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# Multislice computed tomography angiography in the diagnosis of patients with suspected aortic dissection: A single centre experience

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## RESEARCH

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## ABSTRACT

**Background**
Computed tomography angiography (CTA) is widely used as the preferred imaging modality in the diagnosis of aortic dissection with high diagnostic value. However, high radiation dose associated with CTA remains a concern, especially for young patients. Little research is available regarding the correlation between age groups and CT dose values.

**Aims**
To investigate the clinical performance of CTA in diagnosing aortic dissection and determine the correlation between age groups and corresponding CT dose values based on a single centre experience.

**Methods**
A total of 204 patient records were retrospectively reviewed for analysis of the CTA examinations over a period of 12 months. CTA findings regarding the type and extent of aortic dissection were analysed, while radiation dose values in terms of volume CT dose index (CTDIvol) and dose length product (DLP) were compared between different age groups (<30 years, 31–40, 41–50, 51–60, 61–70, and >70 years).

**Results**
Of 204 patients, 170 had abnormal CTA findings with Stanford type A dissection diagnosed in 38 cases and type B dissection in the remaining 132 cases. There were significant differences in CTDIvol and DLP dose values between age groups (p=0.039-0.048) with the groups 31-40 years old having the highest radiation dose than other groups. The mean effective dose for all patients is 11.18mSv.

**Conclusion**
CTA is an accurate imaging modality for diagnosis of aortic dissection; however, reduction of radiation dose is necessary, especially for younger patients due to direct correlations between patient's age and corresponding dose values.

**Key Words**
Aortic dissection, computed tomography, radiation dose

## What this study adds:

**1. What is known about this subject?**
CTA is a widely used less invasive modality in the diagnosis of aortic dissection with high diagnostic accuracy.

**2. What new information is offered in this study?**
There is a direct correlation between patient's age and radiation dose values for patients undergoing aortic CTA examination.

**3. What are the implications for research, policy, or practice?**
It is clinically important to implement low-dose CTA protocols, especially in younger patients, thus, reducing radiation exposure to minimum level while maintaining diagnostic image quality.

## Background

Aortic dissection is a life-threatening disease with high mortality and morbidity, thus, early accurate radiological diagnosis and classification play a significant role in improving patient outcome.[1,2] The role of diagnostic imaging modalities is to confirm clinical suspicion, classify aortic dissection for effective patient management, locate intimal tears and assess dissection extent.[3-8] Of various imaging modalities including computed tomography (CT), ultrasound (transesophageal echocardiography), magnetic resonance imaging (MRI) and invasive angiography, CT angiography (CTA) is commonly performed as the preferred imaging test for diagnosis of aortic dissection.[9]

With advancements of multislice scanning techniques, CTA has shown high diagnostic sensitivity and specificity due to rapid data acquisition with improved spatial and temporal resolution enabling generation of three-dimensional (3D) volume rendering images with isotropic resolution.[3,10-12] With 64- and post-64 slice scanners available in many clinical centres, CT has become a widely used less-invasive imaging modality in many applications including in aortic diseases. The main concerns of CTA are because of relatively high radiation dose and use of contrast medium intravenously. Since CTA of aortic dissection usually includes long anatomic areas covering both thoracic and abdominal aorta or even further down to iliac arteries to determine the extent of aortic dissection, high radiation exposure to patients could be expected from the CTA scans. Despite various methods having been proposed to reduce CT dose such as prospective ECG-gating, automatic tube current and tube potential selection, high-pitch protocol and iterative reconstructions,[13-17] there is little research about comparing radiation dose associated with different age groups of patients undergoing CTA for diagnosis of aortic dissection. The primary aim of this study was to analyse the diagnostic performance of CTA in patients with suspected aortic dissection based on a single centre experience. The secondary aim of the study was to compare radiation dose between different age groups of patients for determining the correlation between patient's age and resulting radiation dose.

## Method

### Retrieval of medical and diagnostic CT records

Ethics approval was waived due to the retrospective nature of the study as only de-identified medical records and images were used for analysis. CTA examinations were performed as a routine practice for diagnosis of aortic diseases.

