Computerized Axial Tomography of the Chest for Visualization of “Absent” Pulmonary Arteries

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SUMMARY To expand the search for central pulmonary arteries in six patients with absence of cardiac-pulmonary continuity, computerized axial tomography (CAT) of the chest was performed. The CAT scans were compared with previous arteriograms and pulmonary vein wedge angiograms. Three patients with type IV truncus arteriosus were studied, and none had a central, right or left pulmonary artery on CAT scan. However, two patients with tetralogy of Fallot with pulmonary atresia and a patent ductus arteriosus to the right lung demonstrated the presence of a left pulmonary artery. In addition, one child with truncus arteriosus with “absent” left pulmonary artery demonstrated a left pulmonary artery on the CAT scan. The CAT scan may therefore enhance our ability to search for disconnected pulmonary arteries in children with complex cyanotic congenital heart disease.

THE PRESENCE of bilateral pulmonary arteries is critical in the decision to consider patients with type IV truncus arteriosus, tetralogy of Fallot with pulmonary atresia, or truncus arteriosus with a unilateral pulmonary artery for surgical correction.1 If a central pulmonary artery can be found in each lung, then appropriate palliative surgery, such as banding of a hypertensive pulmonary artery or shunting to a small, underdeveloped artery, can be used to prepare the artery and lung for open heart surgery. Hypertensive pulmonary arteries are readily defined during diagnostic angiocardiology. The small, underperfused pulmonary artery, however, is difficult to detect. Recent pathologic work suggests that central left and right pulmonary arteries are almost always present and patent, even in patients thought to have type IV truncus arteriosus. Sotomora and Edwards questioned whether truncus type IV even exists.2

The standard method of looking for central pulmonary arteries has been aortography, followed by selec-
tive systemic arterial injections from the central aorta and brachiocephalic vessels. However, the bronchial arteries visualized frequently have little visible communication with the pulmonary arteries and, in some instances, small central pulmonary arteries have been missed due to the very low flow in these vessels. Since 1978, pulmonary vein wedge angiography has been used to try to retrogradely fill these small, low-pressure pulmonary arteries. This technique has allowed visualization of previously unseen vessels in many instances, and reports of surgical shunts into these vessels to enhance their size has validated the significance of this technique.

We expanded our search for previously unvisualized central pulmonary arteries by performing computerized axial tomography (CAT) of the chest to look for disconnected pulmonary arteries. CAT was performed in six patients (table 1): three with type IV truncus arteriosus, two with tetralogy of Fallot and pulmonary atresia with a hypertensive patent ductus arteriosus to the right lung but no documented left pulmonary artery, and one patient with truncus arteriosus and “absence” of the left pulmonary artery. In the latter three patients, a left pulmonary artery was identified.

### Methods

The CAT scans were performed on an AS+E 0500 scanner, each slice taking 5 seconds using 50 mA and 125 kV and a sharp filter function. Contiguous 1-cm-thick tomographic slices were obtained starting at the suprasternal notch and continuing down to the level of the pulmonary veins, before and after the rapid i.v. in-

### Table 1. Angiographic and Computed Axial Tomographic Scan Data in Patients with Absent Pulmonary Arteries

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (years)</th>
<th>Diagnosis</th>
<th>Angiography</th>
<th>Pulmonary vein wedge</th>
<th>CAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>Type IV truncus</td>
<td>Multiple bronchials in both lungs</td>
<td>Not done</td>
<td>No central main, left or right PA</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>Type IV truncus</td>
<td>Multiple bronchials in both lungs</td>
<td>Not done</td>
<td>No central main, left or right PA</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Type IV truncus</td>
<td>Multiple bronchials in both lungs</td>
<td>No central vessels</td>
<td>No central main, left or right PA</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>Tetralogy with pulmonary atresia</td>
<td>PDA to MPA to right lower lobe, bronchials to RML, RUL, and left lung</td>
<td>Not done</td>
<td>10-mm LPA — not connected with aorta</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>Tetralogy with pulmonary atresia</td>
<td>Right ductus arteriosus to right lung, bronchials to right lung, no large left lung vessels</td>
<td>Not done</td>
<td>4-mm LPA — not connected with aorta</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Truncus with “absent” LPA, banded RPA</td>
<td>No LPA seen</td>
<td>Small distal LPA</td>
<td>9-mm LPA — not connected with aorta</td>
</tr>
</tbody>
</table>

Abbreviations: LPA = left pulmonary artery; RPA = right pulmonary artery; PDA = patent ductus arteriosus; MPA = main pulmonary artery; RML = right middle lobe; RUL = right upper lobe; PA = pulmonary artery; CAT = computed axial tomography.

