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Coarctation of the aorta in spiral computed tomography. A case report

Coarctation of the aorta is a congenital obstructive anomaly of the aortic lumen. Coarctation typically occurs in the aortic isthmus, between the left subclavian artery and the ducts. More than half of cases show tubular hypoplasia of the transverse portion of the aortic arch with dilation of the supraaortic vessels. Coarctation-associated lesions include ventricular septal defect and bicuspid aortic valve; aneurysms of the ascending aorta, ducts, intercostal arteries, and circle of the Willis; stenosis of the left subclavian artery; and aberrant right subclavian artery (9).

The diagnosis and treatment of aortic coarctation are based on clinical, echocardiographic, and aortographic findings. Aortography provides the highest-resolution depiction of the coarctated segment and the aortic arch vessels; it also allows measurement of the gradient across the coarctations, visualization of collateral vessels, and assessment for additional cardiac malformations. Echocardiography cannot depict collateral vessels. Multisection CT directly depicts both the stenosis and collateral circulatory pathways, but is not useful for visualizing the aortic gradient, patent ducts, or small cardiac malformations. Nevertheless, multisection CT is useful for planning stent-graft implantation and for postoperative follow-up examination (6, 9).

The aim of the study is to present the use of the spiral CT examination with MPR and VRT reformations in assessment of aortic coarctation, based on case report on adult with aortic coarctation.

MATERIAL AND METHODS

50-year-old man was sent to our department from the department of vascular surgery for CT examination of thoracic aorta. Spiral CT examination of thoracic aorta was performed in vascular protocol with Siemens Somatom Emotion CT scanner. The scanning .was performed before administering the contrast agents, and then enhanced examination was performed, using automatic syringe. 100–150 ml of contrast agent was injected in two phases: in the first phase which last 8 sec 4 ml per sec, and the second phase – 2.5 ml per sec. The scanning was automatically started, when pick enhancement inside the lumen of the examined aorta was reached. After scanning the multiplanar reconstructions (MPR) were performed, and the arteries were assessed in maximum intensity projection (MIP). 3D images were created using Volume Rendering Technique (VRT), and evaluated before and after editing unnecessary bone structures.

RESULTS

Axial CT images reveal the narrowing of the aortic arch, just below the left subclavian artery (Fig. 1).

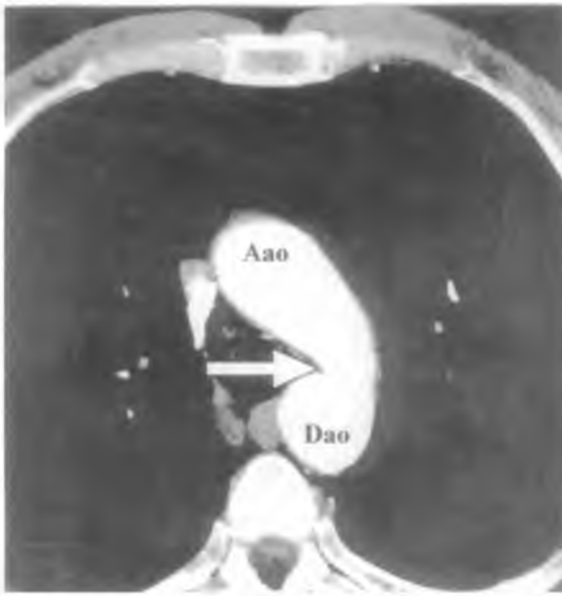

Fig. 1. An axial section at the level of the aortic arch. Coarctation of the aorta marked with an arrow. Aao – ascending aorta; Dao – descending aorta

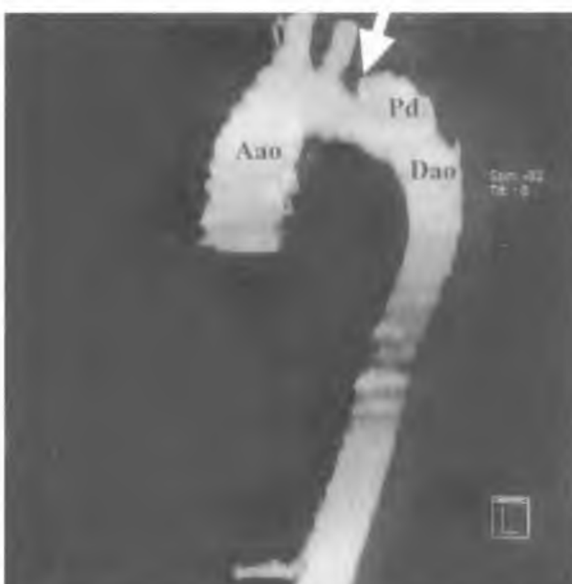

Fig. 2. A MIP reconstruction of the thoracic aorta. Coarctation of the aorta marked with an arrow. Aao – ascending aorta; Dao – descending aorta; Pd – poststenotic dilation

The MIP images in oblique projection reveal the relations of the narrowing and the aortic branches. The poststenotic dilation just below the stenosis is clearly visible (Fig. 2).

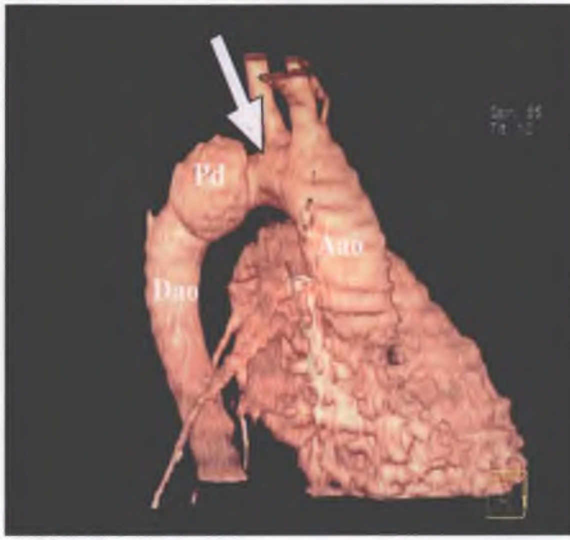

Fig. 3. A VRT image of the thoracic aorta. Coarctation of the aorta marked with an arrow. Blocs in lower left-hand corners show orientation. A indicates anterior; H indicates head; Aao – ascending aorta; Dao – descending aorta; Pd – poststenotic dilation

VRT images clearly demonstrate the anatomy of the anomaly, and the poststenotic dilation (Fig. 3). VRT projection from above is even more informative (Fig. 4).

Fig. 4. A VRT image of the thoracic aorta projected from above. Coarctation of the aorta marked with an arrow. Blocs in lower left-hand corners show orientation. A indicates anterior; H indicates head; Aao – ascending aorta; Dao – descending aorta; Pd – poststenotic dilation

After editing unnecessary heart and pulmonary arteries, the anatomy of the pathology is much more detailed visible on both, oblique projection (Fig. 5) and on images projected from above (Fig. 6).

Fig. 5. A VRT image of the thoracic aorta after editing heart and pulmonary vessels. Coarctation of the aorta marked with an arrow. Blocs in lower left-hand corners show orientation. A indicates anterior; H indicates head; Aao – ascending aorta; Dao – descending aorta; Pd – poststenotic dilation

Fig. 6. A VRT image of the thoracic aorta projected from above, after editing heart and pulmonary vessels. Coarctation of the aorta marked with arrows. Blocs in lower left-hand corners show orientation. A indicates anterior; H indicates head; Aao – ascending aorta; Dao – descending aorta; Pd – poststenotic dilation

DISCUSSION

Aortic stenosis or narrowing of the aortic lumen has several causes. The site of aortic stenosis varies according to the disease or condition that causes stenosis. Stenosis of the proximal descending thoracic aorta is typical of congenital coarctation. The obstruction of blood flow through the stenotic segment may lead to the development of collateral arterial pathways, depending on the level of stenosis (9).

The obstruction of blood flow through the aortic arch provokes the development of collateral vessels that will allow blood to flow from high-pressure to low-pressure areas. Collateral vessels most frequently emerge from the branches of the subclavian arteries above the obstruction and supply blood to the tissues below the obstruction. The collateral pathways that develop most commonly in proximal thoracic aortic stenosis include: subclavian artery–internal mammary artery (internal thoracic artery) – internal costal arteries (retrograde flow)-postcoarctation descending thoracic aorta; subclavian artery – thyrocervical and costocervical trunks – thoracoacromial and descending scapular arteries–postcoarctation descending thoracic aorta; subclavian artery–vertebral artery–anterior spinal artery–intercostal arteries–postcoarctation descending thoracic aorta (9).

In classic coarctation, the narrowing is located just distal to the left subclavian artery. Coarctation at or immediately proximal to the left subclavian artery is rare and compromises that vessel. An aberrant right subclavian artery may arise at or below the coarctation. The aorta just distal to the coarctation is typically dilated. Uniform narrowing of the aortic arch, tubular hypoplasia can be more frequently observed in neonates. A localized coarctation and tubular hypoplasia may coexist or may occur independently (4).

