Accuracy of Spiral Computed Tomographic Angiography in the Evaluation of Aortic Dissection Among Patients with Aortic Disease: a Prospective Study

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Background --- Aortic dissection is the most common acute illness of the aorta. It is a life-threatening medical condition associated with high mortality and morbidity rates. Traditionally, aortography is used to evaluate the presence of this disease entity. However, computed tomographic angiography is now preferred because it is less invasive and its ability to detect associated findings that could lead to the diagnosis of aortic dissection. This study aims to determine the accuracy of spiral computed tomography in the diagnosis of aortic dissection in patients with aortic disease.

Methods --- This is a validation study of patients who were referred to the CT/MRI section of the Philippine Heart Center for the evaluation of aortic disease. Population includes all patients who underwent Computed Tomographic Angiography (CTA) and subsequent aneurysmal repair. CTA were reviewed to evaluate the following: site and extent of aortic dissection, size of aortic aneurysm, aortic wall calcification, presence of luminal thrombus, and aortic branch involvement in relation to aortic dissection. The accuracy of CTA was determined using surgery/ histopathology or angiography as gold standard.

Results --- We enrolled 64 patients who had aortic dissection and fulfilled the eligibility criteria for the study. The predominant CTA finding is the presence of aneurysm followed by the presence of intimal calcification and thrombus formation. Most of these aneurysms are fusiform type and are commonly seen in the infrarenal segment. Among the 64 patients, dissection was correctly diagnosed by CTA in 18 patients, with 1 false positive finding. The most commonly encountered type of dissection is DeBakey1. We observed aortic branch extension of dissection in 4 patients and hemopericardium in 3 patients. The sensitivity of CTA is 100%, specificity is 97.8% positive predictive value is 94.7% and negative predicitive value is 100%.

Conclusion --- With high sensitivity, specificity, positive predictive value, and negative predictive value, CTA is a useful primary and maybe the only imaging modality needed in the evaluation of aortic dissection. ***Phil Heart Center J 2012; 16(2):55-64***

Key Words: Spiral Computed Tomography Angiography ■ Aortic Dissection ■ Accuracy

Aneurysm and dissection are the major aortic diseases. Aortic dissection, is the most common catastrophic condition of the aorta. It is 2-3 times more common than rupture of the abdominal aorta. Patients with an aneurysm exceeding 6 cm can expect a yearly rate of rupture or dissection of at least 6.9%. Approximately 75% of dissections occur in those aged 40-70 years, with a peak in the range of 50-65 years. When left untreated, about 33% of patients die within the first 24 hours and 50% die within 48 hours.[1] Aortography has been the traditional method of assessing suspected aortic disease. However, it is being replaced by newer imaging modalities that are less invasive. With the advent of helical CT with multiplanar and 3D reconstruction and computed tomographic angiography (CTA), CT scanning is quickly replacing conventional angiography as the diagnostic test of choice in many institutions. It can be performed in outpatients and has a lower skin surface dose than conventional and digital

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subtraction angiography. It can recognize the presence of intimal flap, which is the diagnostic feature of aortic dissection. Also, it can demonstrate other imaging information like the presence of mural abnormalities, extraluminal pathologic conditions, the type and location of lesion, extent of the disease, and evaluation of the true and false lumen, which aid in the decision-making of the surgeon. CT angiography also offers decreased acquisition time to the range of the breath hold, which results in lesser motion artifact.

In our institution, a 40-slice Philips Brilliance Computed Tomography Scanner was introduced last October 2005. Since then, aortic angiographic examinations were done on patients referred because of presence of suspected aortic diseases. Suspected cases of aortic aneurysms were either confirmed or initially diagnosed with the help of CT Angiogrpahy. In this prospective study, the accuracy of spiral CT in the diagnosis of aortic dissection in patients with aortic aneurysm was evaluated. Measurements of aortic aneurysms, different types of aortic dissection, prevalence as to gender and age, and presence of other associated aortic diseases, were likewise evaluated.

CTA is an excellent imaging modality for comprehensive evaluation of aortic diseases, particularly aortic dissection, by combining the advantage of conventional contrast-enhanced CT axial images and those of angiography in the form of 3D reformatted images.[3] In a study by Nienaber, 110 patients with clinically suspected aortic dissection either presenting with chest pain or an abnormal radiograph were referred for CTA. They followed a diagnostic protocol that included transthoracic and transesophageal color-flow Doppler echocardiography (TTE and TEE), contrast enhanced computed tomography, and magnetic resonance imaging (MRI). Results showed sensitivities of 98.3, 97.7, and 98.3 % and specificities of 97.8%, 76.9%, and 87.1 % for MRI, TEE, and CT respectively in detecting aortic dissection.[4] Singh reported two (2) cases of dissecting aneurysm in which aortography failed to show evidence of dissection.[5] Sensitivities of 83-94% and specificities of 87- 100% have been reported with the use of CT scanning for the diagnosis of aortic dissection,[4,7,9] while aortography has a sensitivity of 86 to 88% and specificity of 75 to 94%.[10-13]

Forty-nine (49) patients with suspected aortic dissection and twenty-three (23) patients with known aortic dissection were examined with CTA in a study done by Chung.[6] Among the 49 patients with suspected aortic dissection, the diagnosis of aortic dissection was made with CTA in 39 patients, the diagnosis was confirmed at surgery in 15 patients and at correlative CT, MR imaging, or TEE in 16 patients. According to him, further studies of large series of patients are warranted to evaluate the diagnostic accuracy and the ability to demonstrate entry tears and major aortic branch involvement.

Associated aortic CTA findings are valuable in the medical or surgical management. Investigators have calculated an incidence of 5 to 27 cases per million people per year, making aortic dissection the most common aortic disorder requiring surgery.[16-18] Most importantly, the recognition of the intimal flap is critical in determining the need for surgery and the specific approach. Aortic size was a very strong predictor of rupture, dissection, and mortality. For aneurysms greater than 6 cm in diameter, rupture occurred at 3.7% per year, rupture or dissection at 6.9% per year, death at 11%, and death, rupture, or dissection at 15.6% per year.[14] Another pertinent CTA finding is the presence of an intramural hematoma, which if it results from vasa vasorum rupture, can be thought of as an atypical type of dissection.[15] It is difficult to differentiate an aneurysm with an intact wall with a thrombus from an aortic dissection with at hrombosed false lumen. Further investigation should be done.

The four (4) major life threatening complications of Type A (DeBakey I and II) dissection are pericardial hemorrhage, which can lead to tamponade; aortic valve rupture, which causes acute aortic insufficiency; coronary artery dissection, which can result in myocardial infarction; and carotid artery dissection, which can progress to stroke.[15] Detection of these findings in CTA is crucial in the patient's management.

During a three-year period study done by Thorsen, 50 patients were evaluated for the possibility of dissecting aortic aneurysm using high resolution CT. The diagnosis of dissection was made if two contrast-medium-filled channels were identified within the aortic lumen. Eighteen patients were diagnosed with aortic dissection using. Eight (8) patients were evaluated postoperatively and five (5) of these patients had persistence of the double channel. Twenty-four (24) patients had no evidence of aortic dissection on CT. Follow-up was obtained in all patients. There were no known false negative diagnoses and one false positive diagnosis.[20]

In a study done by Sharma involving 28 patients clinically suspected or incidentally diagnosed on ultrasonography or chest x-ray to have aortic disease, only five (5) were confirmed of having a dissection. Four of these patients were operated and out of these, three (3) were confirmed of having dissection on surgery. One patient, which was diagnosed with type II dissection on CTA, had a pseudo-aneurysm of the ascending aorta.[3]

Zeman and colleagues studied 23 patients with aortic dissection. Seven (7) patients were proved to have documented dissection on axial scans. The efficacy of CT was determined using surgery, angiography, or clinical outcome. Small sample size is one of his limitations. Study of a larger number of patients is recommended.[19] To date, no published local studies were made regarding the accuracy of CT in the diagnosis of aortic dissection.

Methods

This is a prospective, validation study involving all patients suspected of having aortic disease who were referred for CTA at the CT/MRI section of the Philippine Heart Center. Excluded were patients patients with history of trauma and aortic surgery prior to referral for CTA.

There were 64 patients included in the study for a period of two years. Patients/patient's relatives were asked to fill-up an informed consent form. Patients' CTA were classified as to presence or absence of aneurysm, and presence or absence of aortic dissection among those with and without aneurysm.

The CTA was performed using a 40-slice Philips Brilliance multidetector row scanner. Localization scanning was done prior to contrast study (5mm collimation, 5-10mm intersection gap) to assess the nature of the lesion and to determine the range of coverage. Also, presence of calcification and intra-mural hematoma were assessed in the non-contrast images. Nonionic iopromide (Ultravist 370) through a 20 gauge catheter positioned in a peripheral vein was used. Spiral scans were subsequently obtained during bolus injection of 100- 150ml of iopromide with an automatic power injector (brand) at a rate of 3ml/sec. The scans were reconstructed at 2-mm intervals. All examinations include routine axial, coronal and sagittal aortic reformations from the initial contrast-enhanced image. Multi-planar reformations and 3D models were likewise reconstructed from the helical data and were compared to axial sections in patients who were proved to have documented aortic aneurysm and/or dissection. Multidetector row CT cases were interpreted at the time of image acquisition by a board-certified staff radiologist. CTA was reviewed to evaluate the following: presence of an aneurysm, its size and extent of aortic aneurysm, presence of aortic dissection, extent of the dissection, aortic wall calcification, presence of luminal thrombus, ulcers, hematoma, contrast extravasation, and aortic branch involvement in relation to aortic dissection. The accuracy of CTA in the diagnosis of aortic dissection was evaluated using surgery or histopath, angiography, or clinical outcome as gold standard.

Data Analysis. The sample size of 39 was computed based on the assumed sensitivity of 90% based on the study done by Singh[5] at an α of 0.05 and relative error of 15%. The mean $\pm$ SD was computed. Chi-square test was used to determine the association of different CT features of aortic dissection. Validity measure, such as as sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were computed.

Results

Eighty nine (89) patients underwent CT aortogram at the Philippine Heart Center from 2007 and 2008. Only 64 were included in the study based on the inclusion and exclusion criteria.

Table 1 shows the age and sex distribution of the population studied. Twenty (20) were females (31%) and forty-four (44) were males (69%) with a mean age of 56.33 ± 16.27. Majority of the population is more than 40 years old (n=52). The youngest is 11 y/o diagnosed of having Takayasu's arteritis and the oldest is 79 years old.

Table 2 shows the prevalence of the CTA findings among the study group. More than half of the population presented with calcifications (72%), thrombus (52%), and aneurysm (81%). Detection of ulcerations was found only in 8% of the patients. Hematoma was seen in 15 patients (23%). Fusiform type of aneurysm is the most common present in 43 patients (67%), followed by the saccular type in 8 patients (12%). Most of these aneurysms involve the infarrenal segment (23 patients, 36%) followed by the descending thoracic segment (9 patients, 14 %). Involvement of the ascending segment was seen in eight patients (12%).

Axial CT scans of the aneurysmal segment showed smallest diameter of 4.3 cm and widest diameter of 10.9 cm among our patients with a mean age of 7.067 ± 1.39. CTA was able to detect 19 dissections (30%), Debakey 1 being the most common seen in 10 patients (53%). Debakey 2 and Debakey 3 classifications were seen in six (32%) and three (16%) patients respectively.

There is one patient presenting with a bilobed type of aneurysm.

Table 1. Demographic characteristics of patients with aortogram patients at the Philippine Heart Center (PHC, 2010)

N=64	Frequency (%)
Age	
< 18 years old	1 (2%)
18 - 40 years old	11 (17%)
> 40 years old	52 (81%)
Gender	
Male	44 (69%)
Female	20 (31%)
Hypertensive	49 (77%)
Diabetic	12 (18%)

Among those with dissection by spiral CT (n=19), there were four (4) cases showing involvement of the arch branches. One (1) case of dissection involving the superior mesenteric artery was documented. Three (3) patients presented with co-existing hemopericardium. Fifty-eight (58) patients underwent transthoracic echocardiography (TTE) immediately prior or after the CTA.

Among these patients, seven (7) were diagnosed with aortic dissection by TTE, six (6) of which correlates positively with the histopath findings. One of the cases which was diagnosed with aortic dissection by CTA and TTE was negative for dissection thru histopath. Out of the 64 patients, one (1) underwent aortogram that revealed an infrarenal aneurysm with no evidence of dissection, which was also seen in the CTA. Two (2) patients had an ultrasound of the aorta that demonstrated an infrarenalaneurysm with no evidence of dissection. Ten (10) patients underwent follow-up again by CTA.

Out of the 19 patients diagnosed of having dissection by CTA, 18 were correctly diagnosed by histopath. The false positive patient for dissection by CTA underwent transthoracic echocardiography and was also found to have a dissection. and was also found to have a dissection.

Table 2. CTA features of patients with referred for CTA at the Philippine Heart Center (PHC, 2010)

Feature N=64	Frequency (%)
Ulcerations	5 (8)
Calcifications	46 (72)
Thrombus	33 (52)
Hematoma	15 (23)
Contrast Extravasation	4 (6)
Presence of aneurysm	52 (81)
Configuration of aneurysm (n=52)	
Bilobed	1 (2)
Fusiform	43 (67)
Saccular	8 (12)
Location of aneurysm (n=52)	
Aortic Root	1 (2)
Aortic Root + Ascending	3 (5)
Aortic Root + Ascending + Arch	2 (3)
Ascending	8 (12)
Ascending + Arch	1 (2)
Descending	9 (14)
Infrarenal	23 (36)
Suprarenal	5 (8)
Presence of dissection	19 (30)
Intimal Flap	19 (30)
Classification of dissection (n=19)	
DeBakey I	10 (53)
DeBakey 2	6 (32)
DeBakey 3	3 (16)
Arch Branches Involvement	4 (21)
Hemopericardium	3 (16)

Table 3 shows the performance of CTA as compared with aortography, surgery and histopath in the diagnosis of aortic dissection.This study shows that CT is highly sensitive (100%, 95% CI:78.1, 100.0), and highly specific (97.8%, 95% CI:87.0, 99.0) in diagnosing aortic dissection with a positive predictive value (PPV) of 94.7% (95% CI: 71.9, 99.7), and a negative predictive value (NPV) of 100% (95% CI: 90.2, 100).

Table 3. Accuracy of spiral computed tomography in the diagnosis of aortic dissection with surgery/histopath or angiography as gold standard (PHC, 2010)

	Surgery/histopath or angiography	
Spiral CT	Positive Dissection	Negative Dissection
Positive Dissection	18	1
Negative Dissection	0	45

Sn	Sp	PPV	NPV
100%	97.8%	94.7%	100%

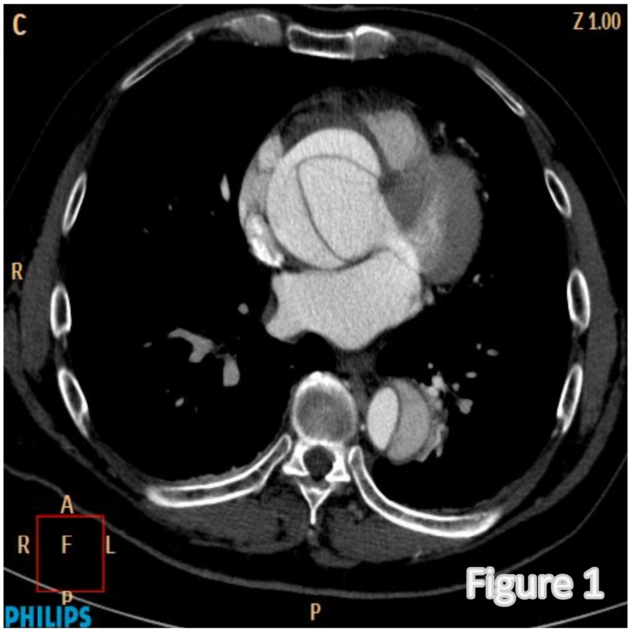
CT Computed Tomography Sn Sensitivity Sp Specificity
PPV Positive Predictive Value NPV Negative Predictive Value