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**Figure 1.** Anteroposterior (A) and lateral (B) views of a retrograde angiogram of the ductus arteriosus of patient 4 shows a main and right pulmonary artery with flow to the right lower lobe only.
Patient 4

Patient 4, who did not have surgery, had tetralogy of Fallot with pulmonary atresia and a patent ductus arteriosus that filled the main pulmonary artery and subsequently the right pulmonary artery, which supplies only the right lower lobe (fig. 1). Blood flow to the left lung and right upper lobe and right middle lobe derived from separate vessels arising from the descending aorta below the level of the ductus arteriosus (fig. 2). No vessel anterior and superior to the left main stem bronchus had been seen during repeat angiocardiography. No pulmonary vein wedge angiogram was performed. The CAT scan (fig. 3) showed a 10-mm vessel in the usual location of a left pulmonary artery, but this vessel failed to connect with the main pulmonary artery.

Patient 5

Patient 5 had tetralogy of Fallot with pulmonary atresia and a left aortic arch. A right patent ductus arteriosus from the innominate arch supplied the right lung. Copious bronchials also supplied the right lung (fig. 4). No direct blood supply of the left lung had been seen by pulmonary or bronchial vessels, so that transpleural collateral vessels were the only known blood supply to the left lung. A CAT scan (fig. 5) showed a 4-mm vessel above the left pulmonary artery as well as the larger right pulmonary artery from the ductus arteriosus. This left pulmonary artery was remote from the ascending aorta or right ductus. A left thoracotomy was performed in November 1979. A 6-mm left pulmonary artery was identified in the operating room. A 4-mm Gortex graft was anastomosed from the descending thoracic aorta to the left pulmonary artery. A thrill was palpated in the operating room, but there was no improvement in the patient's oxygenation after surgery. She developed

Results

Patients 1, 2 and 3 had no new vessels identified, but patients 4, 5 and 6 each had a new vessel visualized.

Figure 2. Retrograde bronchial angiogram from patient 4 shows a large bronchial collateral vessel to the right middle and right upper lobes.

Figure 3. Computed axial tomographic scan from patient 4. The large right pulmonary artery (RPA) crosses the mediastinum and a separate left pulmonary artery (LPA) anterior to the left main stem bronchus (LMSB). This vessel is 9 mm in diameter. R = right lung; L = left lung; AA = ascending aorta; DA = descending aorta.
multifocal premature ventricular complexes and died despite drug therapy, presumably from an arrhythmia, 9 months after surgery. Autopsy showed an occluded shunt into a tiny left pulmonary artery.

**Patient 6**

Patient 6, a child with truncus arteriosus and absent left pulmonary artery (fig. 6), had had banding of the right pulmonary artery performed at 9 months of age. Catheterization at 3 years of age showed the right pulmonary artery pressure to be 33/26 mm Hg without demonstration of a left pulmonary artery. Pulmonary vein wedge angiography in the left lower lobe at 5 years of age showed a small left pulmonary artery, although retrograde filling to the hilus was not seen (fig. 7). A CAT scan showed a 9-mm left pulmonary artery above and anterior to the left main stem bronchus, which failed to connect to the truncus arteriosus (fig. 8). Open heart surgery was performed in May 1981. A small left pulmonary artery was seen that arose from the underside of the aorta. The artery was felt to be approximately 7 mm in diameter and

**Figure 4.** Right lung perfusion in patient 5, who had pulmonary atresia, is through a right ductus arteriosus coming off of the innominate artery (A) and large bronchial collateral vessels from the descending aorta (B).

