

PERIPHERAL VEIN CONTRAST ECHOCARDIOGRAPHY IN ATRIAL SEPTAL DEFECT*

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Indirect findings of atrial septal defect are obtained by means of M-mode echocardiography^{1,2}. Direct visualization of atrial septal defect is possible by two-dimensional echocardiography³. However, false-positive defects may be a diagnostic problem³. Although, peripheral venous contrast echocardiography has been used to detect intracardiac shunts³⁻⁸, this method has not as yet been well established. This study was undertaken to further evaluate the diagnostic capability of peripheral venous contrast echocardiography in patients with isolated atrial septal defect.

Material and Methods

233 children suspected clinically of having isolated atrial septal defect evaluated by physical examination, electrocardiography, and telecardiography were studied. The age range was between one and 17 years (mean age: nine years).

Two-dimensional echo studies were performed using either a mechanical sector scanner (Honeywell, Ultra-Imager) equipped with a 2.5 megahertz transducer or a Toshiba SSH-60A echocardiograph equipped with 3.75 and 5 megahertz transducers. The images were recorded on video-tape for further evaluation.

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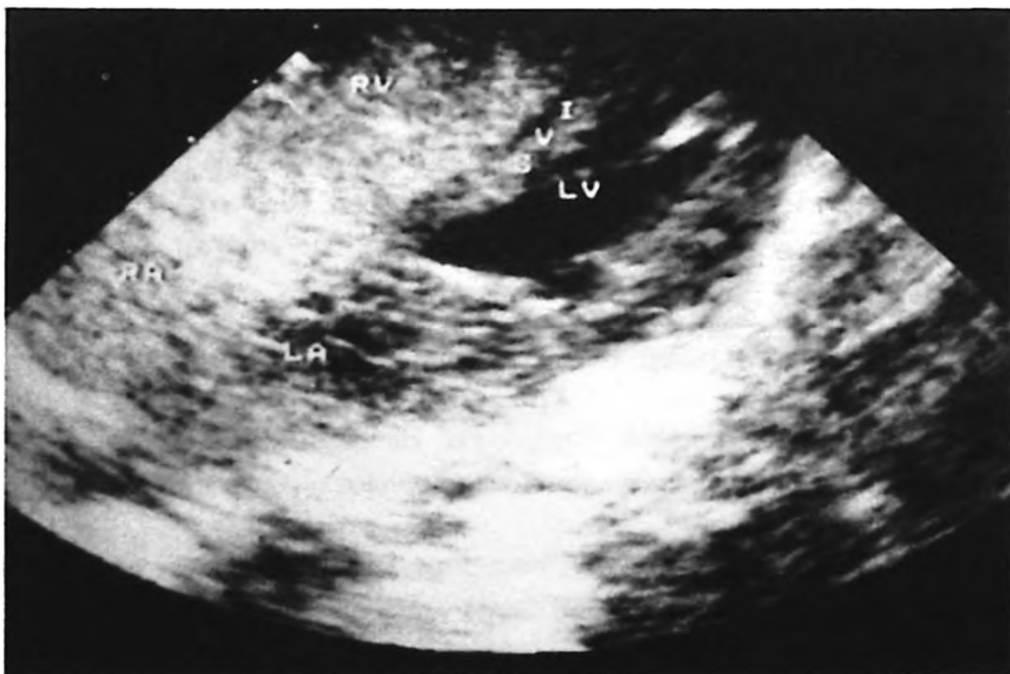
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Three percent saline or 5 percent dextrose was used as contrast material. In patients revealing an unsatisfactory contrast image, CO₂ in the amount of 0.1 cc/kg was added to the saline or dextrose. Peripheral vein contrast material injections were administered in the arm, using a pediatric scalp vein set (gauge 21). A variety of transducer positions were used to visualize the interatrial septum and both atria. These included apical four-chamber, subcostal and modified parasternal short axis projections. This study was conducted on patients who were either in the supine or in the 30-degree left lateral position.

In the first few cases different amounts of echo contrast materials were injected with syringes of different sizes and at varying speeds. The best contrast image was obtained by a rapid injection of 10 cc of echo contrast material, especially 3 percent saline. The study was repeated 3-6 times in each case. If heart failure was present, 5 percent dextrose was preferred. In some cases, intravenous furosemide was given after the study was completed to prevent sodium accumulation if saline was used as the contrast material. Some patients were sedated in order that a comfortable study be performed.

