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Dextrocardia—value of segmental analysis in its categorisation

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SUMMARY Dextrocardia can be defined as a heart in the right chest with the major axis to the right. This definition, however, conveys no information regarding the chamber arrangements and internal anatomy of the heart.

Of 40 patients satisfying this definition in the files of the Brompton Hospital, 33 had angiocardiographic data adequate for complete analysis in terms of connections, relations, and morphology of cardiac segments. They form the subject of this report.

There were 16 (48%) patients with situs solitus, 11 (33%) with situs inversus, and six (18%) with situs ambiguus. Of the cases of situs ambiguus, four exhibited laevoisomerism and two dextroisomerism. Of the 16 patients with situs solitus, six had two ventricles and 10 had univentricular hearts; two patients had concordant and three discordant ventriculoarterial connections, seven had double outlet ventricle, and four a single outlet heart. Of the 11 patients with situs inversus, nine had two ventricles and two a univentricular heart of right ventricular type; the arterial connection was concordant in two, discordant in two, double outlet in six, and single outlet in one. Of the six patients with situs ambiguus and laevo or dextroisomerism, four had two ventricles, and two univentricular hearts; the arterial connection was concordant in one, double outlet in three, and single outlet in two.

Segmental analysis and the use of basic descriptive terms are essential to define the complex anatomy of such hearts.

The term dextrocardia is used by some authors (Van Praagh *et al.*, 1964; Van Praagh and Vlad, 1978) to describe the situation where on plain chest *x*-ray the heart is predominantly in the right hemithorax. Others use the term to describe the situation where the apex or major axis of the heart (Lev *et al.*, 1968; Squarcia *et al.*, 1973) points to the right. As a right-sided position of the heart has no implications for the internal anatomy, controversy about the precise definition or use of the term dextrocardia, or such terms as dextroposition, dextroversion, dextrorotation, or dextrotorsion, is unhelpful. As Van Praagh and colleagues (1964) and Squarcia *et al.* (1973) have shown, segmental analysis is essential for complete description of such hearts. In this paper we describe an analysis of cases from the Brompton Hospital, fulfilling these definitions for dextrocardia, but have used a system of analysis which distinguishes the connections of the cardiac chambers and great arteries from their spatial interrelations (Shinebourne *et al.*, 1976) and which, in addition, describes abnormal morphology without resort to embryological considerations (Tynan *et al.*, 1979).

Patients studied

We have analysed the radiographic, angiographic, and, where appropriate, necropsy data in 40 patients on file at the Brompton Hospital as having their hearts within the right hemithorax, with the major cardiac axis pointing to the right (Fig. 1). The radiographic examination was particularly important since from it information was derived about the disposition of the bronchi and abdominal viscera which permitted the determination of atrial situs, vital knowledge in the analysis of patients with dextrocardia.

In only 33 were the data adequate for definitive and complete analysis and they form the subject of

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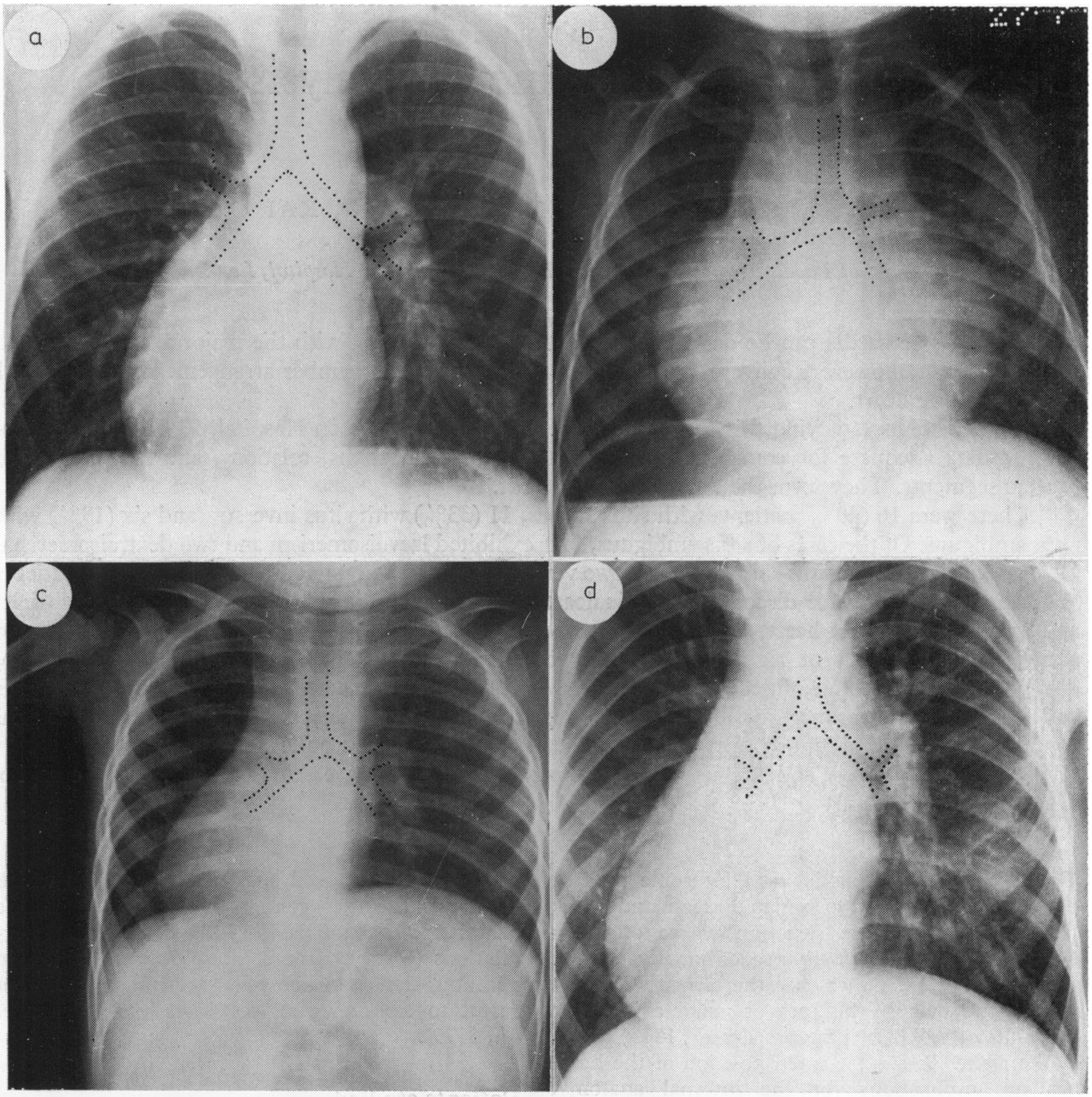

Fig. 1 *Chest radiographs illustrating dextrocardia with situs solitus* (a), *situs inversus* (b), *situs ambiguus with dextroisomerism* (c), *and with laevoisomerism* (d). *Situs was judged from bronchial anatomy which was easily visible on radiographs. It is less obvious on prints and position of bronchi is indicated by dotted lines.*

this report. Each of these patients was analysed in terms of connections, relations, and morphology using the system described elsewhere in detail (Tynan *et al.*, 1979).

Findings

The anatomy of the hearts in the patients studied is shown in the Table. There were 16 patients with situs solitus (48%), 11 (33%) with situs inversus, and six (18%) with situs ambiguus (Fig. 2). Four of the cases of situs ambiguus exhibited laevoisomerism, and two dextroisomerism.

SITUS SOLITUS

In all patients we found visceral, thoracic, and atrial situs to correspond.

Atrioventricular junction (Fig. 3)

Of 16 patients with situs solitus, two had concordant and four discordant atrioventricular connections. The remaining 10 patients had

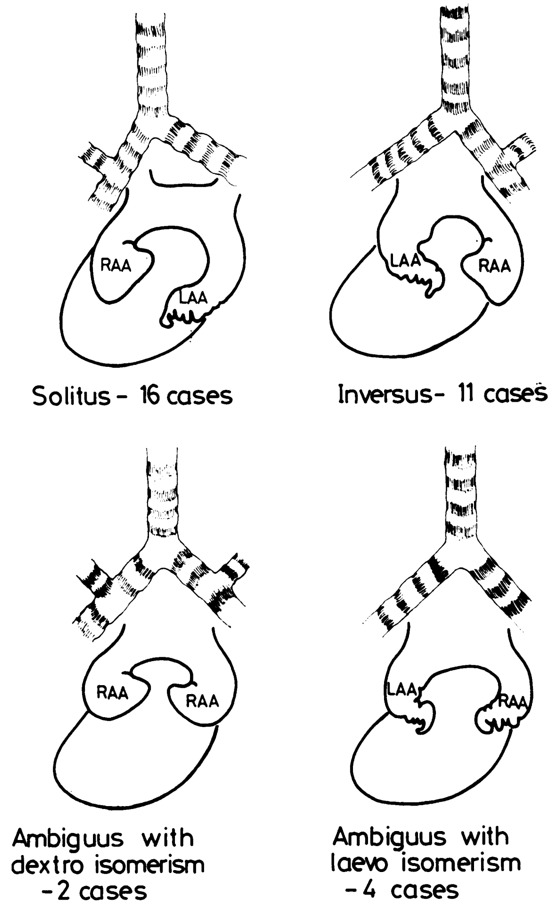

Fig. 2 *Diagram illustrating bronchial anatomy. RAA, right atrial appendage; LAA, left atrial appendage.*

univentricular hearts, six with absent right atrioventricular connection and four with double inlet connections.

Of the 10 patients with univentricular hearts, four had univentricular hearts of left ventricular type, two with double inlet and two with absent right atrioventricular connection. Three patients had univentricular hearts of right ventricular type, two with absent right connection and one with double inlet, while three had univentricular hearts of indeterminate type, one with double inlet and two with absent right atrioventricular connection (Fig. 3). The seven univentricular hearts of right or left ventricular type all possessed rudimentary chambers, four of which were outlet chambers giving rise to a great artery while three were trabecular pouches, having neither inlet nor outlet portions.

The right ventricle was to the right of the left ventricle in one of the six patients with two ventricles (concordant atrioventricular connection), to the left in four (discordant atrioventricular connections), and anterosuperior to the left ventricle in one (concordant atrioventricular connections).

Arterial junction
One of the two patients with concordant atrioventricular connections had concordant ventriculo-arterial connections, the aorta being anterior and to the right of the pulmonary artery. The other had a truncus arteriosus with a right-sided origin of the pulmonary trunk.

Of the four patients with discordant atrioventricular connections, the arterial connections were discordant in one, the aorta being anterior and to the left, and double outlet right ventricle in three. In the latter cases the aorta was anterior and to the left in two and directly anterior in one; all had bilateral infundibula.

Of the 10 patients with univentricular heart, only one, with a main chamber of left ventricular type, had concordant arterial connections. Two univentricular hearts of left ventricular type exhi-

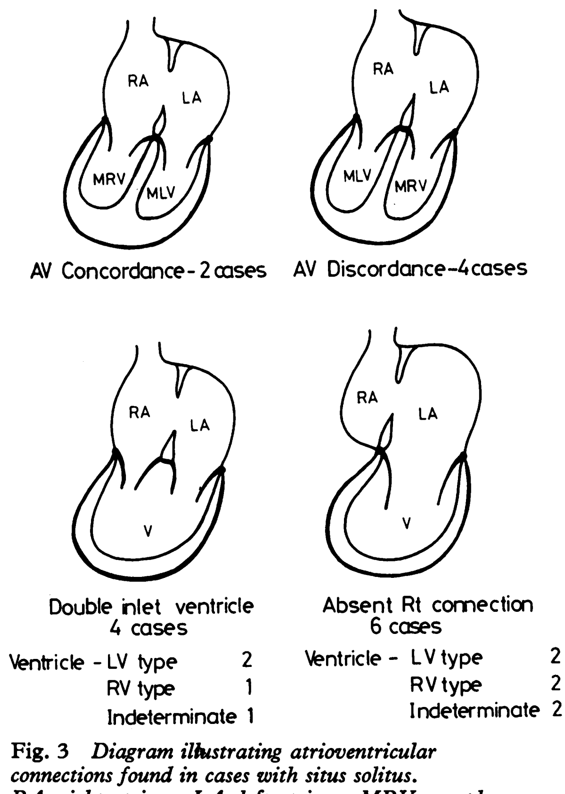

Fig. 3 *Diagram illustrating atrioventricular connections found in cases with situs solitus. RA, right atrium; LA, left atrium; MRV, morphologically right ventricle; MLV, morphologically left ventricle; V, ventricle in univentricular heart; AV, atrioventricular; Rt, right.*

Table *Distribution and anatomy of patients studied; every heart was analysed in terms of connections, relations, and morphology (see text)*

Case no.	*Atrial situs*	*AV junction*		*Ventricular morphology*	*Relation of ventricles and of rudimentary to main chamber*	*Arterial junction*		*Infundibular morphology*
		AV connection	*Mode of connection*			*Arterial connection*	*Relation of arteries*	
1	Solitus	Concordant	2 AV valves	2 ventricles	RV superior to LV	Concordant	AR	Subpulmonary
2	Solitus	Concordant	2 AV valves	2 ventricles	RV to right of LV and anterior	Single outlet truncus		Mitral-truncal continuity
3	Solitus	Discordant	2 AV valves	2 ventricles	RV to left of LV and anterior	Discordant	AL	Subaortic
4	Solitus	Discordant	2 AV valves	2 ventricles	RV to left of LV and anterior	DORV	A	Bilateral
5	Solitus	Discordant	2 AV valves	2 ventricles	RV to left of LV and anterior	DORV	AL side-by-side	Bilateral
6	Solitus	Discordant	2 AV valves	2 ventricles	RV to left of LV and anterior	DORV	AL side-by-side	Bilateral
7	Solitus	Double inlet	R AV valve straddling	UV heart LV type	OC to right of MC and anterior	Concordant	RP	Subaortic
8	Solitus	Double inlet	Common AV valve	UV heart LV type	Pouch to right of MC	Double outlet	A	Subaortic
9	Solitus	Double inlet	L AV valve hypoplastic	UV heart RV type	Pouch posterior to MC	Single outlet-aorta; pulmonary atresia	A	Subaortic
10	Solitus	Double inlet	2 AV valves	UV heart indeterminate type	No rudimentary chamber	Double outlet	A	Subaortic
11	Solitus	Absent R AV connection		UV heart LV type	OC anterior to MC	Discordant	A	Subaortic
12	Solitus	Absent R AV connection		UV heart LV type	OC to right of MC and anterior	Discordant	A R	Subaortic
13	Solitus	Absent R AV connection		UV heart RV type	Pouch to right of MC and posterior	Double outlet	A R	Subaortic
14	Solitus	Absent R AV connection		UV heart RV type	Pouch to right of MC and posterior	Single outlet-aorta; pulmonary atresia	A	Bilateral
15	Solitus	Absent R AV connection		UV heart indeterminate type	No rudimentary chamber	Double outlet	A L	Subaortic
16	Solitus	Absent R AV connection		UV heart indeterminate type	No rudimentary chamber	Single outlet-aorta; pulmonary atresia		Bilateral
17	Inversus	Concordant	2 AV valves	2 ventricles	RV anterior and left of LV	Concordant	P L	Subpulmonary
18	Inversus	Concordant	2 AV valves	2 ventricles	RV anterior and left of LV	DORV	A L	Bilateral
19	Inversus	Concordant	2 AV valves	2 ventricles	RV anterior and left of LV	DORV	A L	Bilateral
20	Inversus	Concordant	2 AV valves	2 ventricles	RV anterior and left of LV	DORV	A L	Bilateral
21	Inversus	Concordant	2 AV valves	2 ventricles	RV to left of LV	Single outlet-aorta; pulmonary atresia	A R	Subaortic
22	Inversus	Discordant	2 AV valves	2 ventricles	RV to right of LV and posterior	Concordant	P	Subpulmonary
23	Inversus	Discordant	2 AV valves	2 ventricles	RV to right of LV and posterior	Discordant	A R	Subaortic
24	Inversus	Discordant	2 AV valves	2 ventricles	RV to right of LV and posterior	Discordant	A R	Subaortic
25	Inversus	Discordant	2 AV valves	2 ventricles	RV anterior and superior to LV	DORV	A	Bilateral
26	Inversus	Double inlet	2 AV valves	UV heart RV type	Pouch posterior to MC	Double outlet	A	Subaortic
27	Inversus	Double inlet	Common AV valve	UV heart RV type	Pouch to left of MC	Double outlet	A R	Subaortic
28	L ambiguus	Ambiguus	2 AV valves	2 ventricles	RV posterior to LV	Concordant	P	Bilateral
29	L ambiguus	Ambiguus	Common AV valve	2 ventricles	RV to left of LV	DORV	A R side-by-side	Bilateral
30	L ambiguus	Ambiguus	Common AV valve	2 ventricles	RV to left of LV and anterior	Single outlet-truncus		Mitral-truncal continuity
31	L ambiguus	Double inlet	Common AV valve	UV heart indeterminate type	No rudimentary chamber	Double outlet	A L	Subaortic
32	R ambiguus	Ambiguus	Common AV valve	2 ventricles	RV to left of LV and anterior	DORV	A	Bilateral
33	R ambiguus	Double inlet	Common AV valve	UV heart LV type	OC to left of MC and anterior	Single outlet-aorta; pulmonary atresia	A L	Subaortic