Medical records and diagnostic CTA images over 12 months (January to December 2018) from a tertiary hospital in Southwest China were retrospectively reviewed of patients with suspected aortic dissection. In this study, the inclusion criterion was patients presenting with chest and or abdominal pain or shortness of breath as the main presenting symptom. Patients with chest trauma, prior surgery history (coronary artery bypass grafting or endovascular stent grafting) were excluded. A total of 3139 patient records were reviewed with assessment of the following details: patient age group, gender, presenting symptoms, abnormal CCTA findings, and radiation dose values.

### CTA scanning protocol

CTA was performed on a second generation 128-slice dual-source CT scanner (Siemens Definition Flash, Siemens Healthcare, Forchheim, Germany) with the following protocols: detector collimation 128×0.6mm, gantry rotation 0.28 s (temporal resolution of 70ms) in all protocols, with tube voltage 100kVp, 100mAs, pitch 0.75 with reconstruction thickness and reconstruction interval being 1.0 and 0.7mm used for body angiography protocol (158 cases); 80–120kVp with automatic tube current modulation, pitch 0.3 with reconstruction thickness and interval being 1.0 and 0.7mm (for aorta and pulmonary artery) for triple rule out protocol (27 cases); 100kVp, pitch 2.0 with automatic tube current modulation with reconstruction thickness and interval being 1.0 and 0.7mm for chest angiography protocol (19 cases), respectively.

Non-ionic contrast medium Iopamidol (80ml) at 370mg/ml (BRACCO, Pharma) was injected intravenously at a flow rate of 4–5.5ml/s, followed by a saline chaser of 50ml. A bolus tracking technique was used to initiate the scan with a CT attenuation of 200 Hounsfield Unit (HU) in the ascending aorta as the triggering threshold.

### Characterisation of patient groups for dose comparison

In order to analyse and compare the relationship between radiation dose and different age groups, we characterised the patients by age into six groups, namely, under 30 years, 31–40 years, 41–50 years, 51–60 years, 61–70 years and over 70 years, respectively. Radiation dose values in terms of volume CT dose index (CTDIvol) and dose length product (DLP) were available from the records for comparison among different groups. Because most of the CTA scans were performed with a combination of chest and abdominal acquisitions, the mean organ-specific conversion coefficient of 0.017mSv/mGy×cm was used as recommended previously.[18]

**Statistical analysis**

Data were analysed using SPSS 24.0 (SPSS Inc, Chicago., IL, USA). Continuous variables were presented as mean±standard deviation, with categorical variables shown as percentages. Kruskal-Wallis one-way ANOVA was implemented to determine if there is any significant correlation between dose values and age groups. Box plots were used to present dose values corresponding to different age groups. A p value of less than 0.05 indicates significant difference.

## Results

After excluding CTA findings of other cardiovascular disease, 204 patient records met the selection criterion for inclusion in the analysis. Figure 1 is the flow chart showing the strategy to select these eligible cases for analysis in this study. Of these patients, 34 cases were found normal without any signs of aortic dissection. In the remaining 170 abnormal CTA findings, Stanford type A dissection was diagnosed in 38 cases and type B dissection in the remaining 132 cases. Chest pain or chest/abdominal pain was the most common presenting symptom (62%), while majority of the remaining patients were diagnosed with aortic aneurysm or dissection previously by ultrasound or CT in another hospital and were referred for CTA examination to further assess the extent of the disease.

Table 1 shows study characteristics with most of the patients falling within age groups of 31 to 70 years old (78% of all cases). There were significant differences in CTDIvol dose values between age groups with the groups less than 50 years having higher radiation dose than those older than 50 years (p=0.048). Similarly, significant differences in DLP were found between age groups (p=0.039) as shown in Figure 2. The highest radiation dose was seen in the patient age group between 31 and 40 years.

Regression analysis shows the same trends between dose values and age groups (Figure 3). Kruskal-Wallis non parametric ANOVA shows that the regression of CTDIvol *vs.* age was significant (p=0.009). There is an expected decrease in CTDIvol of 0.0031 units for each additional year of age. The regression of DLP *vs.* age was also significant (p=0.004). The corresponding figure for DLP is a decrease of 5.4277 units for each individual year of age.

The mean effective dose among all cases was 11.18mSv, with highest radiation dose found in the age group of 31–40 years with 16.58mSv. This is significantly higher than the other age groups. Of 204 cases, 80 patients (39%) had radiation dose more than 10mSv. Of these cases, 31 were noted to have dose value more than 15mSv, with 6 cases exceeding 20mSv.

