Intra-uterine closure of the atrial septum

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SYNOPSIS Two newborn babies with an intact atrial septum are described. In one, the two components of the atrial septum appeared to have become fused after relatively normal initial development; the left side of this heart was hypoplastic. In the other baby the formation of the atrial septum appeared to have been completely anomalous; this heart showed mitral atresia, absence of the left ventricle, and transposition of the great vessels. There was also pulmonary lymphangiectasis in the second case, and it is suggested that this was due to the cardiac malformation obstructing pulmonary venous drainage.

A patent atrial septum is essential for the normal foetal circulation, and an intact septum at birth has rarely been reported. Lev, Arcilla, Rimoldi, Licata, and Gasul (1963) were able to find only 19 cases in the literature, and reported 11 more from their series of 1,150 hearts with congenital malformations submitted to pathological examination.

It is reasonable to suppose that the malformation may be due to the atrial septum forming without a patency in the first place or to closure at a later stage. It might be expected that the first of these possibilities would be associated with a higher incidence and greater severity of other cardiac malformations. We believe the two cases reported in this paper illustrate these points.

CASE REPORTS

CASE 1 The baby was stillborn at 43 weeks by dates to a primiparous mother aged 22 years. Wassermann reaction was unknown, Rh positive. Pregnancy was uneventful. Labour lasted 36 hours with a vertex presentation and forceps delivery. The placenta weighed 383 g. and was unremarkable apart from meconium staining of the cord and membranes.

External appearance The body was that of a female baby, of weight 3,191 g., length 50 cm., head circumference 34 cm. There were petechiae over the thorax and there was generalized cyanosis. The perineum was covered with meconium.

Internal examination There was meconium in the stomach and a small amount in the trachea and bronchi. The liver (164 g.) was slightly enlarged and congested, and there was a slight excess of serous fluid in the peritoneal cavity. Both pleural cavities contained a small amount of blood-stained fluid and there were many petechiae on the lungs and heart.

The systemic veins were engorged and there was a small amount of slightly blood-stained fluid in the pericardial cavity. The heart (23 g.) was slightly enlarged and slightly rotated towards the left because of enlargement of the right side. The right atrium was greatly dilated. The tricuspid ring was 4 cm. in internal circumference and its cusps were normal. The right ventricle was markedly dilated and hypertrophied, the wall measuring up to 0·8 cm. in thickness (Fig. 1). The pulmonary ring, 2·9 cm. in circumference, and the pulmonary trunk were dilated, and the ductus arteriosus was wide with an internal circumference of 1·5 cm. The aortic insertion of the ductus was opposite the origin of the left subclavian artery. The pulmonary veins were engorged and entered the left atrium in the usual way. The left atrium was much smaller than normal but otherwise unremarkable in configura-
tion. The mitral valve ring was much reduced in size, being 2·4 cm. in circumference. There was a small blood cyst on the aortic cusp but otherwise the valve and chordae were unremarkable. The cavity of the left ventricle was much reduced in size but the myocardium was of normal thickness, 0·4 cm. (Fig. 2). The aortic ring was much reduced, 1·5 cm. in internal circumference. It had three cusps of normal configuration. The ascending aorta and arch were of approximately half the normal calibre and its major branches unremarkable.

The ventricular septum was entirely normal. The atrial septum viewed from the right side showed a well-defined fossa ovalis and limbus (Fig. 1). There was a narrow crescentic cavity lying between the limbs of the septum secundum anteriorly and the much thinner but intact septum primum. The orifices of the venae cavae and coronary sinus were normal. Viewed from the left side there was a distinct convex bulge of the septum primum, approximately 0·9 cm. in diameter, with no evidence of an ostium secundum in the usual situation (Fig. 3). The bulge formed the left side of the inter-septal cavity mentioned previously. At the extreme anterior limit of the atrial septum there was a small sulcus, 0·25 cm. in maximum diameter, with slight trabeculation of the surrounding septal tissue (Fig. 4). This gave the distinct impression of a small ectopic ostium secundum which had become completely obliterated by adhesion between the extreme anterior parts of the septum primum and septum secundum. There was no endocardial thickening of the atrial septum or elsewhere in the heart.

Histological examination The lungs showed aspiration of meconium with marked congestion and scattered haemorrhages. Examination of the remaining viscera was unremarkable.