Abbreviations: AV, atrioventricular; A, anterior; R, right; P, posterior; L, left; UV, univentricular; RV, right ventricle; LV, left ventricle; DORV, double outlet right ventricle; PS, pulmonary stenosis; VSD, ventricular septal defect; ASD, atrial septal defect; IVC, inferior vena cava; SVC, superior vena cava; MC, main chamber; OC, outlet chamber

Aortic arch	*Associated anomalies*	*Visceral situs*	*Thoracic situs*
Right	Ventricular septal defect	Solitus	Solitus
Left	Ascending aorta gives R-L pulmonary arteries; ductus—descending aorta	Solitus	Solitus
Left	Ventricular septal defect; pulmonary stenosis	Solitus	Solitus
Left	Ventricular septal defect	Solitus	Solitus
Left	Ventricular septal defect; pulmonary stenosis	Solitus	Solitus
Left	Ventricular septal defect; persistent ductus arteriosus	Solitus	Solitus
Right	Persistent ductus arteriosus	Solitus	Solitus
Right		Solitus	Solitus
Right	Persistent ductus arteriosus	Solitus	Solitus
Left	Pulmonary stenosis	Solitus	Solitus
Left	Atrial septal defect; pulmonary stenosis	Solitus	Solitus
Right	Left juxtaposition of atrial appendages; pulmonary stenosis	Solitus	Solitus
Left	Left juxtaposition of atrial appendages	Solitus	Solitus
Left	Patent foramen ovale; persistent ductus arteriosus	Solitus	Solitus
Left	Severe pulmonary stenosis	Solitus	Solitus
Left	Persistent ductus arteriosus	Solitus	Solitus
Right	Aneurysm of membranous septum	Inversus	Inversus
Left	Severe pulmonary stenosis	Inversus	Inversus
Right		Inversus	Inversus
Left	Supulmonary stenosis; persistent ductus arteriosus	Inversus	Inversus
Left	PDA; VSD; left SVC	Inversus	Inversus
Right	ASD; right juxtaposition of atrial appendages; left IVC-azygos-left SVC	Inversus	Inversus
Right	Ventricular septal defect	Inversus	Inversus
Right	Pulmonary stenosis	Inversus	Inversus
Right	Right SVC; ASD	Inversus	Inversus
Right	Severe pulmonary stenosis	Inversus	Inversus
Right	Pulmonary stenosis	Inversus	Inversus
Right	VSD; ASD; severe PS; left juxtapostion of atrial appendages	Right liver, left stomach	L ambiguus
Left	Left IVC—azygos—left SVC	Midline liver, left stomach	L ambiguus
Left	Right IVC—azygos—right SVC	Right liver, left stomach	L ambiguus
Left	Subaortic stenosis; right IVC—azygos—right SVC	Midline liver, left stomach	L ambiguus
Left	Bilateral SVC; right IVC receives R and L inferior pulmonary veins	Asplenia, midline liver, left stomach	R ambiguus
Left	Persistent ductus arteriosus	Asplenia, left-midline liver, left stomach	R ambiguus

bited discordant arterial connections and the other of left ventricular type had double outlet main chamber. One of the univentricular hearts of right ventricular type had double outlet main chamber, the other two having single outlet with pulmonary atresia. Of the univentricular hearts of indeterminate type, two had double outlet and the other single outlet with pulmonary atresia.

Aortic arch

The aortic arch was left sided in 11 patients (70%) and right sided in five (30%).

Associated anomalies

Persistent ductus arteriosus, ventricular septal defect, and pulmonary stenosis were the commonest anomalies. Two patients had left juxtaposition of the atrial appendages.

SITUS INVERSUS

In all cases we found visceral, thoracic, and atrial situs to correspond.

Atrioventricular junction (Fig. 4)

Eleven patients had situs inversus, of whom five had concordant and four discordant atrioventricular connections. The remaining two patients had double inlet ventricles, in both of which the ventricular morphology was of a univentricular heart of right ventricular type with a posterior right-sided trabecular pouch of left ventricular type.

The right ventricle, in the nine cases with two ventricular chambers, was to the left of the left ventricle in five (all with concordant atrioventricular connections) and to the right in four (with discordant atrioventricular connections).

Arterial junction

The ventriculoarterial connection in the five patients with concordant atrioventricular connections was concordant in one, double outlet right ventricle in three, and single outlet in the other (aorta with pulmonary atresia). Of the four patients who had discordant atrioventricular connections, one had concordant ventriculoarterial connections (Fig. 5). This chamber arrangement has been termed 'isolated atrial inversion' by other workers (Clarkson *et al.*, 1972), and was confirmed at operation in our case. Of the remaining patients, two had discordant ventriculoarterial connections and one double outlet right ventricle. In both the patients with univentricular hearts the arterial connection was double outlet from the main chamber.

In the group as a whole the aorta was anterior to the pulmonary artery in two cases, anterior and to

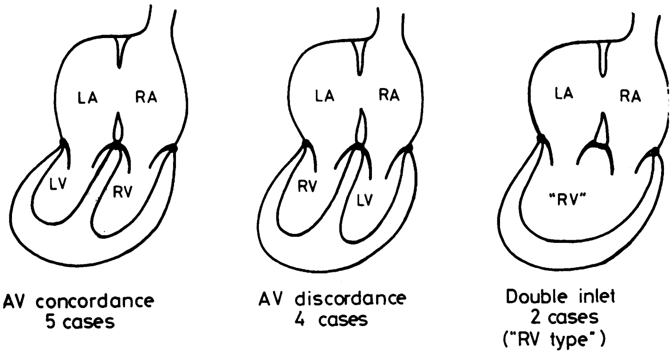

Fig. 4 *Diagram illustrating atrioventricular connections in situs inversus. Abbreviations as for Fig. 3.*

the right in four cases, anterior and to the left in three, posterior and to the left in one, and posterior in one.

