated.