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Atrioventricular Septal Defects

—Pathologic Observations and Double Contrast Specimen Radiography—

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= Abstract =With five specimens of AVSD's from autopsy file of the Seoul National University Hospital, the following items were analysed; 1. external appearance of the heart, 2. atrial and ventricular aspects of the septal defects, 3. inlet septum of the left ventricle, 4. left ventricular outflow tract, 5. aortic valve, 6. atrioventricular valve annulus.

After complete analysis, double contrast specimen radiography was performed. Common pathologic features of the AVSD's were globar external appearance, large septal defect at the atrioventricular junction, short posterior inlet septum or diaphragmatic wall of the left ventricle, elongation and narrowing of the left ventricular outflow tract, anterior and rightward displacement of the aortic valve and malorientation of the atrioventricular valve annulus.

Key Words: ***Congenital heart disease, Endocardial cushion defect, Specimen radiography***

INTRODUCTION

Atrioventricular septum (AVS) is the part of the septum which in the normal heart is the site of attachment of the atrioventricular valves and separates the right atrium from the left ventricle (Becker & Anderson 1982; Goor & Lillehei 1975). Atrioventricular septal defects (AVSD's) are a spectrum of diverse malformations unified by having the same characteristic features of the defect of the AVS (Becker & Anderson 1981, 1982; Gow *et al.* 1984). Various synonyms were introduced for this complex cardiac anomaly, such as endocardial cushion defects (Campbell & Missen 1957; Gerbode *et al.* 1967; Omeri *et al.* 1965; Ugarte *et al.* 1976), persistent atrioventricular canals (Rogers & Edwards 1948; Rastelli *et al.* 1966, 1968), atrioventricular canal malformations or defects (Goor & Lillehei 1975; Soto *et al.* 1981) and atrioventricular defects (Picolli & Gerlis 1979; Picolli & Wilkinson 1979; Macartney *et al.* 1979) and also diverse systems of classification have been suggested and attempted (Becker & Anderson 1982; Goor & Lillehei 1975; Rogers & Edwards 1948; Rastelli *et al.* 1968; Picolli & Gerlis 1979). Unfortunately there is no unanimous opinion yet, concerning the basic anatomic features (Becker & Anderson 1982; Picolli & Gerlis 1979; Picolli & Wilkinson 1979; Macartney *et al.* 1979). The basic abnormality in this malformation could be elucidated through the meticulous dissection and comparative analytical approach. We analyzed five specimens of the AVSD's with the special reference on the common pathologic features and tried to understand the effect of the defect of the AVS on the rest of the heart by comparing the hearts of AVSD's with those without AVSD's. We also attempted to correlate the angiographic findings of the AVSD's with the pathologic features by double contrast specimen radiography, trying to find any significance between these two modalities in the examination of the heart.

MATERIALS AND METHODS

Five specimens of AVSD's from the autopsy file of the Department of Pathology, College of Medicine, Seoul National University were used for this study (Table 1). The followings are items that we put special emphasis on analysis; 1. external appearance of the heart, 2. atrial and ventricular aspects of the septal defects, 3. inlet septum of the

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Table 1. List of the hearts used in this study

Atrioventricular septal defects;

1.*A77-12; common AV orifice, type A,**

2. A77-17; common AV orifice, type B,
secundum ASD
α-TGA
asplenia

3. A82-19; common AV orifice, type C,
Down's syndrome

4. A82-26; common AV orifice, type?,
secundum ASD
single ventricle
truncus arteriosus

5.*A84- 1; partitioned AV orifice
mitral cleft
tricuspid cleft

Other than atrioventricular septal defects;

1. A80-37; VSD
2. A83-130; normal
3. A84-5; pulmonary atresia
4. A84-16; normal
5. A84-18; α-TGA with VSD
6. •A83-27; heart with left ventricular hypertrophy due to chronic hypertension

*; used for photography and radiography

•; used for photography and radiography not used for measurements because it is much larger than the other hearts.

**; Rastelli classification of atrioventricular septal defects with common AV orifice.

AV=atrioventricular, TGA=transposition of the great arteries

left ventricle, 4. left ventricular outflow tract, 5. aortic valve, and 6. atrioventricular valve annulus. Five specimens other than AVSD's were analyzed in the same manner for the comparison (Table 1).

After the complete analysis of the specimens, two hearts with AVSD's adequate for the radiographic examination were selected. Double contrast specimen radiography was performed by painting the endocardial surface of the left ventricle and the atrioventricular valves with barium suspension. Barium suspension used in this study was 65% w/w Barosperse[B]. Water soluble paste was added to the barium suspension to enhance the stickiness. Metallic wire was applied to the left ventricular aspect of the deficient septal crest to visualize the position of it on the radiographs. The specimens were filmed in the conventional anterior-posterior (AP) and lateral views and the axial views including the 4-chamber and elongated right anterior oblique (RAO) projections, by the Philips mammo Diagnost U. For the comparison, a heart with left ventricular hypertrophy due to the chronic hypertension was photographed and radiographed in a similar manner.

RESULTS

Anatomic observation of the normal atrioventricular septum (Fig. 1-A,B):

The atrioventricular septum was clearly identified in the heart with the left ventricular hypertrophy. The AVS was present because the tricuspid valve was attached more toward the ventricular apex than was the mitral valve. It was marked on the heart by inserting the opaque metallic pins along the sites of the septal attachments of the tricuspid and mitral valves in the vertical directions to the septum. The territory of the AVS was roughly triangular or scimitar-like. The apex of this 'triangle' was made of the central fibrous body between the aortic root and the atrioventricular valves anteriorly, while the base was represented by the muscular wall around the crux cordis posteriorly. The superior border on the right side was below the inferior limbus of the fossa ovalis and the orifice of the coronary sinus. It occupied the cephalic aspect of the inlet ventricular septum below the septal (anterior) leaflet of the mitral valve on the left side. It was composed of the small membranous part anteriorly and large and thick muscular part posteriorly.

Common pathologic features of the AVSD's were;

1. Globular external appearance;

The external appearance was globular and the left ventricular outflow tract below the main pulmonary artery was bulged outwardly. The ratio between the AP and lateral diameters of the atrioventricular sulcus was increased, providing the numerical support for the globular external appearance (Table 2,3).