Aortic arch

The aortic arch was right sided in eight patients (73%) and left sided in three (27%).

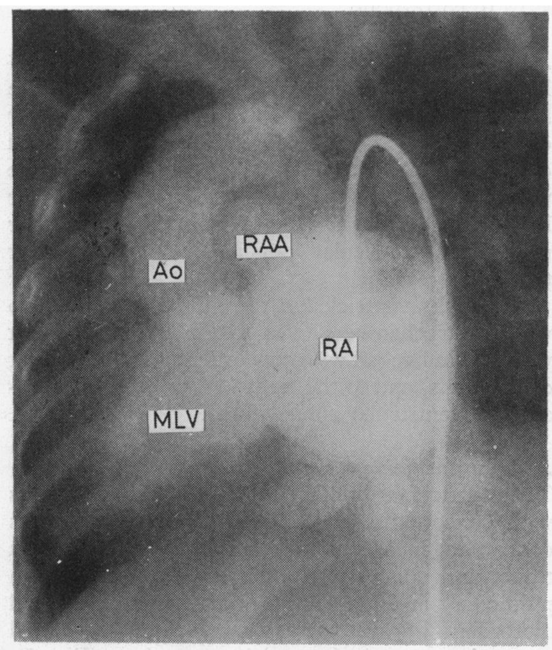

Fig. 5 *Angiocardiogram (injection into right atrium) of patient with situs inversus, atrioventricular discordance, and ventriculoarterial concordance viewed in anteroposterior projection. At operation for atrial septectomy aorta was found to be posterior and to right of pulmonary artery. The chamber connections deduced from the angiocardiogram were confirmed. Note also morphologically right atrial appendage (RAA) juxtaposed behind pulmonary artery (not seen) and catheter entering right atrium via azygos continuation of inferior vena cava. RA, right atrium (left sided); MLV, morphologically left ventricle; Ao, aorta.*

Associated anomalies

Pulmonary stenosis and ventricular septal defect were the commonest lesions. The patient with discordant atrioventricular connections and concordant ventriculoarterial connections (isolated atrial inversion) had right juxtaposition of the atrial appendages with azygos continuation of the inferior vena cava to the left superior vena cava (Fig. 5).

SITUS AMBIGUUS, LAEVOISOMERISM

In four patients atrial laevoisomerism was suggested by the bronchial anatomy on the chest *x*-ray film, confirmed by necropsy in one (Fig. 6). In two of these patients the liver was central (visceral situs ambiguus) but in two the liver was right sided (visceral situs solitus).

Atrioventricular junction (Fig. 7)

Three patients had two ventricles and one a univentricular heart of indeterminate type (without rudimentary chamber). In the biventricular hearts the right ventricle was to the right in one case and to the left in two cases.

The mode of connection was through a common atrioventricular valve in three cases and via two perforate atrioventricular valves in one case.

Arterial junction

Of three patients with two ventricles, one had concordant ventriculoarterial connection, one double outlet right ventricle, and one single outlet (truncus arteriosus). The remaining patient had double outlet from the sole indeterminate ventricular chamber.

The aorta was anterior and to the right in one case, anterior and to the left in one case, and to the left in one case. The remaining case had a truncus with the aortic component posterior to the pulmonary component.

Aortic arch

The aortic arch was left sided in three patients and right sided in one.

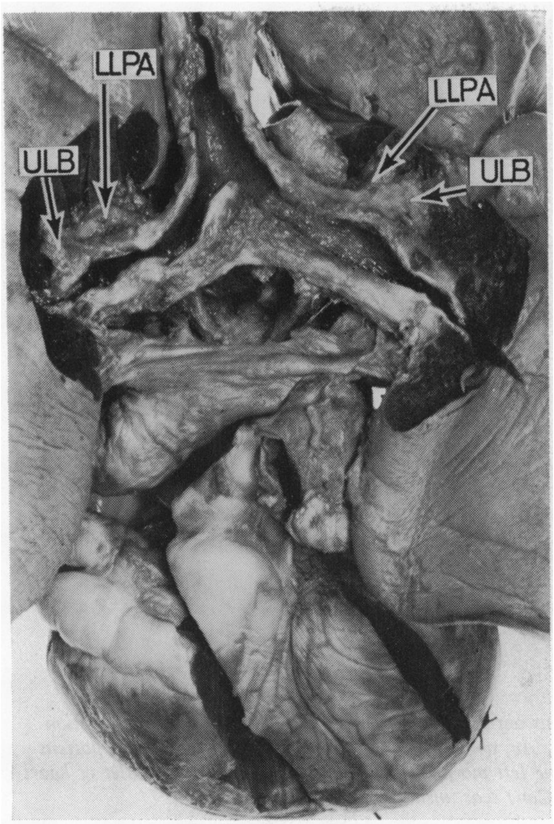

Fig. 6 *Posterior view of specimen with laevoisomerism dissected to show bilateral hyparterial (morphologically left) bronchi. Both lungs were bilobed and atrial appendages were of left morphology. The bronchi are hyparterial as both upper lobe bronchi (ULB) pass below lower lobe pulmonary arteries (LLPA).*

Associated lesions
Three patients had azygos continuation of the inferior vena cava. One patient had left juxtaposition of the atrial appendages (Fig. 8).

SITUS INVERSUS, DEXTROISOMERISM
In two patients atrial dextroisomerism was present, as suggested from the chest x-ray film and confirmed at necropsy in both. Both also had asplenia. In one the liver was central (visceral situs ambiguus) but in the other the liver was left sided (visceral situs inversus).

Atrioventricular junction (Fig. 9)
Two ventricles were present in one patient. The other had a univentricular heart of left ventricular type with outlet chamber of right ventricular type which was anterior and to the left of the main chamber.