The transfer of contrast material from the right atrium into the left atrium was evaluated as "positive contrast" (Fig. 1). Non-contrast blood, passing from the left to the right atrium was termed, "negative contrast" (Fig. 2). Positive contrasts were semiquantitatively graded according to the following criteria: massive shunting 4+; strong shunting 3+; little shunting 2+; very little or questionable shunting 1+. A significant negative contrast effect was graded as 3- or 4-, and 2- contrasts were considered to be questionable. Three positive, 4+ and/or 3-,



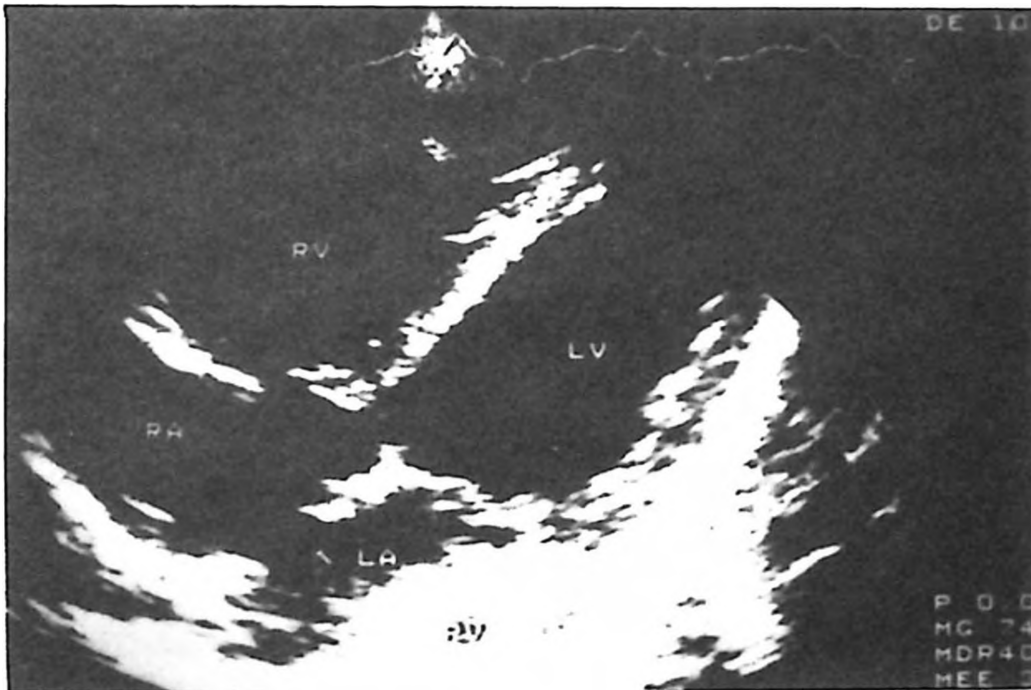
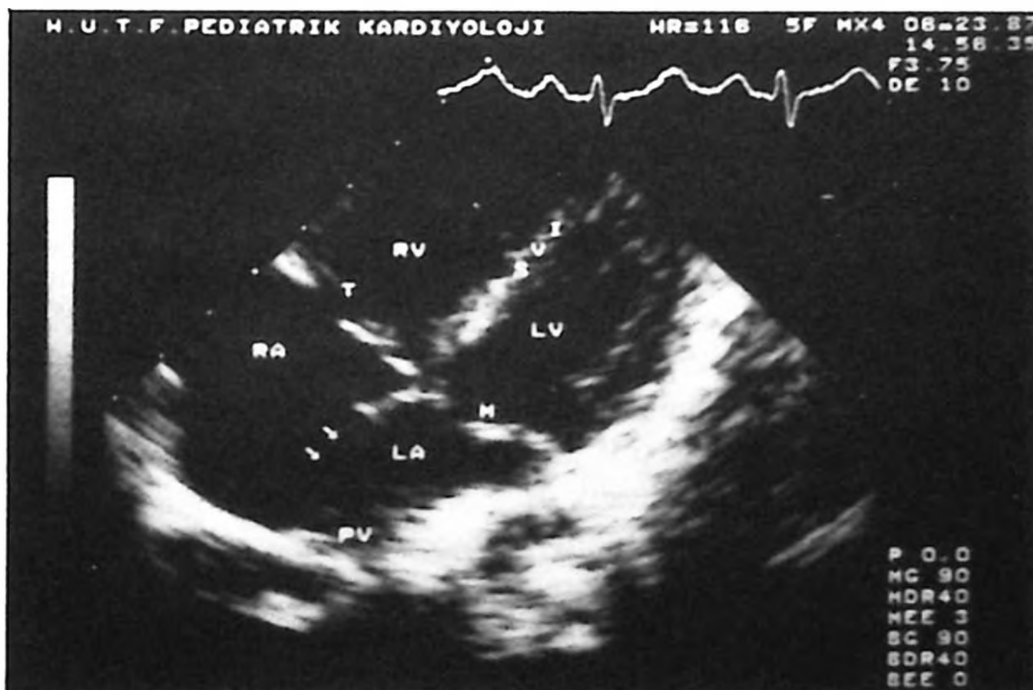