Figure 4 is an example showing Stanford A dissection involving only the ascending aorta, while Figure 5 is another example showing Stanford B dissection with entry tear arising from descending aorta and extending to common iliac arteries.

## Discussion

This study analyses the clinical application of CTA in the diagnostic assessment of patients with suspected aortic dissection from a single centre experience. There are two findings arising from the data analysis: first, CTA as the first line technique in diagnosing aortic diseases is an accurate imaging modality to confirm aortic dissection in terms of type, location and extent of the dissection. This is consistent with the literature reports.[3,7,9-12,19,20] Second, there is a direct correlation between patient age group and radiation dose values with younger patients having higher dose than older groups, highlighting the importance of applying low dose protocols in these patients undergoing routine CTA examinations.

CTA is the method of choice in the diagnosis of cardiovascular diseases because of high diagnostic value, wide availability and less invasiveness.[14] With technical advancements in scanning techniques, CTA can be performed with low-dose protocols with significantly reducing both radiation and contrast medium doses. Because aortic CTA is commonly performed to cover chest, abdominal and even pelvic regions for diagnosis of aortic diseases such as aortic aneurysm or dissection, high-pitch protocol is preferred to reduce radiation dose with coverage of extended z-axis region. Apfaltrer et al. compared high-pitch with standard pitch (3.4 *vs.* 0.8) CTA for examination of the entire aorta in 100 patients.[20] Their results showed that high-pitch CTA protocol led to nearly 50% radiation dose reduction with significantly lower contrast medium when compared to the standard pitch CTA group while achieving diagnostic images. The effective dose was 10 and 18mSv for high-pitch and standard pitch CTA, respectively. Our dose values are similar to their reports, although the age group of 31 to 40 years has higher radiation dose than their high-pitch protocol, but is comparable to the standard pitch group. The high radiation dose in our study is most likely due to the use of low pitch value (0.3–0.75) in more than 90% of the cases, despite low kVp and automatic adjustment of tube current applied in these CTA scans.

Further dose reduction can be achieved with use of low kVp and high-pitch CTA.[21,22] Shen et al. compared two groups of patients undergoing aortic CTA with use of pitch 3.2 in all patients.[21] The low dose CTA group was scanned with 100kVp and low iodine with images reconstructed by a sinogram-affirmed iterative reconstruction (IR) algorithm, and it was compared to the standard CTA group which was done using 120kVp and high iodine with images reconstructed by filtered back projection. No significant differences were found in quantitative assessment of image quality between the two groups, however, both radiation dose (4.40 *vs.* 6.73mSv) and contrast medium weight (20.36 *vs.* 28g) were significantly lower in the low kV and low iodine group than those in the high iodine group ($p<0.001$). Their low dose value is due to the use of a combination of low dose parameters, thus resulting in significantly lower than our dose values. This is confirmed by another study through combining IR with low kVp and automatic tube current modulation (ATCM).[22] Boos and colleagues compared low dose 80 with 100kVp in patients who underwent aortic CTA with use of standard pitch of 1.2 and images reconstructed with IR and ATCM. There were significant differences in both subjective and objective assessments of image quality, but significantly lower radiation dose was observed in the 80 kVp group ($p<0.001$). The mean DLP for overall patients and both groups was 176.2, 139.2 and 292.1mGy.cm, respectively, which is much lower than that in our study (Table 1). The high-pitch chest CTA used in our study produced similar radiation dose when compared to the low-pitch CTA (3.53 *vs.* 11.96mSv), although this was only applied in less than 10% of patients. Therefore, with implementation of low-dose CTA protocols it is possible to produce aortic CTA images with radiation dose less than 5mSv.

Another advantage of CTA in aortic imaging lies in its creation of 3D reconstructions allowing for more accurate assessment of disease extent. Furthermore, intraluminal views such as virtual intravascular endoscopy can be generated to demonstrate true and false lumen as well as entry tears and intimal flap in relation to adjacent structures.[19,23,24] Advanced CT scanning techniques can also perform functional imaging such as CT perfusion,[25] thus, further enhancing the clinical application of CTA in aortic dissection assessment. These techniques serve as a complementary tool to conventional CTA in the diagnosis and pre-surgical planning of aortic dissection, which should be considered when evaluating disease extent.