Arterial junction
The patient with two ventricles had double outlet right ventricle with the aorta directly anterior, and the patient with a univentricular heart had single outlet (pulmonary atresia), the aorta arising from the outlet chamber.

Aortic arch
Both patients had a left-sided aortic arch.

Associated anomalies
Partial anomalous pulmonary venous return was found in one patient.

Discussion

Our study endorses the findings of others (Van Praagh *et al.*, 1964; Squarcia *et al.*, 1973) that a variety of chamber combinations can be found in hearts situated in the right chest with their long axis orientated to the right. We concur, therefore, with the opinion that the term dextrocardia conveys no information regarding chamber organisation and internal anatomy of the heart but should be used only for description of this cardiac position, a feature easily discernible from the plain chest radiograph. In this investigation our cases not only had the greater part of the heart within the right hemithorax but also had the long axis and apex directed to the right. It is possible that cases were not included that others might have categorised

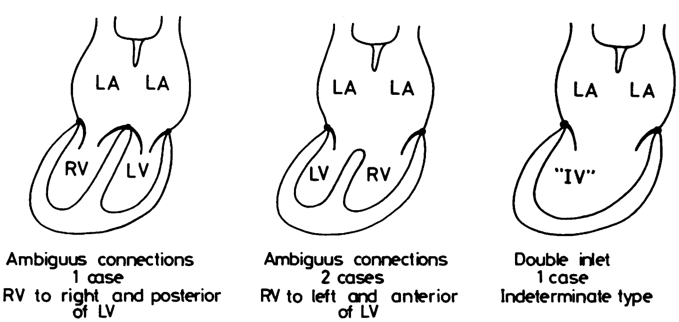

Fig. 7 *Diagram illustrating atrioventricular connections in cases with situs ambiguus and laevoisomerism. Abbreviations as before. IV, univentricular heart of indeterminate type.*

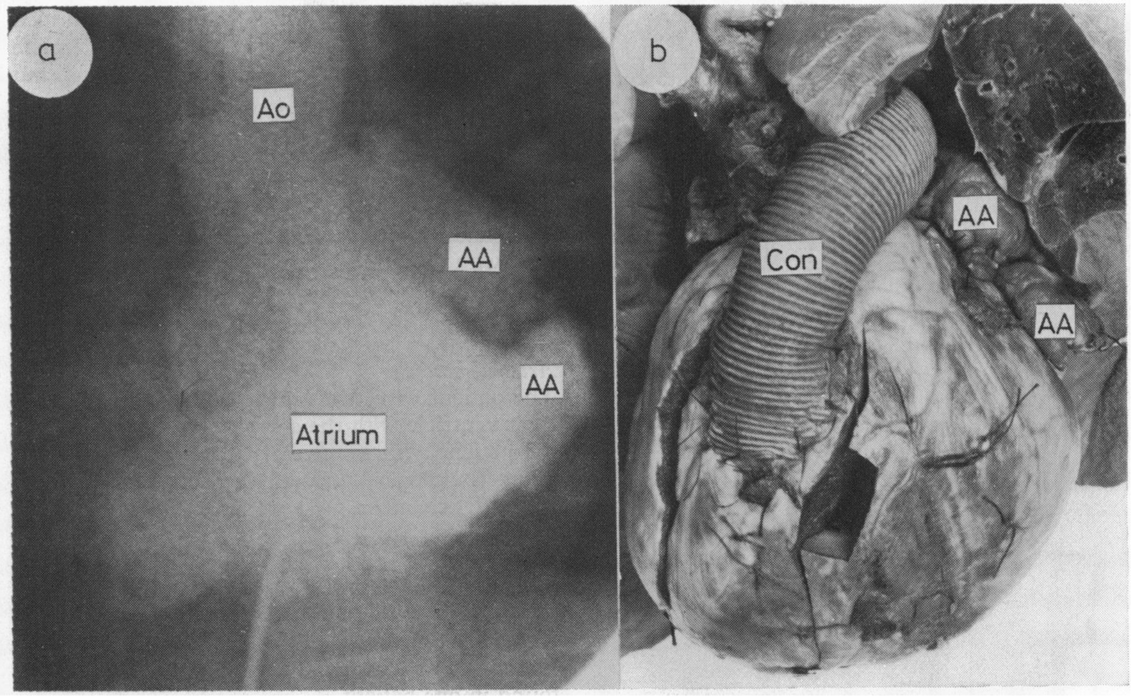

Fig. 8 (a) *Angiocardiogram from a patient with situs ambiguus with laevoisomerism showing left-sided juxtaposition of atrial appendages (AA) as demonstrated by atrial injection. Ao, aorta.* (b) *The necropsy specimen of this patient confirming presence of juxtaposed atrial appendages, both having left morphology. The patient had single outlet of heart with pulmonary atresia, and surgical correction with conduit (Con) was unsuccessful.*

as dextrocardia. However, as we have indicated, arguments concerning the precise definition of dextrocardia are unproductive, the important feature being the segmental arrangement in a heart. In this respect only two of our cases had 'normal' chamber arrangements, compared with 30 per cent of those analysed by Van Praagh *et al.* (1964), though only 7 per cent of those studied by Lev *et al.* (1968) had normal chamber connections. It is possible that these differences reflect the mode of selection of cases. Thus, as shown by the earlier investigations, it is essential to utilise a segmental approach in order adequately to diagnose and classify the cases. We have not, however, found previous approaches (Van Praagh *et al.*, 1964; Squarcia *et al.*, 1973; Van Praagh and Vlad, 1978) to be universally applicable to the anomalies encountered. In contrast, utilisation of the system advocated by Tynan *et al.* (1979) has enabled all hearts to be described simply and unambiguously.