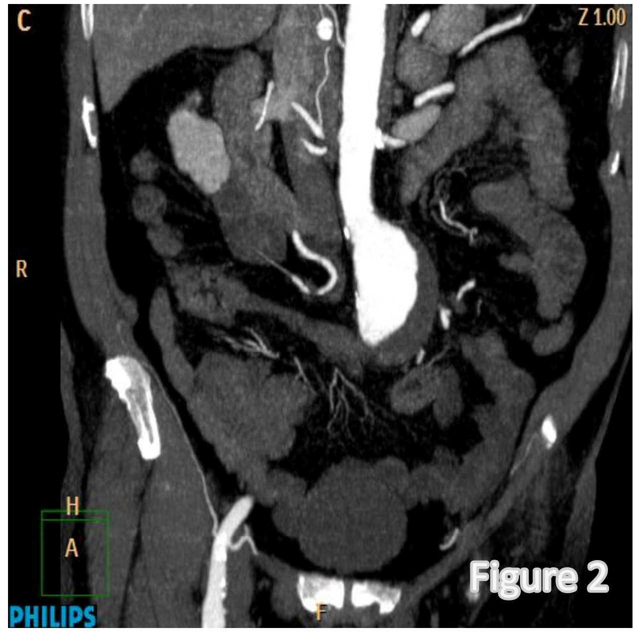
Discussion

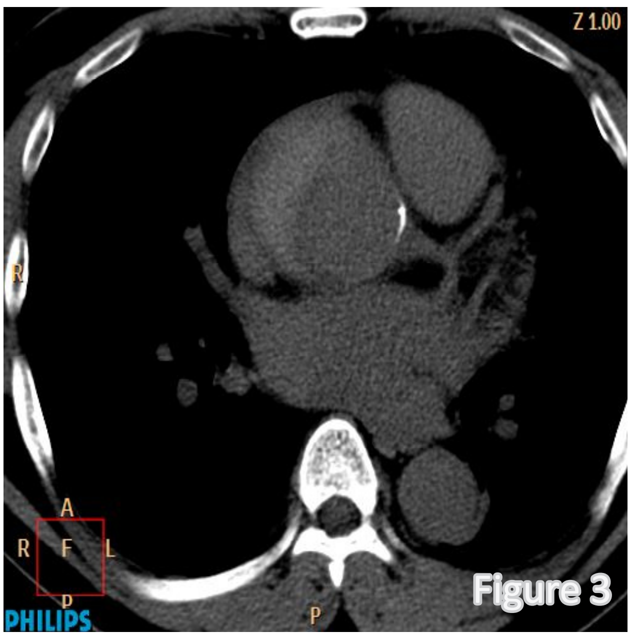
Before the advent of ultrasound, aortography, CT scan and MRI, were used to determine if the patient has an aortic disease was only through postmortem evaluation With the advent of newer imaging modalities, postmortem diagnosis has been abandoned.

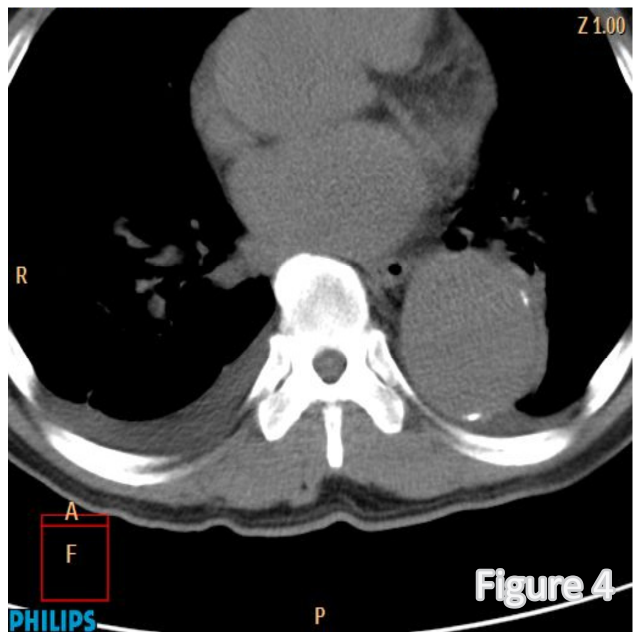
The diagnosis of aortic diseases starts with clinical suspicion. This is the most vital step in diagnosing this catastrophic disease. Confirmation of presence of dissection and differentiating proximal and distal involvement are the next important steps and should be rapid and accurate. Early diagnosis is critical because early intervention can decrease the mortality rate, which is estimated to increase by 1% to 2% per hour in the first 48 hours of ascending aortic dissection.[4]

Thoracic aneurysms mostly involve the descending aorta, which is similarly observed in this study wherein nine (9) out of the 64 patients presented with involvement of the descending aorta. It is followed by aneurysms limited to the ascending aorta (n=8). Aneurysms of the arch occured less often and accounted only for three (3) cases in this study. Out of these three (3) cases, two (2) were positive for dissection.