This study has some limitations. First, the sample size is small as this is based on a single clinical centre experience, in particular, the number of cases for younger patients (less than 40 years) is very small (less than 10 cases). This could be addressed by collecting more cases, preferably through conducting a multi-centre study in the future. Second, there is no record of body weight or body mass index (BMI) for these patients, thus, we could not analyse the relationship between dose values and BMI. Adjustment of tube voltage or tube current as well as contrast medium (both volume and concentration) is based on BMI as shown in most of the studies.[20-22] Although low kVp was used in most of the cases, low-pitch CTA protocol contributed to the high radiation dose. This should draw attention to future aortic CTA scans in these patients. Third, there is no measurement or assessment of CTA image quality as the focus of this study is to compare dose values between different age groups. With implementation of low-dose CTA protocols, evaluation of image quality by qualitative and quantitative methods is necessary. Finally, reduction of contrast medium is equally important during CTA, and use of personalised contrast medium algorithm could be an effective approach for dose reduction.[26]

## Conclusion

This single centre study shows that aortic CTA is an accurate modality for the diagnostic assessment of patients with suspected aortic dissection. Significant differences were found in radiation dose values between different age groups, with the age group of 31–40 years having the highest radiation dose than other groups. Dose reduction is necessary with implementation of low-dose CTA protocols, especially in younger patients.

## References


1. Vilacosta I, Aragoncillo P, Cañadas V, et al. Acute aortic syndrome: a new look at an old conundrum. Heart 2009;95:1130–9.
2. Hiratzka LF, Bakris GL, Beckman JA, et al. 2010 ACCF/ AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/ SVM guidelines for the diagnosis and management of patients with thoracic aortic disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, American Association for Thoracic Surgery, American College of Radiology, American Stroke Association, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of Thoracic Surgeons, and Society for Vascular Medicine. Circulation. 2010;121:e266–369.
3. Abbas A, Brown IW, Peebles CR, et al. The role of multidetector-row CT in the diagnosis, classification and management of acute aortic syndrome. Br J Radiol. 2014;87:20140354.