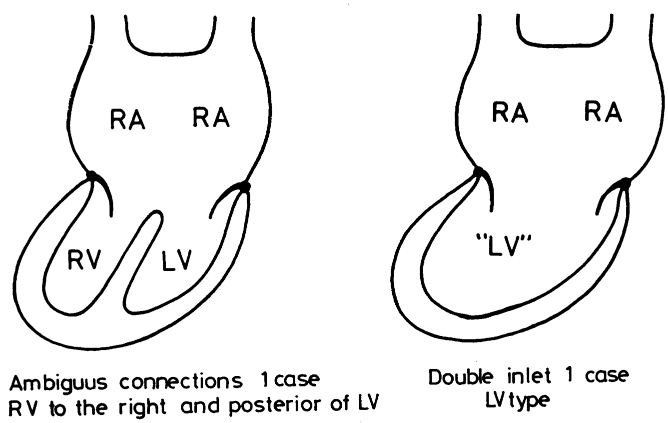

Fig. 9 *Diagram illustrating the atrioventricular connections found in two patients with situs ambiguus and dextroisomerism.*

The hearts investigated here highlight the deficiencies in diagnostic approaches which do not distinguish clearly between anatomical connections and spatial relations.

In the hearts we examined, atrial situs was determined from bronchial anatomy on plain chest radiography. In this way not only could situs solitus and inversus be identified but the laevoisomeric and dextroisomeric forms of situs ambiguus could be distinguished. Atrial situs was confirmed in the cases coming to necropsy. We believe this method of categorising situs to be preferable to those relating atrial morphology to the state of the spleen. Furthermore, if there is doubt from the plain film, bronchial morphology can easily be confirmed by tomography (Partridge *et al.*, 1975) and there is better correlation between atrial and bronchial anatomy than between atrial morphology and presence or absence of splenic tissue or multiple spleens (Macartney *et al.*, 1978).

When describing the ventricular segment of the heart, we found it necessary to be able to describe connections of the atria to the ventricles independently both of spatial relations of chambers within the ventricular mass and of the morphology of the ventricular chambers. Thus, in our cases we found all five types of atrioventricular connection considered possible by Tynan *et al.* (1979), namely concordant, discordant, ambiguus, double inlet, and absence of one atrioventricular connection. In the last category absent right but not absent left atrioventricular connection was seen. The provision of the category for ambiguus connection was necessary to describe the connections in the hearts with situs ambiguus and two ventricles, as the terms concordance and discordance are inappropriate for this arrangement (Tynan *et al.*, 1979). Our cases also illustrated the usefulness of describing type of connection separately from mode of connection, since the ambiguus connection was effected through a common valve in five cases, but through separate right and left valves in one case.

These cases also serve to illustrate what we believe to be a further refinement (Shinebourne *et al.*, 1978) of our initial approach to this connection (Shinebourne *et al.*, 1976). Following Van Praagh's lead, we initially described ventricular relations with ambiguus connection in terms of the loop, as was recently commented upon by Freedom *et al.* (1978). However, because of the additional connotations of 'd- and l-loop', we now prefer to describe the ventricular relations simply in terms of right/left and antero/posterior orientation. One reason for this is the possibility of a 'criss-cross' heart (Anderson *et al.*, 1974) with an ambiguus connection. Previously in a criss-cross heart, we had used 'd-loop' to describe the relation where the morphologically right ventricle was right sided. However, if a criss-cross situation were found with an ambiguus connection, would the relation be described as 'd-loop' or 'l-loop'? As Freedom *et al.* (1978) indicate, the current concept of the loop (Van Praagh and Vlad, 1978) makes it independent of situs. As such, in situs ambiguus it is simply being used to describe ventricular relations. Thus, in the criss-cross situation the left-sided right ventricle, having achieved its position as a consequence of cardiac rotation, can still be recognised as belonging to a d-loop. Is it not, however, simpler to describe the ventricular position in terms of right/left and antero/posterior position rather than asking the observer to interpret the presumed embryological looping of the heart tube? We also submit that simple usage of the right/left and antero/posterior co-ordinates is more useful and more accurate than the terms 'inversion' and 'non-inversion'. The 'inverted' ventricles of classical corrected transposition in situs solitus are rarely, if ever, the mirror image of the normal ventricular arrangement: in the presence of atrioventricular discordance the ventricles tend to be more side by side with horizontal inclination. Furthermore, there is no consensus as to what 'ventricular inversion' describes. For some authors, 'ventricular inversion' in situs inversus describes ventricles occupying the *normal* position for the solitus individual with a normal heart, with the right ventricle anterior and to the right (Espina-Vela, 1978). Such different interpretations are avoided by the use of simple adjectives such as right, left, anterior, and posterior.

The value of describing ventricular morphology independently of the connection is well illustrated by our cases with absence of the right atrioventricular connection ('tricuspid atresia'). These hearts illustrate the wide variability found in hearts having the atrial morphology of classical tricuspid atresia, a possibility predicted in our previous studies (Anderson *et al.*, 1977). Thus, univentricular hearts of right ventricular type, left ventricular type, and indeterminate type were found with absent right atrioventricular connection. We find it difficult to describe these hearts using the loop concept. The finding of such variability in ventricular morphology in hearts with 'tricuspid atresia' has considerable surgical significance. Rudimentary chambers may be posterior or anterior, right sided or left sided, or absent. Most posterior chambers are not suitable for incorporation into the circulation in 'corrective' procedures. We also do not know the effect that ventricular morphology will have on the possible outcome of a Fontan procedure, and clearly this is another factor which must be considered when assessing these cases for possible operation (Fontan *et al.*, 1978).

It is of note that several hearts in our series had the morphology of a main chamber of right ventricular type with a rudimentary chamber of left ventricular type. Five cases were identified (16·5%), three with double inlet connection, and two with absence of the right atrioventricular connection. We believe that in part this relatively high prevalence is the result of an awareness of the anomaly, since we are now finding this malformation with increasing frequency in hearts both with and without dextrocardia (Keeton *et al.*, 1979). Again, identification of this type of ventricular morphology in the univentricular heart is important since it affords a good guide to the likely disposition of the conducting system (Anderson *et al.*, 1978).

