**RADIOLOGIC NOTES IN CARDIOLOGY**

**Right Aortic Arch**

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**SUMMARY**

A right aortic arch usually produces several abnormal shadows on a standard frontal film of the chest. The aortic knob protrudes from the right side of the mediastinum, the trachea is deviated to the left, and the descending aorta can be identified along the right side of the spine. A more conclusive diagnosis can be made from the indentation produced by the arch on the barium-filled esophagus. This also serves to distinguish the two types of right aortic arch. The presence of a large indentation on the posterior aspect of the esophagus is characteristic of the type of arch most frequently associated with a vascular ring. A right arch without a posterior component is commonly associated with significant congenital heart disease.

The diagnosis of a right aortic arch can be made from a frontal film of the chest when the aortic knob is identified along the right border of the mediastinum. However, when the knob is not particularly prominent, it can be obscured by the shadows of the other mediastinal structures, and the anomalous position of the aortic arch may be overlooked. On the other hand, a dilated or tortuous aorta can produce a sizable bulge on the mediastinal contour and may be mistaken for a tumor of the mediastinum or of the lung. In general, these diagnostic problems are easily resolved if the patient is given barium to drink and additional films are made. Not only can the aortic arch be localized from the esophagram, but the two different types of right aortic arch, the mirror-image arch and the arch with a posterior diverticulum, can be accurately differentiated from the pattern of the indentations they produce on the esophagus.

At an early stage in the development of the heart and great vessels, the ascending and descending portions of the aorta are connect-ed by two aortic arches, one on either side of the trachea and esophagus. As the embryo matures, the right arch regresses almost completely while the left one remains and forms the adult aortic arch. The proximal segment of the embryonic right arch normally persists and is incorporated into the root of the right subclavian artery. If, contrary to the normal, the left arch regresses and the right persists, the adult aortic arch will lie on the right side of mediastinum.

The anatomic configuration of a right aortic arch is determined largely by the manner in which the left arch regresses. If the distal portion of the left arch, adjacent to the descending aorta, disappears, the developmental process is essentially a mirror image of the normal. The proximal portion of the left arch is incorporated into the left subclavian artery and the innominate artery forms on the left side. The order in which the vessels originate from this type of arch is the exact reverse of that of a normal left arch. The first vessel to arise from the right arch is the innominate artery, which courses to the left in front of the trachea before bifurcating into the left common carotid and left subclavian arteries. The right common carotid originates next as a separate trunk, and the right
Mirror-image type of right aortic arch in tetralogy of Fallot. Right ventricular angiocardiogram, frontal projection. The ascending aorta (A) is in its normal position. The first branch to originate from the arch is the left innominate artery (In). This gives rise to the left common carotid (LC) and left subclavian (LS) arteries. A Blalock shunt is present, the subclavian artery being turned down and anastomosed to the pulmonary artery (P). The second branch from the aortic arch is the right common carotid artery (RC), and the most posterior branch is the right subclavian artery (RS).

If the interruption of the left arch occurs in its proximal portion, near the ascending aorta, its distal segment does not regress and remains in continuity with the distal portion of the right arch and descending aorta. This remnant of the left arch develops into a diverticulum of the distal adult right arch, extending to the left behind the esophagus. Each of the four major vessels from this arch arises as an

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**Figure 1**

Right aortic arch with posterior diverticulum. (Top) Levocardiogram phase following venous injection of contrast material. The origins of the left common carotid (LC), right common carotid (RC), and right subclavian (RS) arteries are superimposed in this view. The left subclavian artery (LS) arises from a large diverticulum (D), which communicates with the distal portion of the right aortic arch (A). (Bottom) Lateral chest film showing the broad indentation on the posterior aspect of the esophagus (arrow) caused by the aortic diverticulum. (Reproduced through the courtesy of Dr. Walter Whitehouse, by permission.)
Figure 3

Right aortic arch with posterior diverticulum. (Left) Frontal chest film. The superior mediastinum appears widened on both sides. The prominence on the right (A) represents a right aortic knob. The bulge along the left side (D) is rather small for a normal aortic knob and is produced by a large diverticulum arising from the right arch. The shadow of the descending aorta (arrows) can be seen along the right side of the spine. (Top, right) The presence of a right aortic arch is confirmed by the indentation it produces on the right side of the esophagus (arrow). (Bottom, right) Lateral view. The large posterior indentation on the esophagus (arrow) is characteristic of the type of right aortic arch that is usually not associated with congenital heart disease.

individual branch, and there is no innominate artery. The first vessel from the arch is the left common carotid artery, followed in turn by the right carotid and right subclavian arteries. The left subclavian artery is the last branch to arise from the arch and, in almost every case, takes origin from the posterior diverticulum rather than directly from the aorta (fig. 2).³
Development of the lower thoracic aorta and the diaphragm is independent of the formation of the aortic arch. The aorta passes through the diaphragm in its normal position, behind and slightly to the left of the esophageal hiatus, regardless of the location or type of aortic arch. Therefore, in both the mirror-image type of right arch and the right arch with a posterior diverticulum, the descending aorta must swing over to the left side before reaching the diaphragm.\textsuperscript{1} The level at which the aorta crosses the midline is quite variable and is of no diagnostic significance.