CASE 2 A male baby was born at 36 weeks to a 22-year-old, gravida 3, mother. There was anaemia during pregnancy and labour was induced because of hydramnios. Labour was uneventful with a vertex delivery and lasted 11 hours. The baby was in poor general condition at birth and he survived for only 45 minutes. The placenta was said to be unhealthy and weighed 1 lb. 4 oz.

External appearance The body was slightly cyanosed. The length, 48 cm., corresponded to 39 weeks' gestation, and the weight, 2·363 g., to 37 weeks'.

Internal examination Outside the thorax the only features of note were congestion of the liver (93·5 g.) and spleen (10 g.), a deep fissure on the anterior surface of the spleen, and a small yellow adrenal rest on the spermatic cord near the right testis.
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The venae cavae were unremarkable. The heart weighed 14 g. (normal 15·5 g.). The right atrium was slightly dilated and communicated with a single ventricle through a tricuspid valve 2·5 cm. in circumference. The ventricle had an average thickness of 0·4 cm. and gave rise to the aorta anteriorly and the pulmonary trunk posteriorly so that the great arteries were transposed. The pulmonary outflow tract was unobstructed; the circumference of the valve ring and the trunk was normal, measuring 1·6 cm. The aortic outflow tract was partly obstructed by a prominent ridge of muscle, approximately 0·4 cm. wide, which passed from the anterior wall of the ventricle to the lateral wall below the left posterior cusp (Fig. 5). Between the ridge and the valve was a small, deeply trabeculated, infundibular chamber. There was no stenosis of the aorta or its valve; the aorta was 1·35 cm. in circumference and its branches were unremarkable. The left atrium was very small and was lined by thickened endocardium (Fig. 6); into it drained four small pulmonary veins but it did not communicate with either the right atrium or the single ventricle.

The atrial septum was intact and appeared to be an exceedingly muscular structure with an average thickness of 0·45 cm. The lower third was thinner and formed an aneurysmal bulge on the right side of the septum. There was no evidence of a fossa ovalis or limbus on the right side (Fig. 7). On the left side (Fig. 6) there was a round coarsely trabeculated area approximately 0·7 cm. in diameter with an overlying muscular arch similar to the pseudo-limbus illustrated by Lev et al. (1963, Fig. 2). The lower part of this area formed the aneurysmal bulge referred to above. The heart was sliced at right angles to the plane of the atrial septum; this confirmed the above findings and in particular emphasized the muscular nature of the atrial septum (Fig. 8).

There was 90 ml. of clear, amber-coloured fluid in the right pleural cavity and 65 ml. in the left. Both lungs were collapsed and had a finely lobulated surface. There were a few small subpleural haemorrhages of the right upper lobe. The cut surfaces of both lungs had a honeycomb appearance with numerous small cystic spaces.

**Histological examination** The macroscopic features were confirmed and in particular the trabeculated muscular nature of the atrial septum, and the marked fibroelastosis of the left atrium (Fig. 9). There were prominent internal pads of fibro-elastic tissue at the atrial end of the pulmonary veins and there was also slight focal fibroelastosis in the right atrium. The aneurysmal part of the septum consisted of collagenous and elastic fibrous tissue. No infiltration with inflammatory cells was seen.

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**FIG. 5. Aortic outlet of ventricle showing prominent subvalvular muscular band of case 2.**

**FIG. 6. Atrial septum, left side, of case 2. Note the trabeculation and the pseudo-limbic arch.**

**FIG. 7. Atrial septum right side of case 2. Note the aneurysmal bulge and absence of a fossa ovalis.**
FIG. 8. Vertical slice through the heart of case 2 showing the thick muscular atrial septum with a thin aneurysmal lower part.

FIG. 9. Longitudinal section of atrial septum of case 2. Note the endocardial sclerosis on the left side, the muscular upper part of the septum and the fibrous lower part. Elastin and Van Gieson × 7.

FIG. 10. Lung (case 2) showing lymphangiectasia. Elastin and Van Gieson × 20.
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The normal patency of the atrial septum depends upon the development of an ostium secundum in the upper part of the septum primum, and upon the incomplete nature of the septum secundum. The holes in the two septa overlap each other slightly to form the foramen ovale, but the patency of the atrial septum as a whole depends largely upon the separation of the septa by the greater pressure in the right atrium.