Juxtaposition of the atrial appendages was not infrequent in our series. Otero Coto *et al.* (1978) have also pointed to an association between right-sided apex and juxtaposition with a left-sided aorta. However, the aorta was left sided in only one of our cases. All the cases were identified during life, a possibility discussed by Deutsch *et al.* (1974).

At the arterial junction we again found categorisation to be facilitated by describing separately the connections, the arterial relations, and infundibular morphology. It seems to us that if this is done there can be little room for controversy concerning such matters as 'transposition' or the 'conus'.

In conclusion, we have studied a series of patients whose hearts were within the right hemithorax with their long axes orientated to the right, this being the only information to be drawn from the term 'dextrocardia'. The identification and categorisation of the extremely varied chamber arrangement within these hearts was greatly facilitated by use of a descriptive system accounting separately for connections, relations, and morphology.

References

Anderson, R. H., Shinebourne, E. A., and Gerlis, L. M. (1974). Criss-cross atrioventricular relationships producing paradoxical atrioventricular concordance or discordance. *Circulation*, **50**, 176–180.

Anderson, R. H., Wilkinson, J. L., and Becker, A. E. (1978). Conducting tissue in the univentricular heart. In *Embryology and Teratology of the Heart and the Great Arteries*, pp. 62–78, ed L. H. S. Van Mierop, A. Oppenheimer-Dekker, and C. L. D. Ch. Bruins. Boerhaave Series. No. 13. Leiden University Press, The Hague.

Anderson, R. H., Wilkinson, J. L., Gerlis, L. M., Smith, A., and Becker, A. E. (1977). Atresia of the right atrioventricular orifice. *British Heart Journal*, **39**, 414–428.

Clarkson, P. M., Brand, P. W. T., Barratt-Boyes, B. G., and Neutze, J. M. (1972). Isolated atrial inversion, visceral situs solitus, visceroatrial discordance, discordant ventricular d-loop without transposition, dextrocardia. *American Journal of Cardiology*, **29**, 877–881.

Deutsch, V., Shem Tov, A., Yahini, J. H., and Neufeld, H. N. (1974). Juxtaposition of atrial appendages: an angiographic observation. *American Journal of Cardiology*, **34**, 240–244.

Espina-Vela, J. (1978). Letter. Septal defect in transposition of great arteries. *American Journal of Cardiology*, **42**, 692.

Fontan, F., Choussat, A., Brom, G., Chauve, A., Deville, C., and Castro-Cels, A. (1978). Repair of tricuspid atresia. Surgical considerations and results. In *Paediatric Cardiology 1977*, pp. 567–580, ed R. H. Anderson and E. A. Shinebourne. Churchill Livingstone, Edinburgh.

Freedom, R. M., Culham, G., and Rowe, R. D. (1978). The criss-cross and superoinferior ventricular heart: an angiographic study. *American Journal of Cardiology*, **42**, 620–628.

Keeton, B. R., Shinebourne, E. A., Macartney, F. J., Hunter, S., Mortera, C., Rees, P., Tynan, M. J., Wilkinson, J. L., and Anderson, R. H. (1979). Univentricular heart of right ventricular type with double or common inlet. *Circulation*, **59**, 403–411.

Lev, M., Liberthson, R. R., Eckner, F. A. O., and Arcilla, R. A. (1968). Pathologic anatomy of dextrocardia and its clinical implications. *Circulation*, **37**, 979–999.

Macartney, F. J., Partridge, J. B., Shinebourne, E. A., Tynan, M. J., and Anderson, R. H. (1978). Identification of atrial situs. In *Paediatric Cardiology 1977*, pp. 16–26, ed R. H. Anderson and E. A. Shinebourne. Churchill Livingstone, Edinburgh.

Otero Coto, E., Quero Jimenez, M., Cabrera, A., Deverall, P. B., and Caffarena, J. M. (1978). Aortic levoposition without ventricular inversion. *European Journal of Cardiology*, **8**, 523–542.

Partridge, J. B., Scott, O., Deverall, P. B., and Macartney, F. J. (1975). Visualization and measurement of the main bronchi by tomography as an objective indicator of thoracic situs in congenital heart disease. *Circulation*, **51**, 188–196.

Shinebourne, E. A., Macartney, F. J., and Anderson, R. H. (1976). Sequential chamber localisation—logical approach to diagnosis in congenital heart disease. *British Heart Journal*, **38**, 327–340.

Shinebourne, E. A., Tynan, M. J., Anderson, R. H., and Macartney, F. J. (1978). Atrioventricular connexions. In *Paediatric Cardiology 1977*, pp. 27–35, ed R. H. Anderson and E. A. Shinebourne. Churchill Livingstone, Edinburgh.

Squarcia, H., Ritter, D. G., and Kincaid, D. W. (1973). Dextrocardia: angiographic study and classification. *American Journal of Cardiology*, **32**, 965–977.

Tynan, M. J., Becker, A. E., Macartney, F. J., Quero Jimenez, M. Shinebourne, E. A., and Anderson, R. H. (1979). The nomenclature and classification of congenital heart disease. *British Heart Journal*, **41**, 544–553.

Van Praagh, R., Van Praagh, S., Vlad, P., and Keith, J. D. (1964). Anatomic types of congenital dextrocardia: diagnostic and embryologic implications. *American Journal of Cardiology*, **13**, 510–531.
Van Praagh, R., and Vlad, P. (1978). Dextrocardia, mesocardia and levocardia. In *Heart Disease in Infancy and Childhood*, 3rd edn, pp. 638–695, ed J. D. Keith, R. D. Rowe, and P. Vlad. Macmillan, New York.

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