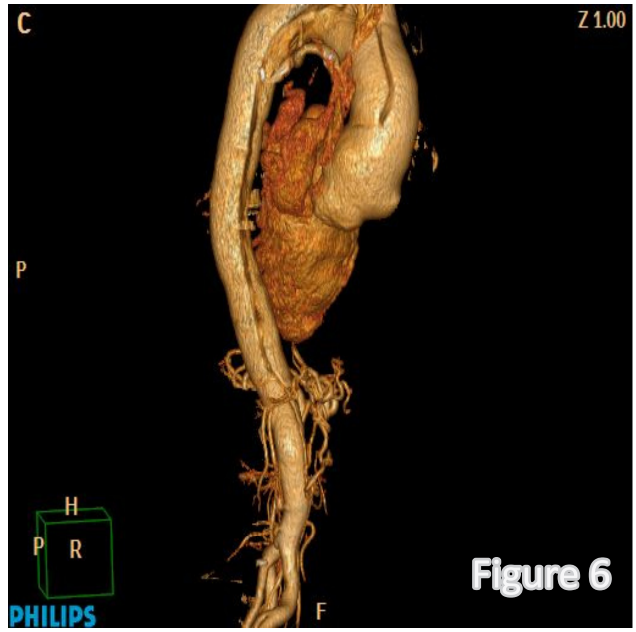


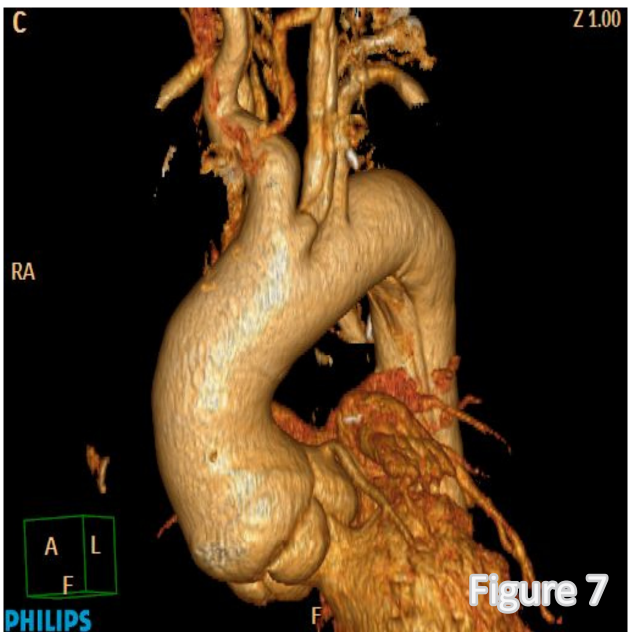


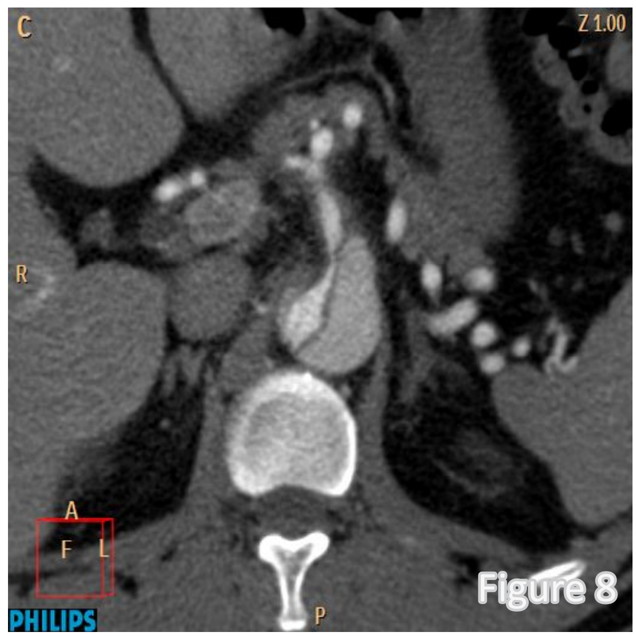




Computed Tomographic Angiography (CTA) findings in subjects with aortic dissection and/or aortic aneurysm ***Figure 1*** shows an aneurysm involving the ascending segment of the aorta with dissection extending to the descending thoracic segment. ***Figure 2*** illustrates a CT aortogram of an infrarenal anurysm. ***Figure 3*** shows a noncontrast CT scan showing presence of cresentric hyperdensity along the wall of the ascending aorta which represents intramural hematoma. ***Figure 4*** shows a noncontrast CT scan showing presence of intimal calcifications.







Computed Tomographic Angiography (CTA) findings in subjects with aortic dissection and/or aortic aneurysm ***Figure 5*** shows a sagittal view of a CT scan showing a long segment dissection involving almost the entire aorta (DeBakey 1). Pericardial effusion is also seen. ***Figure 6*** is a 3D reconstruction of the same patient (DeBakey 1). ***Figure 7*** illustrates a dissection involving the arch branches. ***Figure 8*** demonstrates a dissection involving the superior mesenteric artery.

Among the 18 patients with dissection, 11 were found to have aneurysms involving the thoracic segment (*Fig 1*). The involvement of the descending aortic thoracic aneurysms may extend distally to involve the abdominal aorta. These thoracic aortic aneurysms are less common than aneurysms of the abdominal aorta.

Among the patients included in our study, 52 out of 64 presented with aneurysm, 23 of which are infrarenal in location. (*Fig. 2*). Only one of these infrarenal aneurysms was positive for dissection. Two related lesions to aortic aneurysm and dissection are intramural hematoma (*Fig. 3*) and penetrating atherosclerotic ulcer. They can present with symptoms identical to those of dissection, and are generally treated the same. Aortic intramural hematoma is likely related to hemorrhage from the vasa vasorum and is identified on unenhanced CT as a crescentic high-attenuating clot within the media, with internally displaced calcification.