Fig. 1: Four chamber view echocardiograms. (a) Two-dimensional echocardiogram before injection of contrast material illustrates atrial septal defect (arrows). (b) Following peripheral vein contrast injection, right atrium and right ventricle filled with contrast material. Passage of 4+ contrast material from the right atrium to the left atrium through the atrial septal defect is seen. (RA, right atrium; RV, right ventricle; IVS, interventricular septum; T, tricuspid valve; M, mitral valve; PV, pulmonary vein).



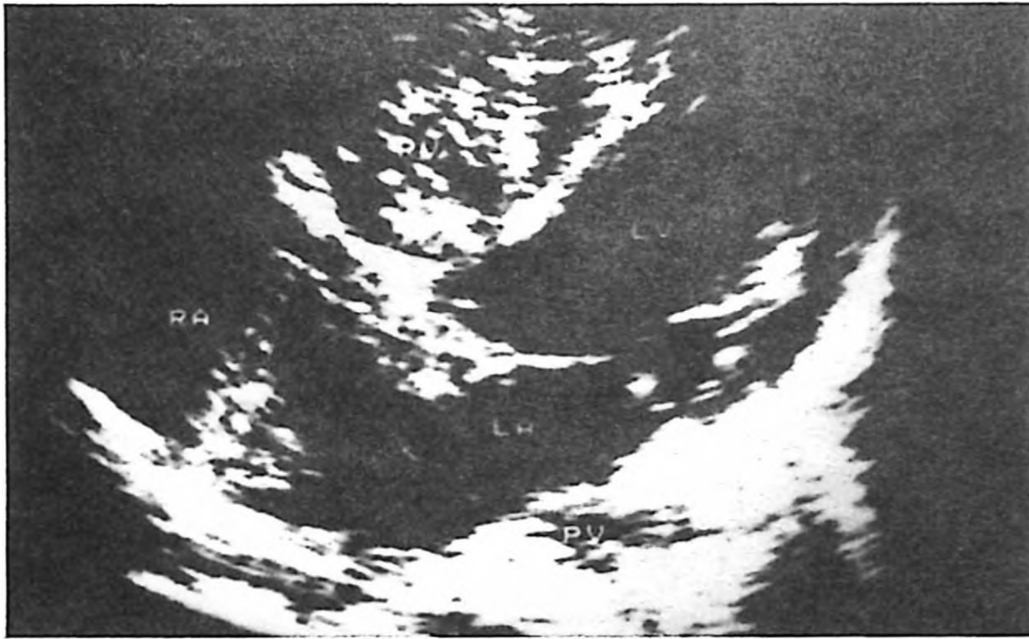


Fig. 2: Four chamber view echocardiograms. (a) Two-dimensional echocardiogram before injection of contrast material illustrates atrial septal defect (arrow). (b) Following peripheral vein contrast injection right atrium and right ventricle filled with contrast material. Arrow indicates 4– contrast effect resulted in the passage of non-contrast blood from the left atrium to the right atrium through the atrial septal defect. (RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricle; PV, pulmonary vein).

4– contrast shuntings were considered to be definite evidence of an interatrial leak. It was decided that these patients were candidates for atrial septal defect closure. In the first few cases we were very cautious, and the surgery was performed as soon as possible in order to obtain a prompt surgical diagnosis. The patients with an insignificant contrast effect were evaluated as candidates for cardiac catheterization and angiocardiography.

Results

154 patients showed a grade 3 or 4 positive and/or negative contrast effect. Among these patients 123 had only positive, nine negative, and 22 both positive and negative shunting. Of those 154 cases, 92 underwent atrial septal defect closure. The procedure was successful in all patients operated, the size of the defect being 2×2 cm or larger. Of the 31 patients with 1+ or 2+ shunting, 14 patients were catheterized. Thirteen of them were diagnosed as having atrial septal defect while one patient showed no evidence of atrial septal defect. Forty-eight cases did not reveal any contrast effect. Ten of them were catheterized. Six were diagnosed as atrial septal defect. Among the remaining four patients, one showed no cardiac pathology. However, two demonstrated mild pulmonary stenosis. One case showed evidence of partial anomalous pulmonary venous return with one of the left pulmonary veins draining into the left

innominate vein by way of the vertical vein. The other pulmonary veins were normally connected to the atrium. Angiography and catheter manipulation revealed no evidence of atrial septal defect.