If the ostium secundum fails to appear, or the septum secundum forms a complete partition, the atrial septum will be an intact structure from about the eighth week onward. The normal shunt from the right atrium to the left would not occur, and as at this stage there is little pulmonary venous blood flow, hardly any blood would enter the left side of the heart. Profound hypoplasia of the left atrium, mitral valve, left ventricle, and aorta might be expected to result, and is in fact a common feature of reported cases. Of the 30 cases reviewed by Lev et al. (1963), for example, 11 had stenosis or atresia of the mitral valve, and in 17 the aorta or its valve were similarly affected. Complete absence of the left ventricle, as in our second case, was reported by McIntosh (1926) and Hyman (1946). Transposition of the great vessels does not appear to have been previously recorded in this condition.

Relatively minor abnormalities of development of the atrial septum might be expected to result in an inadequate patency. For example, the septum secundum might be so extensive as to cover completely the ostium secundum, or a similar end result would follow if the ostium secundum failed to reach its normal size. In either case, the reduced shunt from the right atrium to left might well be sufficient to promote relatively normal development of the left side of the heart; but there would be a risk of the restricted and somewhat devious channel through the atrial septum becoming prematurely obliterated by adhesions between its two components.

The 12 babies described by Naeye and Blanc (1964) appear to constitute a third group of cases; they showed evidence of pre-natal and post-natal pulmonary hypertension and congestive failure, but development of the left side of the heart was normal. In nine of the babies the foramen ovale was abnormally small at birth, 4 mm. or less in diameter, and in the other three there was no patency at all. We agree with Naeye and Blanc that in this group the normal left to right interatrial shunt must have been maintained at an adequate level until late in prenatal life.

We suggest that our cases support this view of the pathogenesis. Case 1 showed anatomical features indicating normal development of the septum secundum but a small ectopic ostium secundum which later became obliterated by adhesions between the two leaves of atrial septum; though the left side

All lobes of the lungs showed numerous prominent lymphatic spaces in the subpleural, interlobular and peribronchial connective tissue (Fig. 10). They had a thin wall lined by endothelium and often contained lymphocytes. The alveolar pattern was immature with a lining of cuboidal cells, and there was poor expansion. The blood vessels, especially the veins, were engorged and thin-walled.

Unexpectedly, lymphangiectatic spaces were also found in the upper trachea, deep and superficial to the cartilage, and in the capsular and interlobular connective tissue of the thyroid gland (Fig. 11).

Representative sections from the remaining organs showed no significant changes.

Discussion

The normal patency of the atrial septum depends upon the development of an ostium secundum in the upper part of the septum primum, and upon the incomplete nature of the septum secundum. The holes in the two septa overlap each other slightly to form the foramen ovale, but the patency of the atrial septum as a whole depends largely upon the separation of the septa by the greater pressure in the right atrium.

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FIG. 11. Trachea (case 2) showing lymphangiectasis. Haematoxylin and eosin × 193.
of the heart showed marked hypoplasia, the mitral and aortic valves were not atretic. On the other hand, the atrial septum of case 2 was completely anomalous and showed no indication of a fossa ovalis or ostium secundum; here the left atrium was minute, the mitral valve atretic, and the left ventricle completely absent.

Pulmonary lymphangiectasis, a striking feature of case 2, has been the subject of two papers by Laurence (1955, 1959). He described a total of 13 cases and concluded that the condition is the result of anomalous pulmonary development with retention of prominent lymphatics characteristic of the early foetal lung. He specifically stated that 'no blockage of the veins or lymphatic vessels has yet been observed to suggest secondary lymphangiectasis', and the high incidence of other malformations he simply accepted as evidence of a primary developmental anomaly. In fact, four of his 13 cases (cases 3, 6, 7, and 8) showed marked hypoplasia of the left side of the heart with mitral atresia in two, and in addition, case 12 had unspecified multiple malformations involving the heart. In our view this association is more than coincidental, and we suggest that pulmonary lymphangiectasis is frequently secondary to such lesions of the left side of the heart. These could well obstruct the pulmonary venous flow and cause increased lymphatic drainage with consequent retention of the large lymphatics characteristic of the early foetal lung.

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