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ANOMALOUS PULMONARY VENOUS DRAINAGE

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Cases of drainage of the pulmonary veins into the right side of the heart have been well summarized by Brody (1942). He reported 38 cases of complete, and 68 cases of partial, drainage of the pulmonary veins into the right atrium or its tributaries.

The purpose of this paper is to record a further case, and to summarize the cases not reported by Brody and those which have been reported during the last 10 years. With the development of thoracic surgery, angiocardiography, and cardiac catheterization during recent years these cases now have some clinical importance apart from their anatomical interest.

Case Report

The cadaver was that of a muscular man aged 66. The heart was large but within normal limits considering the degree of muscular development. The interatrial septum was closed, and there were no cardiac abnormalities. An upper, larger, and a lower, smaller, pulmonary vein arose from the anterior part of the upper lobe of the right lung. These two veins joined into a very short, broad common trunk which opened into the superior vena cava, inferior and anterior to the opening of the azygos vein (Fig. 1). A large, lower, right pulmonary vein passed into the left atrium, and the drainage of the left lung was normal. The cause of death was not known, but there was no evidence that it was due to any cardiac or respiratory disease.

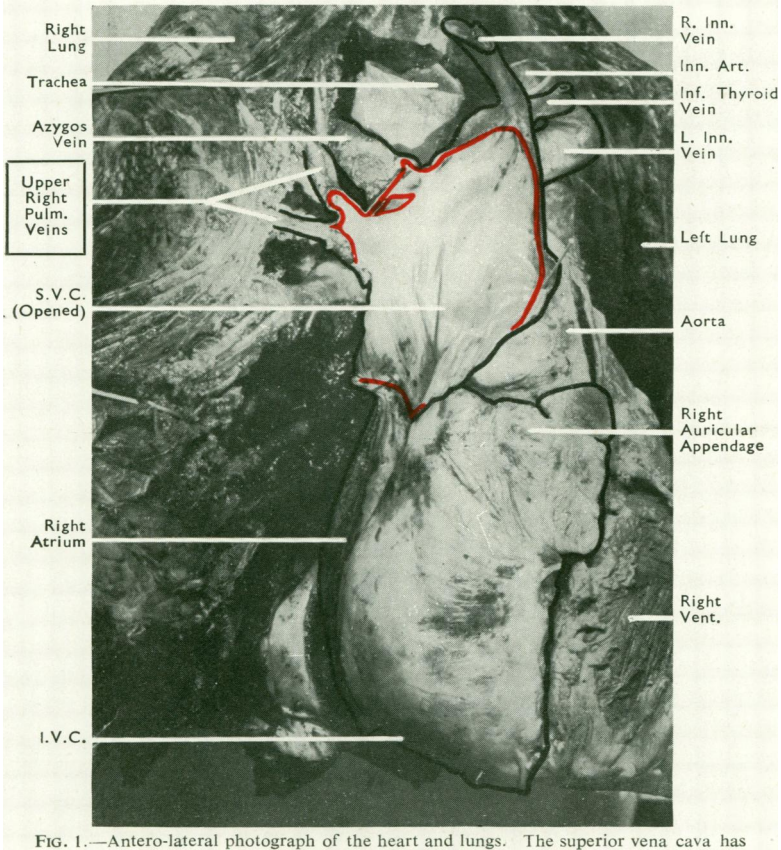

FIG. 1.—Antero-lateral photograph of the heart and lungs. The superior vena cava has been opened.

Discussion

A study of the cases reported by Brody and the cases in Tables I, IIA, and IIB reveals that there is a sharp division into two types; the first of complete anomalous drainage with or without associated cardiac anomalies, which rarely survive early childhood; the second group showing partially anomalous drainage which survive to adult life and have been discovered by post-mortem examination, as an operative finding, or by angiocardiography. It is therefore this latter group which will be of greater importance and interest to clinicians.