2. Large septal defect at the atrioventricular junction (Fig, 2,3):

The atrial element of the defect extended only a short distance from the line connecting the central fibrous body and the crux cordis and formed a shallow arch. The roof of the arch was the inferior limbus of the fossa ovalis and was below the orifice of coronary sinus in all cases. The inferior limbus was well developed in three cases. In two cases with secundum ASD, thin stripe or band of inferior limbus was present between the central defect and the secundum ASD. In contrast to a mild atrial extension, the ventricular element of the defect extended far into the inlet ventricular septum, giving a characteristic feature of "scooped-out" phenomenon (Table 2). The membranous septum was deficient totally or partially.

3. Short posterior inlet septum or diaphragmatic wall of the left ventricle (Fig. 2-A, 3-A):

The apex-crux cordis distance measured from the left ventricular aspect was short for the size of the heart. This shortening became more impressive when it was contrasted to the elongated outflow tract. This phenomenon could grossly be recognized as a deep "V" shaped posterior atrioventricular sulcus, the apex of the "V" pointing the cardiac apex.

4. Elongation and narrowing of the left ventricular outflow tract (Fig. 2-A, 3-A):

As the heart was deformed due to the absence of the central skeleton (AVS) that the absolute data measured could not be used as the parameters of the elongation and that the comparison between the data might be fallacious. But there was fairly constant impression of the elongation of the left ventricular outflow tract. The impression of the elongation was enhanced as the lumen was encroached upon by the apically displaced mitral valve or mitral component of the common atrioventricular valve on the ventricular septal crest. The ratio between the lengths of the inlet and outlet septum was invariably increased, whether it was due to the shortening of the inlet septum or the elongation of the outflow tract or both. In addition to the elongation and narrowing, the free wall of the left ventricular outflow tract except the short subaortic segment beneath the main pulmonary artery was bulged outwardly.

5. Anterior and rightward displacement of the aortic valve;

In the normal, the aortic valve was wedged be-

Table 2. Measurements of the morphologic parameters of the atrioventricular septal defects (cm)

Case	External dimension		Internal Dimension***		Dimension of septal defect		
	AP*	lateral**	apex-crux	apex-aorta	AP•	atrial••	ventricular•••
A77-12	2.9	2.9	3.1	3.7	1.2	0.2	1.2
A77-17	2.3	2.8	2.8	3.7	1.4	0.3	1.4
A82-19	2.0	2.3	2.5	2.9	1.2	0.1	0.5
A82-26	2.0	1.8			1.3	0.2	1.2
A84- 1	5.3	4.5	4.9	6.9	3.0	0.3	2.5

*; distance between the origin of left anterior descending coronary artery and the crux
**; lateral diameter of the atrioventricular sulcus
***; see Fig. 1-A and 2-A.
•; distance between the central fibrous body and the crux along the defect margin
••; atrial extension of the defect
•••; ventricular extension of the defect

Table 3. Ratios between the morphologic parameters of the heart examined

	AVSD's mean(SD)	Other than AVSD's mean(SD)
$\frac{\text{external AP dimension}}{\text{external lateral dimension}}$	0.996(0.153)	0.676(0.050)
$\frac{\text{internal AP dimension*}}{\text{external lateral dimension}}$	0.564(0.114)	0.302(0.047)
$\frac{\text{apex-aorta distance}}{\text{apex-crux distance}}$	1.270(0.101)	1.050(0.030)

* Internal AP dimension is the distance between the central fibrous body and the crux cordis

tween the two atrioventricular valves. In the AVSD's, the aortic valve was dislodged from it's normal wedged position, and was displaced anteriorly, to the right side and superiorly.

6. Malorientation of the atrioventricular valve annulus (Fig. 2,3):

In the normal hearts, the tricuspid and mitral valves were in parallel planes with the short gap of the AVS between them. In the AVSD's, the septal aspect of the atrioventricular valve annulus was apically displaced and the mitral valve or component unusually had low attachment. There was no gap between the two components of the atrioventricular valves. The tricuspid valve or component was in the more coronal plane and the mitral valve or component in the more sagittal plane. The AP diameter of the atrioventricular valve annulus measured from the central fibrous body and the crus cordis was increased together with the anterior displacement of the aortic valve and downward displacement of the crux cordis.

Other abnormal features that were not common to all cases are listed in Table 1.

Radiographic Features of the AVSD's (Fig. 2,3):

1. Absent AVS;

In the radiographs of the normal heart, the AVS was the segment or the plane extending from the noncoronary cusp to the crux cordis (Fig. 1). The en face of the left ventricular aspect of the AVS was best demonstrated in the elongated RAO and the foreshortened profile of the AVS in the 4-chamber view. In the elongated RAO view of the AVSD's, the deficient AVS was represented by the large concave defect extending from the aortic valve to the crux cordis beneath the apically displaced atrioventricular valves. Similar, but less striking, finding of deficient AVS could be appreciated in the conventional AP view. In the 4-chamber view, the profile of the deficient AVS was represented by the defect of the septal wall from the aortic valve to the crux cordis (upper free margin of the deficient ventricular septum).

2. Short posterior inlet septum or diaphragmatic wall of the left ventricle:

The shortness of the posterior inlet septum and the disproportion between the inflow and outflow tracts could be recognized in the conventional AP view, simply be comparing the apex-crux cordis distance and the apex-aortic valve distance. Similar finding could be appreciated in the elongated RAO view. In the 4-chamber view of the normal heart, the major part of the apex-aortic valve distance was the posterior inlet septum, while the AVS occupied the short subaortic segment below the aortic valve. In the AVSD's, the posterior inlet septum was foreshortened and occupied only a half or a little more of the apex-aortic valve distance.