The clinical importance of the two types of right aortic arch differs considerably. About three fourths of mirror-image arches are found in association with significant congenital heart disease,\textsuperscript{3} most commonly, tetralogy of Fallot or persistent truncus arteriosus. There is no particular association between a right arch with a posterior diverticulum and cardiac anomalies. The latter type of arch, however, commonly forms a vascular ring encircling the trachea and the esophagus. The ring is formed by the aortic arch on the right side, the pulmonary artery in front of the trachea, and the aortic diverticulum and left subclavian artery behind the esophagus. The circle is closed by the ductus arteriosus, which usually extends from the pulmonary artery to the left subclavian artery, along the left side of the trachea and esophagus. In the great majority of cases, the ring is loose and does not cause significant compression. This is confirmed by the fact that most arches of this type are first discovered as an incidental finding on a routine chest film.

The upper portion of the ascending aorta lies to the right of the midline, regardless of the location of the aortic arch. When the arch is on the right side, the aorta curves directly posteriorly over the right main bronchus before it arcs downward to become the descending aorta. In the frontal view, the segment of aorta at the apex of the arch lies parallel to the X-ray beam so that it is projected in cross section, and its border is sharply outlined on the film. The medial and inferior aspects of the border blend with the mediastinal shadow but the lateral and superior portions are outlined by the adjacent lung and form the aortic knob (fig. 3). This shadow, together with the absence of an aortic knob on the left side, is diagnostic of a right aortic arch.

In some cases, the aortic knob is small and does not protrude from either side of the mediastinum. Nevertheless, the position of the arch can usually be inferred from the position of the trachea on the frontal chest film. On an adequately penetrated film, the tracheal air shadow appears as a broad, vertical, radiolucent band. The trachea is normally in the midline at the thoracic inlet but is pushed to one side by the aortic arch as it descends into the chest (fig. 4). Deviation of the trachea is usually not marked in young adults, in whom the aorta is of normal size, but as the aorta becomes sclerotic and dilated the displacement becomes more prominent.

In the older patient, the vessels arising from the aorta are often tortuous and dilated and can obscure the upper border of the aortic knob. The right arch then appears simply as a rather diffuse paratracheal mass, similar to a mediastinal tumor. The possibility of an anomalous aortic arch should be considered, however, if the left side of the mediastinum is less prominent than normal and especially if a normal aortic knob cannot be identified. In addition, when the aortic arch is on the right side, the shadow of the descending aorta can usually be seen along the right side of the spine (fig. 3).

The problem of localizing the aortic arch is sometimes complicated when the diverticulum associated with a right arch is unusually prominent. The diverticulum may extend far enough laterally to bulge from the left border of the mediastinum and mimic the appearance of a normal aortic knob. However, the shadow of the diverticulum tends to be smaller than a true aortic knob and is definitely smaller than the shadow produced by the aortic arch on the right side of the mediastinum (fig. 3). In addition, the trachea is deviated to the left by...
Figure 4

Mirror-image type of right aortic arch with anomalous origin of the left subclavian artery in a 10-year-old girl with isolated infundibular stenosis. The aortic knob is relatively small and is completely hidden within the boundaries of the mediastinum. However, the trachea (arrows) is deviated to the left, strongly suggesting the presence of a right arch.

The right arch, and the descending aorta lies to the right of the spine. A similar combination of shadows can be produced by a double aortic arch, and angiography may be required to exclude this anomaly.

In infants, it is often not possible to locate the aortic arch on routine films because the aortic knob and the borders of the mediastinum are largely obscured by the thymus gland. Deviation of the trachea is of little help in this age group because the trachea is relatively mobile and its position varies considerably with slight changes in the attitude of the infant. The descending aorta tends to be hidden within the posterior mediastinum. The position of the arch can
Figure 5

Same patient as in figure 4. The presence of a right arch is confirmed by the indentation (arrows) it produces on the right side of the esophagus. The oblique lucency crossing the esophagus in this region is caused by an anomalous left subclavian artery coursing behind the esophagus.

usually be identified if the esophagus is filled with barium or some other radiopaque material when the films are made.

The posterior portion of the aortic arch, be it on the right side or the left, is in contact with the esophagus. When the esophagus is distended, the aorta produces an indentation on its lateral border, on the same side as the arch. Both types of right aortic arch produce a similar depression on the right border of the opacified esophagus (figs. 3-6). The indentation is rather localized and conforms to the size of the aorta, tending to be more prominent in older patients.

The aortic arch with a posterior diverticulum not only indents the right border of the esophagus but also produces a marked anterior bowing of its upper portion (figs. 2 and 3). This is best seen in the lateral projection. On the other hand, the mirror-image type of arch, with a left innominate artery, does not have a posterior component (fig. 7). A lateral film of
Same patient as in figure 4, lateral view. The posterior indentation of the esophagus (arrow) produced by the anomalous left subclavian artery is considerably smaller than that caused by an aortic diverticulum.

the barium-filled esophagus will serve to differentiate the two types of aortic arch, in almost all cases. If a mirror-image arch crosses to the left side high in the chest, at the level of the carina, it can produce a localized posterior indentation of the esophagus resembling that caused by a diverticulum. However, this is extremely rare.

Occasionally, the pattern of origin of the vessels from a mirror-image right arch is atypical, the left subclavian artery arising directly from the aorta rather than from an innominate artery. The situation is analogous to that of anomalous origin of the right subclavian artery from a normal aortic arch (dysphagia lusoria). When the left subclavian arises as the last branch of the right arch, it courses to the left behind the esophagus and
is seen, in the frontal projection, as a narrow indent its posterior border. This indentation band of lucency crossing the shadow of the opacified esophagus. The defect is angled upward and to the left (fig. 5). In the lateral view, the posterior indentation of an anomalous left subclavian is much smaller than that produced by an aortic diverticulum (fig. 6). This distinction is quite important because the significance of the mirror-image right arch is the same regardless of where the left subclavian arises. So long as there is no posterior diverticulum of the arch, the likelihood of associated congenital heart disease remains great.

References

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