[21] In our study, there were 15 cases out of the 64 subjects who presented with intramural hematoma by CTA in the non- contrast scans. The predominant etiology of aneurysms of the descending thoracic aorta is atherosclerosis. These aneurysms tend to begin just distal to the origin of the left subclavian artery and maybe either fusiform or saccular.

The pathogenesis of atherosclerotic aneurysms in the thoracic aorta are likely similar to that of abdominal aneurysms, but this has not been extensively examined. Correlating it with our patients, five (5) presented with ulcerations and 46 had intimal calcifications (*Fig. 4)* which are findings in atherosclerotic aortic disease. Most of our patients presented with fusiform type of aneurysm.

Acute dissection usually presents within the first two weeks, while the term chronic presents more than two months following the initial event. The more recently added subacute designation is used to describe the period between two weeks and two months. The type of dissection determines whether or not surgery is needed. There are two known classifications of dissections based on the segment of the aorta involved, Stanford and DeBakey Classification. Stanford type A denotes involvement of the ascending aorta, with or without involvement of the arch or the descending aorta regardless of the site of the primary intimal tear. Type B corresponds to all others, or dissections that do not involve the ascending aorta. DeBakey Classification, on the other hand, describes dissection as to type 1, involving the whole aorta, type 2 involving the ascending aorta, and type 3 involving the descending aorta. Therefore, Stanford type A dissection includes DeBakey types 1 and 2, and Stanford type B is the same as DeBakey type.[34] In our study, DeBakey type 1 (*Fig. 5 and 6*) is the most common dissection encountered (n=10, 52.6%). Type A dissections require surgery while Type B dissection, if stable, are treated medically. However, surgery or stenting is also warranted if they extend or compromise the renal arteries, visceral branches or the extremities.