Echocardiography and angiography are the traditional imaging modalities used to diagnose congenital heart disease. Echocardiography with Doppler performs well in defining intracardiac anomalies and estimating hemodynamics. However, it is limited by a small field of view, a variable acoustic window, inability to penetrate air and bone, and difficulty in delineating extracardiac vascular structures in their entirety. Cardiac catheterization and angiography is and invasive modality that yields important hemodynamics data while clearly defining anatomy in vessels that are accessible to catheterization. However, angiography often gives only indirect information regarding venous connections and arterial anatomy distal to high grade stenosis or atresia. It also uses high doses of ionizing radiation and is limited by the risk inherent to iodinated contrast material (4, 6).

Magnetic resonance imaging and computed tomography play a valuable role in bridging the gaps created by echocardiography and angiography, specifically with regard to extracardiac arterial and venous anatomy and connections in patients with congenital heart disease. MR imaging and CT can assist in making appropriate decision in evaluation of and surgical planning for patients who have previously undergone surgical or other interventional cardiac procedures, especially if vascular access is difficult or undesired (3, 6, 7). The direct multiplanar image capability of MR imaging allows precise depiction of the complex and often unexpected cardiac and extracardiac arterial and venous morphologies present. MR imaging also has the advantage of not exposing the patient to ionizing radiation. Rapid image acquisition sequences such as single-shot echo-planar imaging and half-Fourier single-shot turbo spin-echo imaging are continuing to evolve (3, 6, 7). These advances make MR imaging more practical for sick young patients and lessen the duration of sedation. MR imaging has proved to be effective in diagnosis of coarctation of the aorta, aortic arch anomalies with vascular rings, pulmonary arterial and venous connections, and complex univentricular lesions (3, 6, 7).

Treatment of aortic coarctation with balloon angioplasty or surgery is usually performed on the basis of typical clinical and echocardiographic findings without reliance on further imaging with MR or CT. In patients with atypical clinical or echocardiographic findings, MR imaging and CT yields helpful information, which resulted in changing of the treatment plan (3, 6). MRI angiography or spiral CT can confirm diagnosis of aortic coarctation suspected because of clinical symptoms. Coexistent vascular anomalies of aortic arch can also be detected (1, 2, 5). MR and CT are especially useful in demonstrating extracardiac anatomy, in which application they nave become procedures of choice for aortic arch lesions (3, 6). CT has the advantages of easy availability and very short scanning times. Radiologists have developed a facility for using CT in vascular imaging. Contrast material-enhanced helical CT allows the precise timing necessary for accurate extracardiac arterial and venous vascular imaging. Multiplanar reformations are currently readily available, decreasing the inherent disadvantage of CT images acquisition exclusively in the transaxial plane. The drawbacks of CT include patients' exposure to ionizing radiation and the risk of iodinated contrast material. Adjustment of specific technical factors has been shown to minimize the radiation dose in patient undergoing CT. Such adjustment includes setting the lowest diagnostic tube current according to patients' weight. In addition doubling the pitch refused radiation dose by half (6).

Visualization of aortic isthmus by cross-sectional echocardiography in patients with aortic coarctation is often inadequate. After 3-dimensional reconstruction of CT and MRI the pathological conditions are more fully appreciated. For CT imaging SSD or VRT spatial images may be used. Subtraction of the chest wall from the source images before the display is necessary (1, 2, 8).

Multisection CT can depict the aorta and thoracoabdominal collateral pathways in less than 1 minute and provide high-quality arterial-phase imaging date suitable for multiple two-dimensional and three-dimensional reformations. Two-dimensional and three-dimensional reformations can be performed by means of maximum-intensity projection (MIP), shaded surface display (SSD) and volume rendering techniques (VRT) (9). The most useful reformations for visualizing the various aspects of the thoracic aorta are coronal (for ascending and descending aorta), sagittal oblique (for the aortic arch) and sagittal curved oblique (for supraaortic trunks). Clipped SSD and VRT images from which thoracic cage has been omitted are most useful for detecting thoracic aortic stenosis (9).

CONCLUSIONS

Spiral CT examination enables detailed visualization of the anatomy of aortic coarctation. The stenosis, anatomical relation, and poststenotic dilation may be easily evaluated. MIP reformations provided images similar to angiography, while VRT images provide true spatial, three-dimensional images. The possibility to edit and remove unnecessary bone, and vascular structure enable better visualization of the pathology, without obscuring structures. The limitations of the CT examination of aortic coarctation include the lack of assessment of the hemodynamics of the anomaly. The quick examination time, wide accessibility and relatively low cost make spiral CT examination with VRT reconstruction very useful imaging modality in assessment of aortic coarctation.