3. Elongation and encroachment of the left ventricular outflow tract:

In the conventional AP view of the normal heart (Fig. 1-C), the subaortic outflow tract was wide open and overlapped by the inflow tract. In the AVSD's it was sprung from the atrioventricular valves and it escaped from the inflow tract. The narrow tunnel was formed between the mitral valve or component and the left ventricular free wall which was bulged outwardly. It was encroached upon by the apically displaced mitral valve or component on the "scooped-out" ventricular septal crest. The encroachment was more evident in the imaginary diastolic phase (Fig. 3-B). The mural attachment of the anterior mitral valve or component and the lateral leaflet or the leaflets themselves contribute to the diastolic "goose-neck" deformity. The narrowing of the left ventricular outflow was also demonstrated in the 4-chamber view and was actually due to the mural attachment of the mitral valve or component.

4. Malorientation and deformity of the atrioventricular valves:

As the mitral valve or component was in the more sagittal plane, the septal attachment of the mitral valve was in front of the mural attachment, the latter being only a little to the left of the former. It is self-evident from this observation that the diastolic "goose-neck" deformity by the mural attachment or the most apical aspect of the displaced valve leaflet. The mitral valve or component did not meet the left ventricular free wall in the conventional AP and 4-chamber views. In the normal, the inflow and outflow tracts were always superimposed and the mural attachment of the mitral valve met the free wall in these projections. The site of the cleft between the anterior and posterior components of the mitral valve was around the center of the deficient septal crest in the conventional AP view. It was just above the top of the deficient ventricular septum in the 4-chamber view, because the posterior component of the mitral valve was in the parallel plane to the X-ray beam due to the craniocaudal tilt and was foreshortened. The perception of the accurate location of the cleft was important, as the systolic cleft was the opening of the regurgitant flow into the atria. The space of interventricular communication below the anterior component of the atrioventricular valve was the wide area below the aortic valve and the space below the posterior component was the small area above the crux cordis in the 4-chamber radiograph. The aortic valve-crux cordis distance which denotes the AP diameter of the atrioventricular valve annulus was increased. In the 4-chamber view, the aortic valve-crux cordis distance occupied near half of the apex-aortic valve distance.

DISCUSSION

In the earlier reports on the persistent common atrioventricular canal defects, the observations were centered mainly on the structural anomalies of the atrioventricular valves and the adjacent atrial and ventricular septa (Rogers & Edwards 1948; Rastelli *et al.* 1966; Rastelli *et al.* 1968). Recent reports put emphasis on the shortness of the inflow tract and/or the elongation of the outflow tract of the left ventricle in this anomaly (Goor & Lillehei 1975; Teckhoff & Stamm 1973; Blieden *et al.* 1974; Ebert & Goor 1978). More recently Backer and Anderson proclaimed the term "atrioventricular septal defects" for the group of malformations commonly termed "endocardial cushion defects", "persistent atrioventricular canal malformations" or "atrioventricular canal defects" (Berker & Anderson 1982). They emphasized the effect of the absent atrioventricular septum on the rest of the heart and proposed the term, atrioventricular septal defects.

If we accept deficient AVS as the basic malformation of AVSD and reconstruct the imaginary model by eliminating the AVS from the normal heart, the whole features of our observations and the earlier reports on the "endocardial cushion defects" might be explained accordingly as below.

As the posterior aspect of the AVS around the crux cordis is wide, the defect of the AVS results in the shortening of the diaphragmatic aspect of the left ventricular inlet septum. In the normal heart, the aortic valve is wedged between the two atrioventricular valves and the distance between the posterior aspect of the aortic valve and the crux cordis is very short (Picolli & Gerlis 1979). This is thought to be due to the binding effect of the heavy musculature of the AVS. As this binding force of the AVS is lost in the AVSD's, the aortic valve together with the left ventricular outflow ract springs from its normal wedged position and the crux cordis depresses, and they become wide apart. The free wall of the left ventricle bulges outwardly. The short subaortic segment dose not bulge, because the main pulmonary artery in front of it presses it. As both ends of the atrial and ventricular septa are fixed on the central fibrous body anteriorly and the crux cordis posteriorly, the central aspects of the free margins of the atrial and ventricular septa recoil away from the defect. So the lower margin of the atrial septum is arched and the ventricular septum in "scooped-out". We can argue more than expected is missing, especially in the ventricular aspect. But it may be postulated that the defect of the AVS can really involve the adjacent atrial and ventricular septa. As the site of the septal attachment of the atrioventricular valves is lost, they are deformed and maloriented. The septal aspects of the atrioventricular valves usually are displaced toward the cardiac apex and a large interatrial shunt usually ensues. They may be displaced in the opposite direction toward the cardiac base and are related to the lower margin of the atrial septum. This is true for a few cases in the literatures (Picolli & Gerlis 1979; Becker & Anderson 1982). The interatrial shunt was either none or minimal in present series. As we realized the effect of the absent AVS on the rest of the heart, we conform to the Becker and Anderson's suggestions.

But there also is the problem in the term AVSD's, bacause the supratricuspid type of the left ventricular-right atrial communication is basically the defect of the AVS. Goor and Lillehei did call this group of malformations AVSD's regardless of the types (Goor & Lillehei 1975). But the transtricuspid and subtricuspid types are not the defect of the AVS. As the defect of the AVS is not the common feature of the left ventricular-right atrial communications, their terminology has the fundamental fault.

The AVSD's are commonly divided into the complete and partial types, according to the morphology of the atrioventricular valves or the presence of the interventricular shunt or both (Becker & Anderson 1981, 1982; Goor & Lillehei 1975; Campbell & Missen 1957; Omeri *et al.* 1965; Ugarte *et al.* 1976; Roger & Edwards 1948; Rastelli *et al.* 1966; Rastelli *et al.* 1968). In the AVSD's with separate atrioventricular valves, *i.e.* the partial AVSD's, there usually is no significant interventricular communication and they are commonly termed "ostium primum atrial septal defect" (Omeri *et al.* 1965; Rogers & Edwards 1948; Macartney *et al.* 1979).

Although the defect present permits the interatrial shunting, it is not in fact the defect of the atrial septum. It is mainly the atrioventricular septal defect converted into the interatrial communication (Becker & Anderson 1982). The presence of the inferior limbus of the fossa ovalis, which is the lowest part of the interatrial septum, in the large number of the reported cases (Wakai & Edwards 1958) as well as in our five cases supports this explanation. Briefly the interatrial communication in the AVSD's should not be called "ASD".