**Figure 5.** Computed axial tomographic scan of patient 5 shows a 4-mm left pulmonary artery anterior to the left main stem bronchus.
FIGURE 6. Ventriculogram from patient 6 shows a large right pulmonary artery and no apparent left pulmonary artery.

could not be used for surgery. The anatomy most closely resembles the type A III truncus arteriosus described by Van Praagh and Van Praagh.8

Discussion

Improved techniques for open heart repair of patients with tetralogy of Fallot with pulmonary atresia and truncus arteriosus have made it more important to define the pulmonary blood supply in patients in whom the pulmonary flow is not directly from the heart. If there is confluence of the pulmonary flow, such as in type I truncus arteriosus or tetralogy with pulmonary valve atresia, then appropriate surgery can be planned. However, nonconfluence of the two pulmonary arteries frequently leads to unequal pulmonary flow to the two lungs. Recent pathologic information suggests that poorly perfused unilateral pulmonary arteries, though sometimes quite small, are almost always present. We have therefore attempted to use CAT of the chest to demonstrate the presence of these arteries and their approximate size.

In our three patients without a previously demonstrated pulmonary artery to either lung, whose total blood flow by conventional angiography has been from the descending aorta and who have therefore been classified as having type IV truncus arteriosus, CAT failed to demonstrate hilar vessels. This is discouraging for these patients but may indicate that their pulmonary arteries, if present, are so distal within the lung structure as to be unusable by standard

FIGURE 7. A left lower pulmonary vein wedge angiogram from patient 6 reveals a hypoplastic left pulmonary artery beyond the hilus of the left lung.

FIGURE 8. Computed axial tomographic scan of this patient shows an 8-mm left pulmonary artery (LPA) at the level of the carina. AA = ascending aorta; RPA = right pulmonary artery; DA = descending aorta; R = right lung; L = left lung.
surgical techniques. Sotomora and Edwards suggest that most of these patients do have two pulmonary arteries within the lungs themselves.2

However, the three patients who had an angiographically patent right pulmonary artery each had a left pulmonary artery demonstrated by CAT scan. In one case, the left pulmonary artery was just 4 mm, but in the other two cases, left pulmonary arteries of nearly 1 cm in diameter were visualized.

CAT of the chest is a safe and relatively easy way to visualize pulmonary arteries. In this small group of patients, CAT revealed previously undetected central pulmonary arteries in three patients, though three other patients with the clinical picture of type IV truncus arteriosus were not demonstrated to have central pulmonary arteries at this time. Identification of previously unvisualized pulmonary arteries by CAT appears to be a valuable adjunct to angiography in these patients.

Acknowledgment

We thank David Factor for preparing the line drawings and Terry Howe for her assistance in typing this manuscript.

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The Potentiation of Warfarin Anticoagulation by Amiodarone

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SUMMARY The potentiation of the anticoagulant effect of sodium warfarin by amiodarone is reported in 10 patients. Amiodarone appears to augment the depression of vitamin K–dependent coagulation factors caused by warfarin by an uncertain mechanism, and may lead to serious bleeding. The maintenance dose of warfarin should be halved when amiodarone and warfarin are prescribed together.

AMIODARONE, a benzofuran derivative, is an effective drug in controlling supraventricular and ventricular arrhythmias, including the arrhythmias associated with the Wolff-Parkinson-White syndrome.1-6 It often controls arrhythmias when other drugs have failed. Its main reported side effects include reversible corneal opacities, changes in thyroid function, photosensitivity, and pulmonary infiltrates.2,6

The use of amiodarone in patients with cardiac disease may result in its therapeutic combination with coumadin derivatives prescribed for thromboembolic prophylaxis. Recently, Martinowitz et al.7 suggested an interaction between amiodarone and sodium warfarin. We report our experience in 10 patients who demonstrated the effect of amiodarone in potentiating the anticoagulant properties of the coumadin derivative warfarin, with the possibility of life-threatening consequences.

Patient Details, Warfarin Administration and Laboratory Monitoring

Ten patients were referred for the management of drug-resistant arrhythmias and were prescribed a single daily dose of amiodarone. The clinical details are summarized in table 1. Nine patients were already receiving sodium warfarin for thromboembolic prophylaxis after cardiac valve surgery or because of paroxysmal atrial fibrillation or transient cerebral ischemia; the remaining patient was prescribed warfarin after a pulmonary embolus and was already taking amiodarone. The dose of warfarin was monitored by weekly or monthly one-stage prothrombin times as indicated, expressed as a percentage of a control value (10.5–12.5 seconds) using a nomogram (prothrombin activity). The nomogram was constructed using saline dilutions of normal plasma and an exponential curve.
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Circulation. 1982;65:1020-1025
doi: 10.1161/01.CIR.65.5.1020

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/65/5/1020

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