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SUMMARY

Coarctation of the aorta is a congenital obstructive anomaly of the aortic lumen. Coarctation typically occurs in the aortic isthmus, between the left subclavian artery and the ducts. The aim of the study is to present the use of the spiral CT examination with MPR and VRT reformations in assessment of aortic coarctation, based on case report on adult with aortic coarctation. A 50-year-old man was sent to our department from the department of vascular surgery for CT examination of thoracic aorta. Spiral CT examination of thoracic aorta was performed in vascular protocol with Siemens Somatom Emotion CT scanner. The scanning was performed before administering the contrast agents, and then enhanced examination was performed, using automatic syringe. 100–150 ml of contrast agent was injected in two phases: in the first phase which last 8 seconds 4 ml per sec, and the second phase – 2.5 ml per sec. The scanning was automatically started, when pick enhancement inside the lumen of the examined aorta was reached. After scanning the multiplanar reconstructions (MPR) were performed, and the arteries were assessed in maximum intensity projection (MIP). 3D images were created using Volume Rendering Technique (VRT), and evaluated before and after editing unnecessary bone structures. Axial CT images reveal the narrowing of the aortic arch, just below the left subclavian artery. The MIP images in oblique projection reveal the relations of the narrowing and the aortic branches. The poststenotic dilation just below the stenosis is clearly visible. VRT images clearly demonstrate the anatomy of the anomaly, and the poststenotic dilation. VRT projection from above is even more informative. After editing unnecessary heart and pulmonary arteries, the anatomy of the pathology is much more detailed visible on both, oblique projection, and on images projected from above. Spiral CT examination enables detailed visualization of the anatomy of aortic coarctation. The stenosis, anatomical relation, and poststenotic dilation may be easily evaluated. MIP reformations provided images similar to angiography, while VRT images provide true spatial, three-dimensional images. The possibility to edit and remove unnecessary bone, and vascular structure enable better visualization of the pathology, without obscuring structures. The limitations of the CT examination of aortic coarctation include the lack of assessment of the hemodynamics of the anomaly. The quick examination time, wide accessibility and relatively low cost make spiral CT examination with VRT reconstruction very useful imaging modality in assessment of aortic coarctation.

Koarktacja aorty w spiralnej tomografii komputerowej. Opis przypadku

Koarktacja aorty jest jej wadą wrodzoną. Najczęstszym miejscem zwężenia jest cieśń aorty pomiędzy lewą tętnicą podobojczykową a przewodem Botala. Celem pracy jest zaprezentowanie możliwości uwidocznienia i oceny koarktacji aorty w tomografii komputerowej z użyciem rekonstrukcji MPR i VTR na podstawie opisu przypadku osoby dorosłej z koarktacją aorty. Pięćdziesięcioletni mężczyzna został skierowany do naszego zakładu z oddziału chirurgii naczyniowej w celu wykonania badania aorty piersiowej. Badanie komputerowe aorty piersiowej zostało wykonane przy użyciu protokołu naczyniowego aparatem Siemens Somatom Emotion. Skanowanie zostało wykonane przed oraz po dożylnym podaniu 150 ml środka kontrastowego przy użyciu automatycznej pompy infuzyjnej. Po skanowaniu wykonano rekonstrukcje MPR, MIP oraz VTR. Skany osiowe ukazały zwężenie łuku aorty tuż za lewą tętnicą podobojczykową. Rekonstrukcje MIP w projekcji skośnej projekcji pokazały dokładne umiejscowienie przewężenia w stosunku do odgałęzień łuku aorty. Poststenotyczne poszerzenie zlokalizowane tuż za zwężeniem zostało

wyraźnie pokazane. Rekonstrukcje VTR uwidoczniły przestrzenne stosunki anatomiczne anomalii oraz poststenotycznego poszerzenia. Spiralna tomografia komputerowa umożliwia dokładne uwidocznienie anatomii koarktacji aorty. Zwężenie, stosunki anatomiczne oraz poszerzenie postenotyczne może zostać łatwo ocenione. Rekonstrukcje MIP zapewniają obrazowanie podobne do zdjęć angiograficznych, podczas gdy rekonstrukcje VTR zapewniają w pełni przestrzenne obrazowanie. Możliwość edycji i usunięcia niepotrzebnych i przesłaniających widok struktur kostnych i naczyniowych umożliwia lepsze uwidocznienie zmian patologicznych. Ograniczenia techniki TK obejmują brak możliwości oceny hemodynamiki zmian. Zalety to szybki czas badania, szeroka dostępność i relatywnie niski koszt badania.