As there is no unanimous opinion on the criteria for the subclassification of the AVSD's into the complete and partial types and there are the rarer forms which cannot be categorized into either type, the recent efforts are made for the algorithmic method of classification. The f orementioned cardinal features could best be understood morphologically as the results of the absence of the atrioventricular septum, thus justifying the term "atrioventricular septal defects" for this type of cardiac anomaly. It was also noted that double contrast specimen radiography could contribute a great deal for the correlation of premortem angiography and actual morbid anatomy of the heart.

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LEGENDS FOR FIGURES

Fig. 1. Photographs and radiographs of the normal atrioventricular septum.

A. Septum viewed from the left side (after standard photograph, negative was printed backwards to yield comparable view to that seen in frontal radiograph). Anterior leaflet of the mitral valve(MV) is lifted up toward the atrial septum. Metallic pins are inserted along the septal attachment of the tricuspid valve. The AVS is between the mitral annulus (arrows) above and the line connecting the heads of the pins. The apex-aortic valve distance (A-CFB) is only a little larger than the apex-crux cordis distance (A-CC). A=apex, CC=crux cordis, CFB=central fibrous body, AO=aorta, MV=mitral valve.

B. Septum viewed from the right side (standard photograph). Metallic pins are inserted along the sites of septal attachments of the mitral upper row) and tricuspid (lower row) valves. Triangular or scimitar-like area demarcated by the heads of the pins is the AVS. FO=fossa ovalis, IL=inferior limbus, CS=coronary sinus, TV=tricuspid valve.

C. Radiograph in conventional AP view. Outlined by contrast are the left ventricle, the aorta and the mitral valve. The heads of the pins in the upper row and tails of the lower row demarcate the left ventricular aspect of the AVS. The AVS lies in oblique plane to the X-ray beam. The inflow and outflow tracts are superimposed upon each other. The mural attachment of the mitral valve meets the left ventricular free wall (arrow). Comprare with A.

D. Radiograph in lateral view. The AVS lies in oblique plane to the X-ray beam. The mitral orifice (arrows) is in the upper posterior aspect of the left ventricle.

E. Radiograph in 4-chamber view. The foreshortened profile of AVS occupies the short segment below the aortic valve. The inflow and outflow tracts are superimposed upon each other. The annulus of the posterior mitral valve (arrows) meets the ventricular free wall.

F. Radiograph in elongated RAO view. The X-ray beam is in the vertical direction to the AVS. The en face of the AVS is demonstrated between the aortic valve and crux cordis. AD=aorta, LV=left ventricle, RV=right ventricle, LA=left atrium.

Fig. 2. Photographs and radiographs of case 1 (AVSD with common atrioventricular orifice, Rastelli type A).

A. Left side of the septum (photograph printed in backwards). The inlet septum (A-CC) is short compared to the outlet septum (A-CFB). The atrial aspect of the defect above the line connecting the CFB and the CC (dotted line) is shallow arched. The ventricular aspect of the defect extends far into the inlet septum and is "scooped--out". Compare the shape of the defect and the territory of the normal AVS in Fig. 1-A. The free wall of the left ventricle (arrows) shows outward bulging except the subaortic aspect beneath the pulmonary artery (PA). The anterior common leaflet (AC) is lifted up toward the atrial side. Several chordae connect the anterior and posterior common leaflets (AC, PC) and the ventricular septal crest.

B. Right side of the septum (standard photograph). The inferior limbus of the fossa ovalis (IL) is well developed and forms the roof of the defect. The free margin of the defect is not unlike the superior border of the normal AVS in Fig. 1-B.

C. Radiograph in conventrional 4-chamber view. Outlined by contrast are the left ventricle, the aorta, the atrioventricular valves and the margins of the defect. The crest of the deficient ventricular septum is marked by the metallic wire. Compare with A. The disproportion between the lengths of the inflow and outflow tracts is apparent. The narrow tunnel of outflow tract is between the anterior leaflet (AC) and the ventricular free wall. The gap between the atrioventricular valves (AC, PC) and the ventricular septal crest (curvilinear opaque line) is the space of the interventricular communication. The site of coaptation of the atrioventricular valves is above the center of the ventricular septal crest.

D. Radiograph in lateral view. Left side of the atrioventricular orifice (arrows) is in front of the left ventricle. This malorientation explanes the unusual catheter course from in front instead of from behind during the cardiac catheterization (Yoo, et al 1985).

E. Radiograph in 4-chamber view. The opaque wire in the ventricular septal crest is foreshortened and is in profile. The posterior end of the wire (crux cordis) corresponds to the top of the visualized inlet ventricular septum (IVS). The narrow tunnel is formed between the atrioventricular valve (arrow) and the ventricular free wall.

F. Radiograph in elongated RAO view. The en face of the defect is well demonstrated.

Fig. 3. Photograph and radiographs of case 5 (AVSD) with partitioned atrioventricular orifice, and large interatrial and small interventricular shunt).

A. Left side of the septum (photograph printed backwards). The disproportion of the inlet and outlet septum is evident. The anterior and posterior components (AC, PC) of the atrioventricular valves are connected by the thin bridge of tissue above the ventricular septal crest. In other words, the atrioventricular orifice is partitioned and the tricuspid and mitral valves are cleft. Several chordae connect the valve leaflets and the septal crest with the small space of interventricular communication.

B-E. Radiograph in conventional AP, lateral, 4-chamber and elongated RAO views. The interruption in the metallic wire is the site of the cleft in the mitral valve. The cleft is around the centre of the ventricular septal crest in the conventional AP view and just above or around the top of the inlet ventricular septum (IVS).