Aortography was considered to be the first definitive modality of choice in diagnosing aortic diseases. It involves injection of contrast media into the aorta, which identifies the site of the dissection. It can evaluate well the major branches of the aorta as well as the communication site between true and false lumen if there is presence of dissection. It can detect thrombus in the false lumen if there is abnormality in the intimal contour upon injection of the contrast.

However, it is invasive and is not a practical modality for critically ill patients primarily because of the duration of procedure and because of the effect of large amount of contrast material to the patient, which can lead to renal failure. Another limitation to the use of aortography in the acute setting is the need for trained personnel. The time required to assemble this team varies with each institution, making aortography less useful when compared to other immediately available diagnostic tests. It also requires arterial access, which can be painful and precipitate rupture or dissection extension. The diagnosis of dissection depends on visualization of the intimal flap, two distinct lumens, or compression of the true lumen by flow through an adjacent false lumen, but if the intimal flap is thin or not oriented perpendicular to the plane of the angiogram, it can misdiagnose the presence of dissection. It can also falsely diagnose dissection when contrast equally opacifies each lumen, making it difficult to distinguish a separate true and false lumen. The diagnosis of intramural hematoma may also be difficult if there is absence of intimal disruption, however, penetrating atherosclerotic ulcer is usually easily visualized.

TEE may be used to better delineate the aorta. It is highly sensitive but less specific. TEE is excellent at detecting concomitant periaortic problems such as pecardial effusion, aortic regurgitation and coronary involvement. It is quickly performed by a trained personnel and maybe done at the patient's bedside with the patient under sedation to allow functional cardiac assessment. There is no exposure to radiation or injection of contrast material.[4, 22, 23] It is, however, limited to experts. The proximal aortic arch is observed by interference from air within the trachea and there is lack of visualization of abdominal aorta if it is involved. Four of our patients underwent TEE immediately before and after the CTA was done and two dissections were seen by this modality.

MRI is another new modality, which is useful in defining thoracic aortic anatomy and detecting aortic diseases. It provides excellent visualization of tear localization, aortic regurgitation, side branch involvement and complications. There is no exposure to ionizing radiation and is non-invasive. Sensitivity and specificity are outstanding, however, it is time-consuming and is difficult for hemodynamically unstable patients. It is expensive compared to most diagnostic modalities. Only limited hospitals can provide this service. Another limitation is contraindication in patients with pacemakers or heart valve prostheses.[4,22]

CT scan, like MRI, is a non-invasive modality for diagnosing aortic dissection. Locally and internationally, it is widely available and is the diagnostic method of choice in most institution. Rapid scanning after an intravenous bolus injection of contrast material allows the detection of differential filling rates in the true and false lumina. Secondary findings include internal displacement of intimal calcifications and aortic widening. It allows distinction of type A from type B aortic dissection, allows imaging of the entire aorta and demonstrates the extent of involvement and organ ischemia.[24] It permits follow-up of aortic dissection, aneurysm or intramural hematoma. Disadvantages include exposure to ionizing radiation. It uses iodinated contrast material, to a limited amount, which may cause hypersensitivity reaction to the patient.

In a study by Dr. Khan,[25] the experience with the use of helical CT Scan is limited and its role in the diagnosis of aortic dissection needs to be defined further. In our study, the sensitivity and specificity of CT scan in determining presence of aortic dissection is 100% and 97.8% respectively. One patient was diagnosed with DeBakey type I dissection by CT scan, which turned out to be negative by surgery or histopath. However, TEE done on this patient likewise revealed presence of dissection.

In our institution, this is the diagnostic modality mostly used as follow-up for patients (n=9) with aortic aneurysm and/or dissection who underwent surgery or for monitoring purposes. It readily determined presence of intramural hematoma. This intramural hematoma, if without evidence of rupture or definite intimal tear, may represent the earliest stages of dissection with impending risk of rupture. Detection of this lesion will help prevent the delay of management.

Conclusion

From this local study, we have established the high sensitivity and specificity of CTA in the diagnosis of aortic dissection. It makes sizing and surveillance of aneurysm relatively easy for the attending physician and for the patient as well. Therefore, high-quality helical CT techniques are useful as the primary imaging modality in the evaluation of acute aortic dissection. It can be used as the first screening test and may be the only necessary imaging study for a patient with a suspicion of dissection.

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