Compere and Forsyth (1944) state that if 75% of the pulmonary blood is returned to the left atrium there will be no cardio-respiratory symptoms. Their statement would appear to be supported by the present case and by the recent cases reported in the literature. From a scrutiny of Table I of this paper and the tables in Brody's

TABLE I

INCOMPLETE DRAINAGE OF THE PULMONARY VEINS INTO THE RIGHT ATRIUM OR ITS TRIBUTARIES

Author	Sex	Age	Anomalous Drainage	Mode of Discovery
Sömmerring (1808)			Right upper into lymphatic duct	Necropsy
Töply (1882)	M	20	All left into superior vena cava, except two small veins which entered left ventricle	,,
Heller (1908)			Upper right into superior vena cava	,,
Konaschko (1929)			Two right into superior vena cava	,,
Compere and Forsyth (1944)	M	48	Upper right into superior vena cava	,,
Hughes and Rumore (1944)	M	55	,, ,, ,, ,, ,, ,,	,,
,, ,, ,, ,,	M	44	Upper left into left innominate	,,
Conant and Kurland (1947)	M	37	All left into left innominate	Necropsy for pulmonary tuberculosis
Brantigan (1947)	—	—	Upper right into superior vena cava	Lobectomy
,, ,,	—	—	,, left ,, left innominate	Thoracoscopy
Johnson and McRae (1948)	M	8	,, right ,, superior vena cava	Angiocardiography
Grishman, Poppel, Simpson, and Sussman (1949)	M	24	Lower ,, ,, inferior vena cava	,,
,, ,, ,, ,,	M	22	,, ,, ,, ,, ,, ,,	,,
,, ,, ,, ,,	M	26	,, ,, ,, ,, ,, ,,	,,
Dotter, Hardisty, and Steinberg (1949)	M	27	,, ,, ,, ,, ,, ,,	,,
,, ,, ,, ,,	M	41	,, ,, ,, ,, ,, ,,	,,
Drake and Lynch (1950)	M	24	,, ,, ,, subdiaphragmatic part of inferior vena cava	Thoracotomy
Knutson, Taylor, Pruitt, and Dry (1950)	F	24	Upper right into superior vena cava	Cardiac catheterization
,, ,, ,, ,,	M	21	Right into superior vena cava	,, ,,
Cooke, Evans, Kistin, and Blades (1951)	M	20	Lower right into subdiaphragmatic part of inferior vena cava	Thoracotomy; angiocardiography; cardiac catheterization

TABLE IIA

TOTAL DRAINAGE OF THE PULMONARY VEINS INTO THE RIGHT ATRIUM OR ITS TRIBUTARIES WITHOUT OTHER MAJOR CARDIAC ABNORMALITIES

Author	Sex	Age	Site of Anomalous Drainage	Comment
Conn, Calder, MacGregor, and Shaner (1942)	—	7 days	Through a common trunk into superior vena cava	Patent foramen ovale
Kernan (1944)	M	4 mths	Through a persistent left superior vena cava to left innominate and hence to (right) superior vena cava	,, ,, ,,
Graham, P. M. (1944)	F	8 ,,	Through a common trunk into right atrium	,, ,, ,,
Taussig (1947)	M	8 ,,	Coronary sinus	,, ,, ,,
,, ,,	F	4 years	Through a persistent left superior vena cava to left innominate and hence to (right) superior vena cava	,, ,, ,,
Mykschowszky (1948)	M	18 days	Through a common trunk which perforated the diaphragm with the oesophagus and opened into the ductus venosus	
Vass and Mack (1949)	F	19 mths	Coronary sinus	,, ,, ,,
Edwards and DuShane (1950)	M	6 days	Through a common trunk which perforated the diaphragm with the oesophagus and opened into the ductus venosus	Patent foramen ovale; atresia of left side of the heart
Butler (1952)	—	—	Through a common trunk which perforated the diaphragm through a separate foramen and opened into the left branch of the portal vein, immediately to the left of the opening of a patent ductus venosus	Patent foramen ovale
Edwards, DuShane, Alcott, and Burchell (1951)	M	7 weeks	Through a common dilated sac into the superior vena cava	,, ,, ,,

TABLE IIB

TOTAL DRAINAGE OF THE PULMONARY VEINS INTO THE RIGHT ATRIUM OR ITS TRIBUTARIES ASSOCIATED WITH OTHER MAJOR CARDIAC ABNORMALITIES