=국문초록=

心房室中隔缺損症

—病理學的 觀察 및 病理標本二重造影—

서울大學校 醫科大學 放射線科學教室

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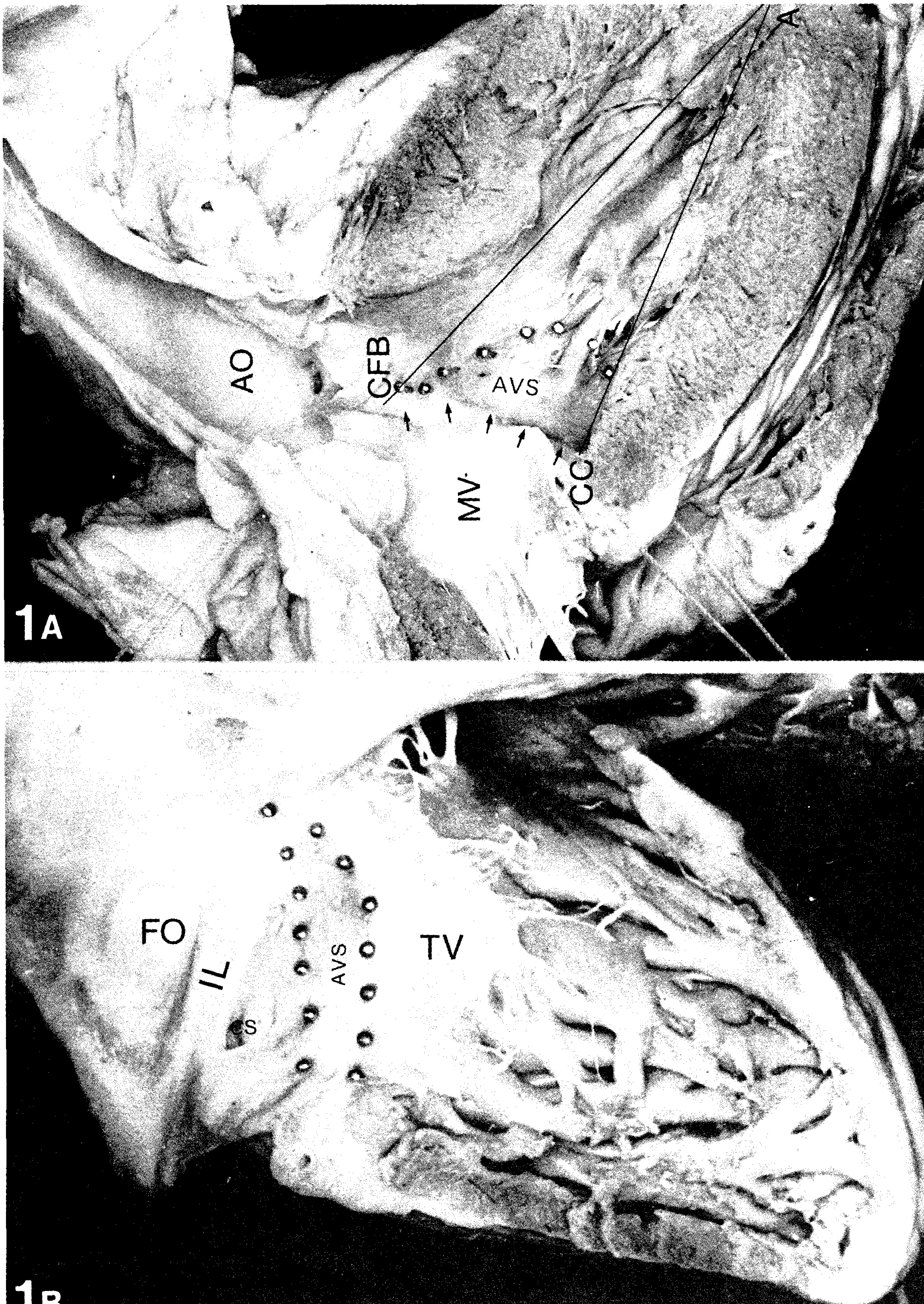
徐正旭・池堤根

心內膜床缺損症(endocardial cushion defects), 共通房室瓣口開存症(persistent atrioventricular canals), 心房室缺損症(atrioventricular defects)等으로도 불리우는 心房室中隔缺損症은 正常心臟의 左心室과 右心室사이에 存在하는 房室中隔의 不在를 共通分母로 하는 心臟畸形의 集合이다. 著者들은 서울大學校 醫科大學 病理學教室 所藏 病理標本中 5例의 心房室中隔缺損症을 對象으로 그 共通的 病理所見을 中心으로 觀察하여 다음과 같은 結果를 얻었다.

1. 心臟의 前後徑이 增加되어 全體的으로 球形이었다.
2. 房室中隔에 該當하는 部位의 缺損이 있었다.
3. 左心室의 橫隔膜쪽 壁과 流入部 中隔이 短縮되어 있었다.
4. 左心室 流出路는 伸長되고 좁아져 있었다.
5. 大動脈瓣은 前・右側으로 轉位되어 있었다.
6. 房室瓣輪의 中隔缺損部 주위는 心尖쪽으로 轉位되어 있었고 비교적 垂直面에 位置하고 있었다.