4. Ueda T, Chin A, Petrovitch I, et al. A pictorial review of acute aortic syndrome: discriminating and overlapping features as revealed by ECG-gated multidetector-row CT angiography. Insights Imaging. 2012;3:561–71.
5. Nienaber CA. The role of imaging in acute aortic syndrome. Eur Heart J Cardiovasc Imaging. 2013;14:15–23.
6. Ciccone MM, Dentamaro I, Masi F, et al. Advances in the diagnosis of acute aortic syndromes: role of imaging techniques. Vasc Med. 2016;21:239–50.
7. Nienaber CA, Kische S, Skriabina V, Ince H. Noninvasive imaging approaches to evaluate the patient with known or suspected aortic disease. Circ Cardiovasc Imaging. 2009;2:499–506.
8. von Kodolitsch Y, Nienaber CA, Dieckmann C, et al. Chest radiography for the diagnosis of acute aortic syndrome. Am J Med. 2004;116:73–7.
9. Moore AG, Eagle KA, Bruckman D, et al. Choice of computed tomography, transesophageal echocardiography, magnetic resonance imaging, and aortography in acute aortic dissection: International Registry of Acute Aortic Dissection (IRAD). Am J Cardiol. 2002;89:1235–8.
10. McMahon MA, Squirrell CA. Multidetector CT of aortic dissection: a pictorial review. Radiographics. 2010;30:445–60.
11. Chin AS, Fleischmann D. State-of-the-art computed tomography angiography of acute aortic syndrome. Semin Ultrasound CT MR. 2012;33:222–34.
12. Chiu KW, Lakshminarayan R, Ettles DF. Acute aortic syndrome: CT findings. Clin Radiol. 2013;68:741–8.
13. Tan SK, Yeong CH, Ng KH, et al. Recent update on radiation dose assessment for the state-of-art coronary computed tomography angiography (CCTA) protocols. Plos One. 2016;11:e0161543.
14. Sun Z, Al Moudi A, Cao Y. CT angiography in the diagnosis of cardiovascular disease: a transformation in cardiovascular CT practice. Quant Imaging Med Surg. 2014;4:376–96.
15. Lim HK, Ha HI, Hwang HJ, et al. High-pitch, 120 kVp/30 mAs, low-dose dual-source chest CT with iterative reconstruction: Prospective evaluation of radiation dose reduction and image quality compared with those of standard-pitch low-dose chest CT in healthy adult volunteers. PloS One. 2019;14:e0211097.
16. Mangold S, De Cecco CN, Wichmann JL, et al. Effect of automated tube voltage selection, integrated circuit detector and advanced iterative reconstruction on radiation dose and image quality of 3rd generation dual-source aortic CT angiography: An intra-individual comparison. Eur J Radiol. 2016;85:972–78.
17. Winklehner A, Gordic S, Lauk E, et al. Automated attenuation-based tube voltage selection for body CTA: Performance evaluation of 192-slice dual-source CT. Eur Radiol. 2015;25:2346–53.
18. Goetti R, Baumuller S, Feuchtner G, et al. Highpitch dual-source CT angiography of the thoracic and abdominal aorta: is simultaneous coronary artery assessment possible? AJR. 2010;194:938–44.
19. Sun Z. Multislice computed tomography angiography in the diagnosis of cardiovascular disease: 3D visualizations. Front Med. 2011;5:254–70.
20. Apfaltrer P, Hanna EL, Schoepf UJ, et al. Radiation dose and image quality at high-pitch CT angiography of the aorta: intraindividual and interindividual comparisons with conventional CT angiography. AJR Am J Roentgenol. 2012;199:1402–09.
21. Shen Y, Sun Z, Xu L, et al. High-pitch, low-voltage and low-iodine concentration CT angiography of aorta: assessment of image quality and radiation dose with iterative reconstruction. PloS One. 2015;10:e0117469.
22. Boos J, Aissa J, Lanzman RS, et al. CT angiography of the aorta using 80 kVp in combination with sinogram-affirmed iterative reconstruction and automated tube current modulation: effects on image quality and radiation dose. J Med Imaging Radiat Oncol. 2016;60:187–93.
23. Sun Z, Cao Y. Multislice CT virtual intravascular endoscopy of aortic dissection: A pictorial essay. World J Radiol. 2010;28:440–8.
24. Qi Y, Ma X, Li G, et al. Three-dimensional visualization and imaging of the entry tear and intimal flap of aortic dissection using CT virtual intravascular endoscopy. PloS One. 2016;11:e0164750.
25. Liu D, Liu J, Wen Z, et al. 320-row CT renal perfusion imaging in patients with aortic dissection: a preliminary study. PloS One. 2017;12:e0171235.
26. Tan SW, NG KH, Yeong CH, et al. Personalized administration of contrast medium with high delivery rate in low tube voltage coronary computed tomography angiography. Quant Imaging Med Surg. 2019;9:552–64.

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## PEER REVIEW

Not commissioned. Externally peer reviewed.

## CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

## ETHICS COMMITTEE APPROVAL

Ethics approval is waived due to retrospective nature of the study.