Author	Sex	Age	Site of Anomalous Drainage	Associated Anomalies
Turner (1882)	M	15 mths	(Left) superior vena cava	Patent foramen ovale; patent ductus; cor biloculare
Michaelsohn (1920)	M	21 years	,, ,, ,, ,,	Cor biloculare; situs inversus
McIntosh (1926)	M	6 mths	Upper right to superior vena cava; left atrium drained by a vein to the superior vena cava	Mitral atresia; absent interventricular septum; patent ductus
Hu (1929)	M	7 ,,	Through a common trunk to left gastric vein	Situs inversus
Barge and van Oijen (1932)			Upper right to superior vena cava; rest to inferior vena cava	
Ingalls (1932)	F	2 ,,	Through a persistent left superior vena cava to left innominate and hence to (right) superior vena cava	Dextrocardia
Feldman and Chalmers (1933)	M	1 mth	The four pulmonary veins opened separately into right atrium	Transposition of great vessels; patent foramen ovale
Goltman and Stern (1939)	M	14 mths	Through a persistent left superior vena cava to left innominate and hence to (right) superior vena cava	Situs inversus; persistent truncus
Young (1947)	—	Stillborn	Through a common trunk which perforated the diaphragm anterior to oesophagus and opened into portal vein	Cor biloculare
Howald (1949)		2 ,,	Superior vena cava	
,, ,,		6 ,,	Hepatic veins	
Mehn and Hirsch (1947)	M	12 days	Ductus venosus	Multiple anomalies
Weinberg and Kolson (1949)	M	6 ,,	Through a common trunk into portal vein	Patent interventricular septum; persistent truncus
Edwards and DuShane (1950)	M	21 ,,	Through a vein which connects the left atrium to to the left innominate vein	Patent interventricular septum

paper it can be seen that it is rare for one lung to be drained to the left atrium while the other lung possesses complete anomalous drainage to the right atrium. As Brantigan (1947) points out, this is a comforting observation to thoracic surgeons performing pneumonectomy.

Including the present case, there have been reports of 151 cases of anomalous drainage into the right side of the heart; of these, 62 cases have exhibited complete anomalous drainage and 89 have been partially anomalous. A summary of this latter group is given below:

Right Pulmonary Veins	
Into Superior vena cava	30
Right atrium	13
Inferior vena cava	11
Superior vena cava and right atrium	3
Vena azygos	2
Superior vena cava and vena azygos	1
Left superior vena cava	1
Coronary sinus	1
Lymphatic duct	1
	63
Left Pulmonary Veins	
Into Left innominate vein	18
Left superior vena cava	2
Superior vena cava	1
Left subclavian vein	1
Single atrium	1
Coronary sinus	1
	24
Right and Left Pulmonary Veins	
Into Coronary sinus	1
Right atrium	1
	2
Total	89

EMBRYOLOGICAL BASIS FOR THE ANOMALIES.—The development of the pulmonary veins has been studied by Brown (1913) in the cat, and more recently by Auër (1948) in man; these papers can be consulted for further references on this subject.

The primitive fore-gut, including the developing lung buds, is surrounded by a plexus of thin-walled vessels which communicate with the cardinal (systemic) veins. About the 3 mm. stage several evaginations are said to arise from the dorsal wall of the venous end of the heart tube; these evaginations establish connexions with the splanchnic plexus. The common pulmonary vein is normally formed from the most cephalic of these connexions between the venous end of the heart and the splanchnic plexus. The opening of the common pulmonary vein, originally median in position, is subsequently displaced to the left side of the future interatrial septum. Especially in those papers in which the original evaginations are said to arise from the sinus venosus it is not clear how this displacement occurs (Davies and MacConaill, 1937; Brown, 1913). The single pulmonary vein is subsequently absorbed until there are four openings into the heart.

From this short account it can be seen that if other connexions of the splanchnic plexus persist, either partial or complete anomalous pulmonary drainage will result.

Anomalous Drainage Into	Embryological Explanation
Superior vena cava, Vena azygos, Innominate vein	Persistence of the connexion between the splanchnic plexus and the cardinal veins
Coronary sinus, Inferior vena cava	Persistence of the more caudal evaginations
Right atrium	Failure of the common pulmonary vein to be displaced to the left of the interatrial septum
Portal system	Persistence of the connexion between the splanchnic plexus and the plexus of veins around the mid-gut

Owing to the fact that the total number of specimens examined cannot be determined, it is impossible to give any estimation of the frequency of these anomalies. But the number of cases recorded has increased in recent years with the increase in the necessary examinations, and it can be concluded that these anomalies should not be regarded as rare. The possibility of anomalous pulmonary venous drainage should be considered during cardiac catheterization, angiocardiography, and in intrathoracic surgery.

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