著者들은 正常心臟으로부터 房室中隔을 除去한 心臟模型을 상상함으로써 위에 列擧한 病理所見을 房室中隔이 缺損됨으로써 派生하는 結果로 說明할 수 있었다. 著者들은 心房室中隔缺損症 5例中 2例를 barium을 利用하여 二重造影함으로써 心血管造影所見과 病理所見의 聯關을 試圖하였다.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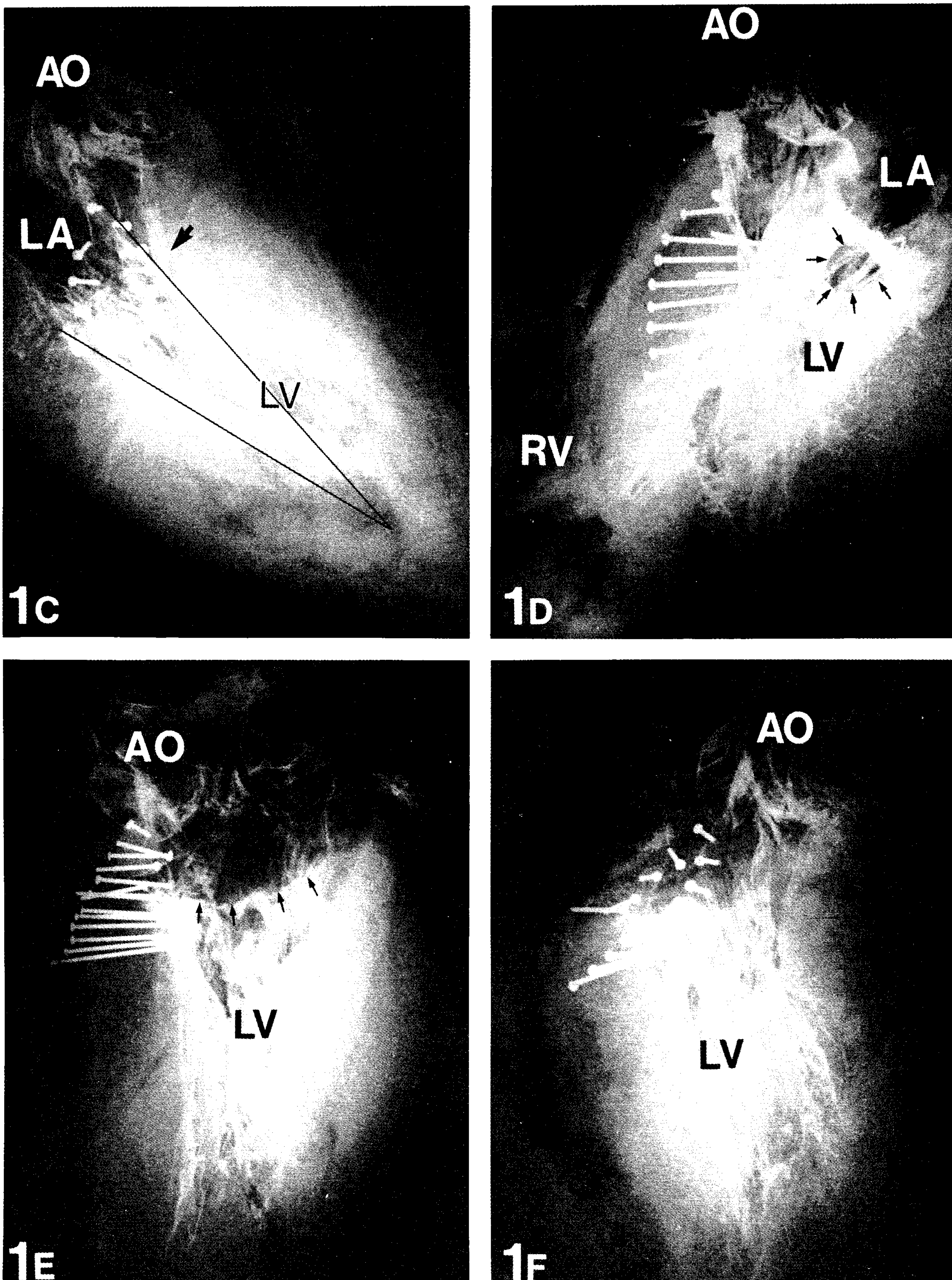