Discussion

Among the cases with a 3+, 4+ and/or 3-, 4- contrast effect, 92 underwent surgical treatment. In all, a surgical diagnosis of large atrial septal defect was obtained and the defects were closed. This result shows that the method presented is a safe and reliable one. Stark et al⁹ operated on four cases with atrial septal defect diagnosed by two-dimensional echocardiography and suggested that further experience be gained regarding the subject. Bourdillon et al⁵ studied ten patients with atrial septal defect using two-dimensional contrast echocardiography. They stated that the method was a potentially valuable one in identifying atrial septal defect.

In 31 cases with a 1+ or 2+ contrast effect, the diagnosis was accepted as not definite, although among those cases 14 were catheterized and atrial septal defect was diagnosed in 13. In the remaining one patient with a 1+ contrast effect no intracardiac shunt was detected by cardiac catheterization and angiocardiography. These findings are compatible with our description of 1+ contrast defined as a "very little or questionable contrast effect".

In 48 of our 233 cases, a contrast effect could not be seen. Of these 48 cases, ten were catheterized and the presence of atrial septal defect was detected in six. Among 14 cases diagnosed by cardiac catheterization Ginzton et al⁶ were not able to detect atrial septal defect in one patient using two-dimensional contrast echocardiography. These results demonstrate that two-dimensional contrast echocardiography may fail to detect atrial septal defects in some cases. This occurs probably because of technical difficulties. We recommend cardiac catheterization and angiocardiography in the evaluation of such cases.

On the other hand, in our five patients among the catheterized 24 cases suspected clinically of having atrial septal defect, there were no septal defects; one of these cases had a partial anomalous pulmonary venous return without an atrial septal defect. Ginzton et al⁶ found no intracardiac shunt in cardiac catheterization in their six patients among the 20 cases with clinical atrial septal defects. These findings, as traditionally accepted, show that just a clinical diagnosis alone is not sufficient for a definite diagnosis of atrial septal defect.

Weyman et al^{4,8} found that non-contrast containing areas characteristically occurred immediately to the right of the atrial defect. They observed that a similar area of negative contrast had never been seen in patients with intact interatrial septae. This was explained by the flow of non-contrast containing blood from the

left atrium to the right atrium through the atrial septal defect. This finding (3– or 4– contrast effect) was present in our nine patients, and was shown to be definite evidence of a large atrial septal defect. However, a negative contrast effect is relatively difficult to evaluate. An echocardiographer should be aware of misinterpreting negative contrast images resulting from other sources, since in normal cases, continuous inflow from the inferior vena cava and coronary sinus is non-contrast containing.

Twenty-two patients showed both a negative and positive contrast effect. This occurs in atrial septal defect with the change of pressures in the right and left atria throughout the cardiac cycle⁷. The dominant shunt is left-to-right during the major part of the cardiac cycle. A right-to-left shunt of blood is present at the onset of ventricular contraction or during early ventricular diastole⁷. Appearance of a significant contrast effect (3+ or 4+) in a high percentage of our patients is a result of the latter hemodynamic event.

During the application of the technique, contrast injections were repeated using different transducer positions. The best evaluations were made using a modified transducer position between the parasternal short axis and the apical four chamber views. In this projection, four chambers were seen and care was taken on both sides of the atrial septum and left atrial cavity for positive and negative contrast effects.

We conclude that our method is not sensitive for a definite detection of atrial septal defect. However, the results discussed above obtained from 3+, 4+ and/or 3–, 4– contrast effects indicate that this method is a specific one.

We strongly recommend the application of peripheral contrast echocardiography in cases with a clinical suspicion of atrial septal defect.

Summary

This study was carried out on 233 children suspected clinically of having atrial septal defect with the aim of investigating the diagnostic capability of peripheral venous contrast echocardiography. The transfer of contrast material from the right atrium into the left atrium was evaluated as “positive contrast”, while noncontrast blood, passing from the left atrium into the right atrium was termed “negative contrast”. Positive contrasts were quantitated in four grades. A significant negative contrast effect was graded 3– or 4–. Three positive, 4+ and/or 3–, 4– contrast effects were considered definite evidence of an atrial septal defect. Among the cases with the above findings 92 underwent surgical closure of atrial septal defect. The procedure was successful in all patients operated; the size of the defect was large. This result demonstrates that the method applied is a safe and reliable one. However, in a group of cases without the above

echocardiographic findings the presence of an atrial septal defect was detected by cardiac catheterization and angiocardiography. Therefore, we can conclude that the method applied is not a sensitive, but a specific one, for definite detection of atrial septal defect.

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