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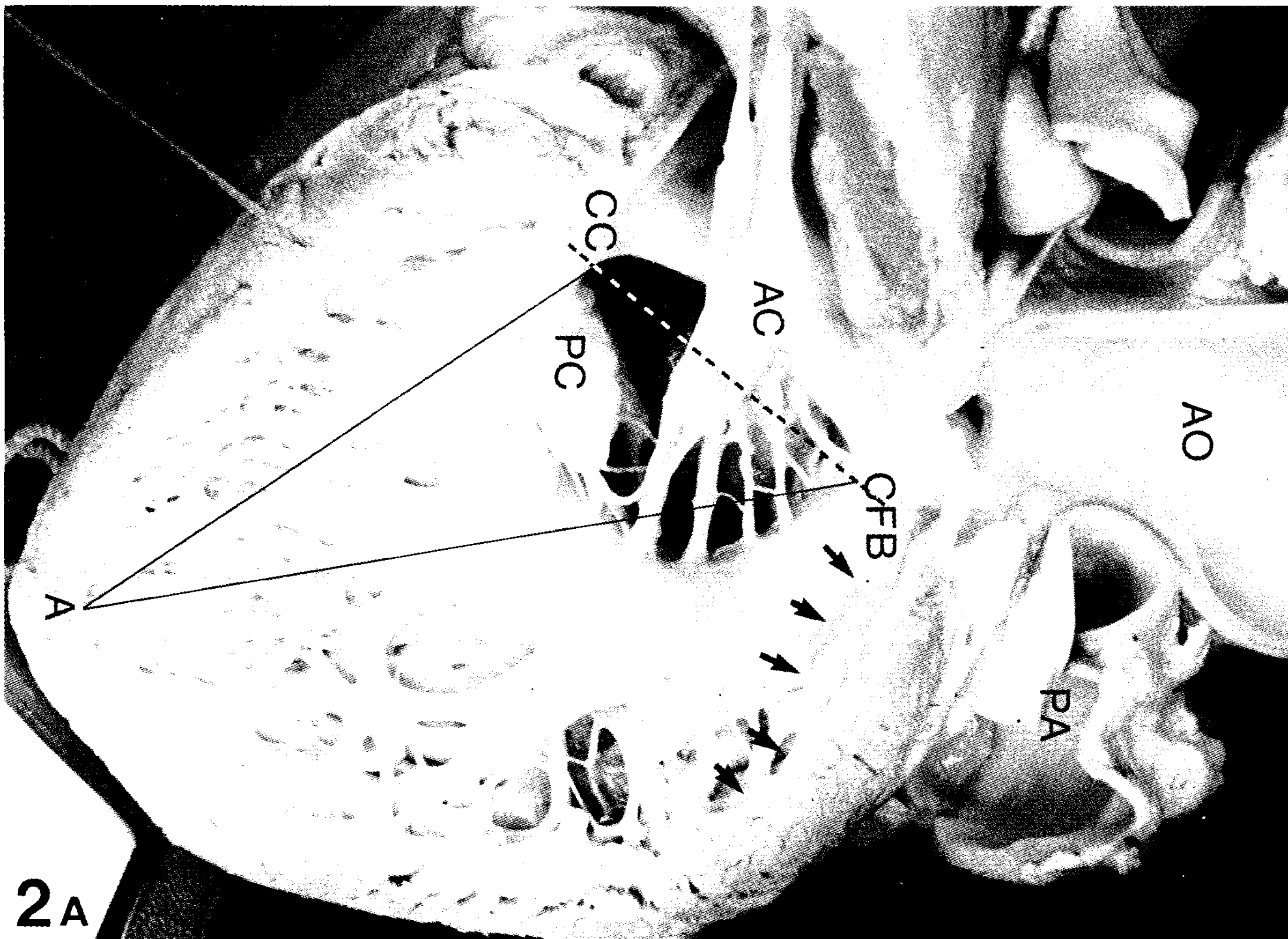
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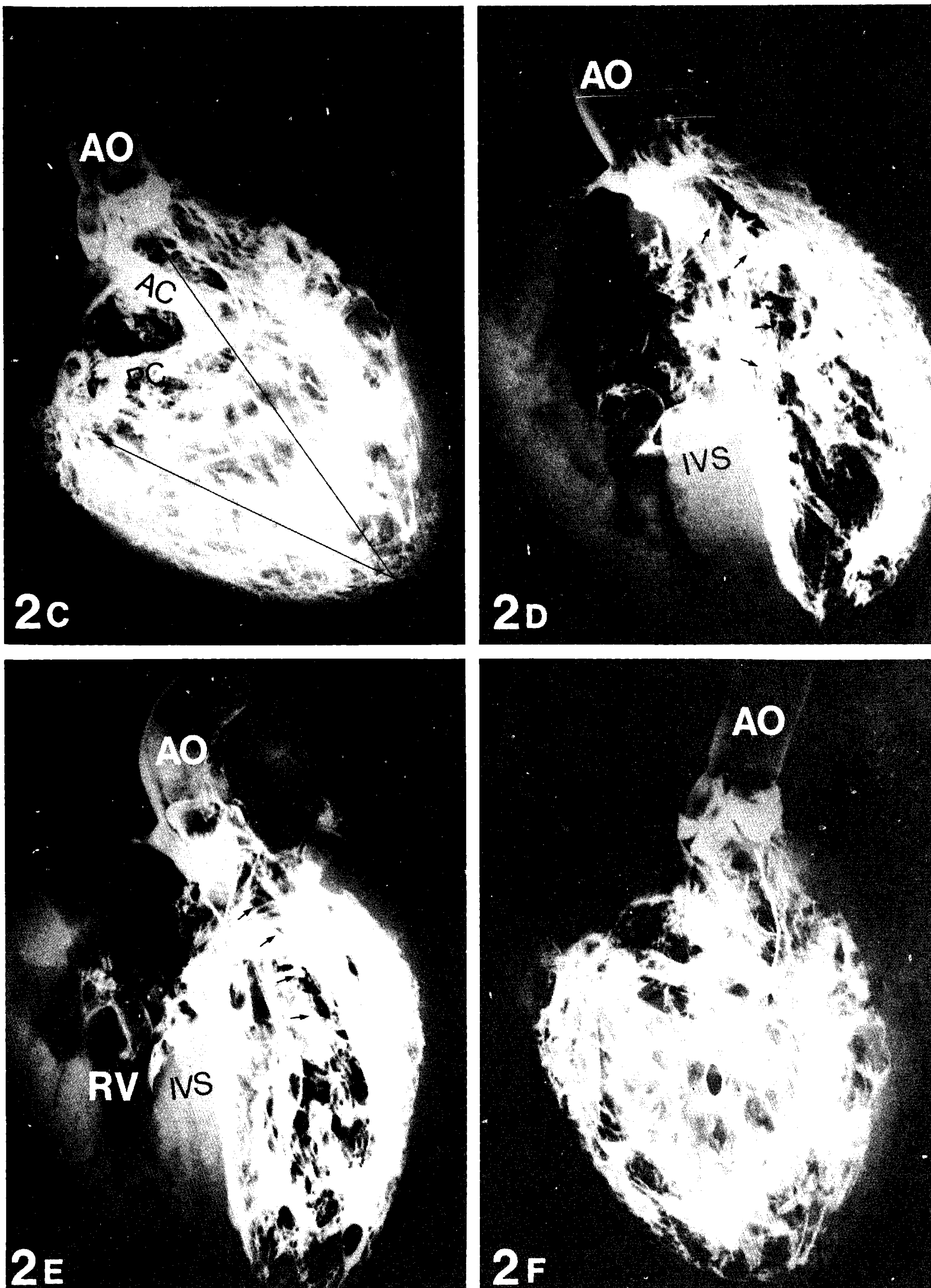
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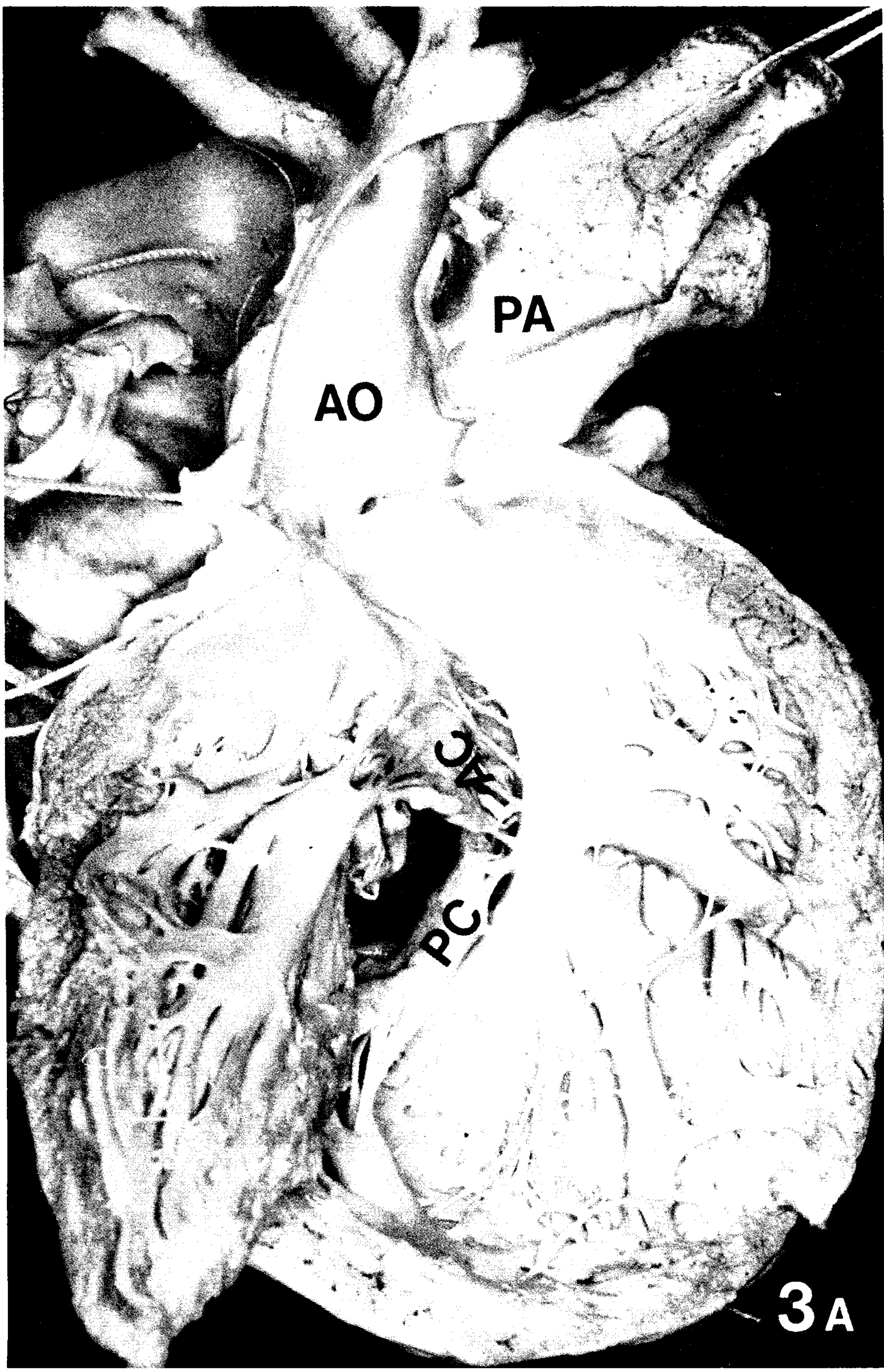
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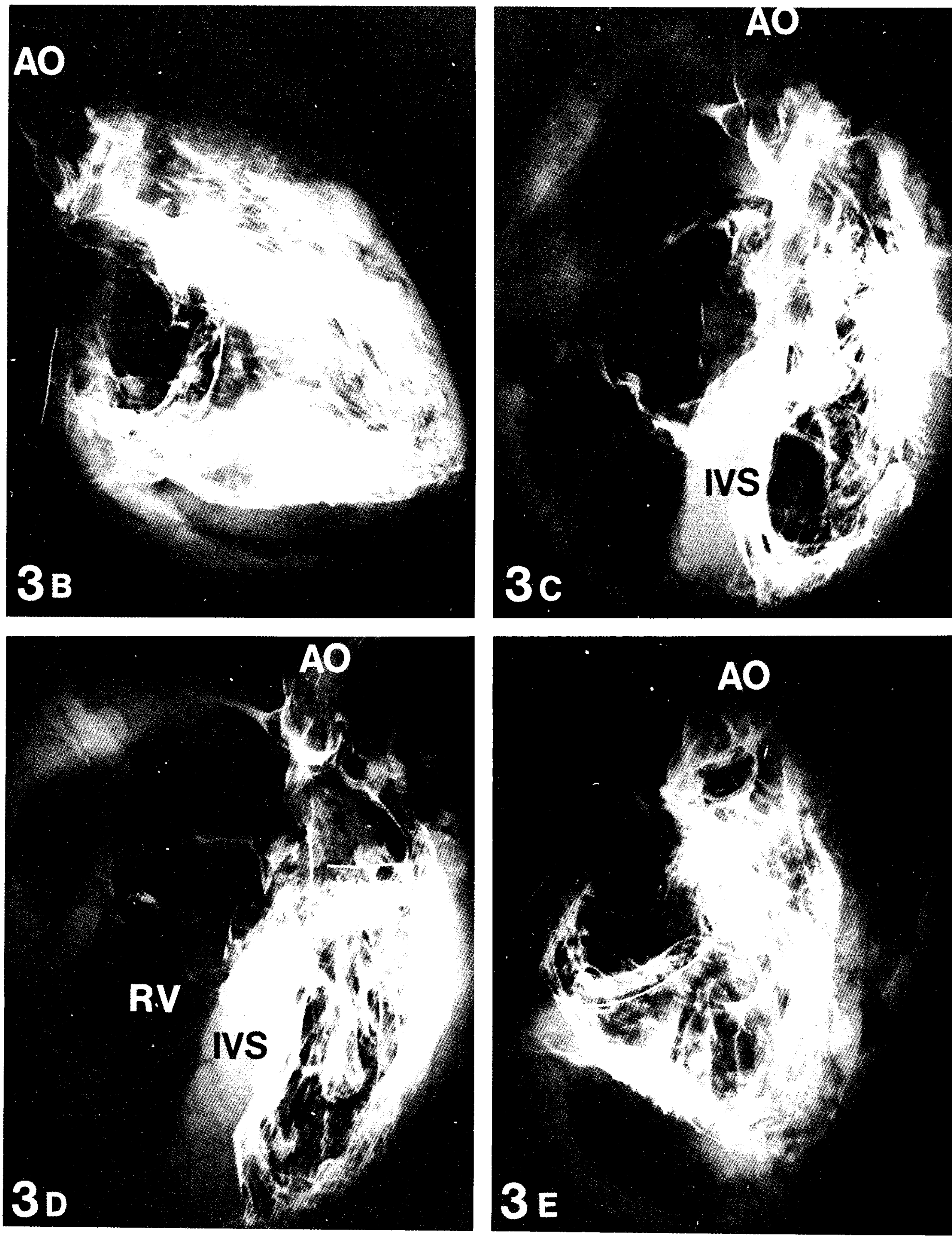
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