**Figure 1: Flow chart shows search strategy to identify eligible CTA cases of aortic dissection**

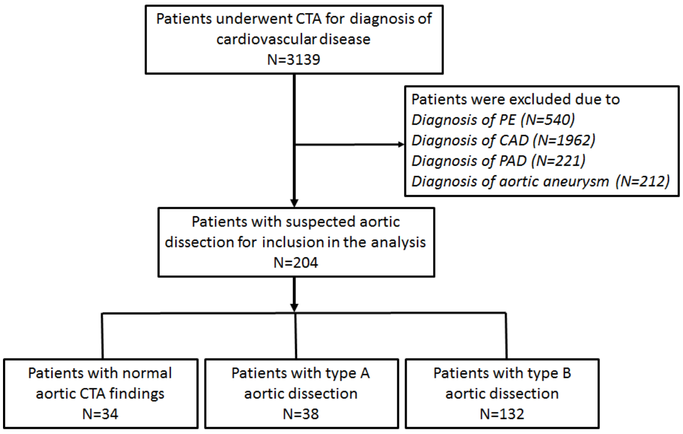
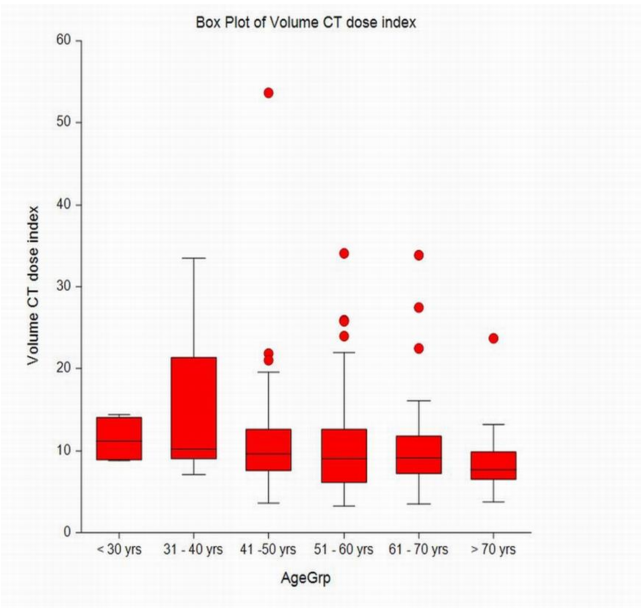
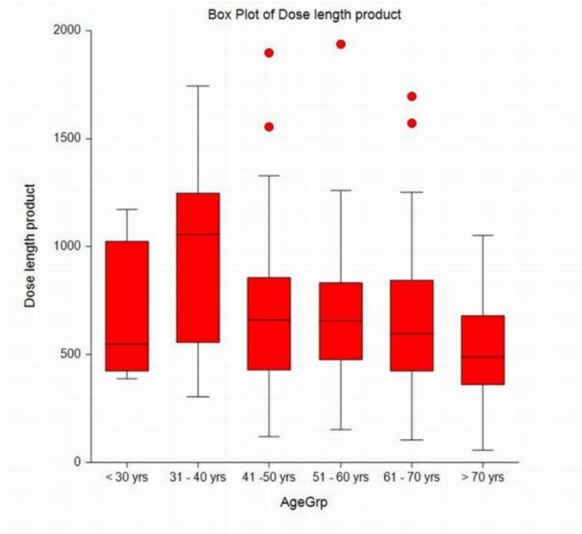



**Figure 2: Bot plots showing comparison of radiation dose values among different age groups. A: CTDIvol in relation to different age groups with age group 31-40 years having the highest values. B: DLP in relation to different age groups with age group 31-40 years having the highest values**

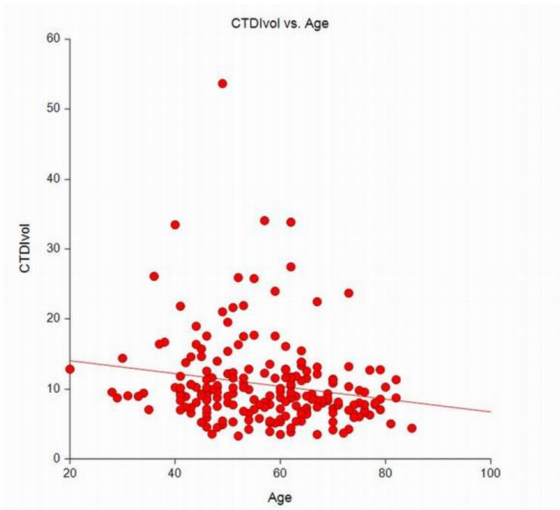



A

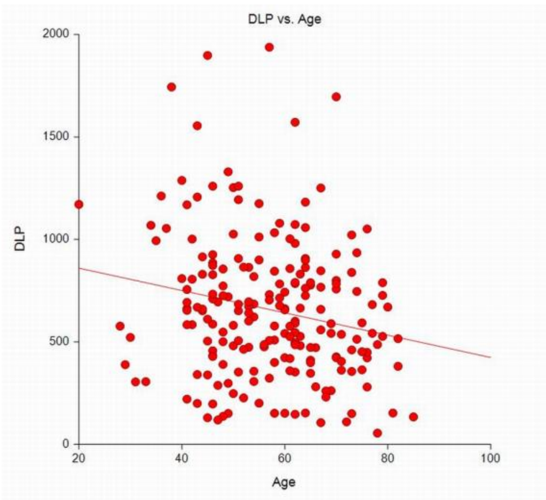



B

**Figure 3: Regression analysis showing correlation between dose values and different age groups. These regression coefficients are significantly different from zero showing significant differences (p=0.004-0.009) between CTDIvol *vs.* age (A) and DLP *vs.* age (B), with higher dose values seen in younger patients than the older groups**

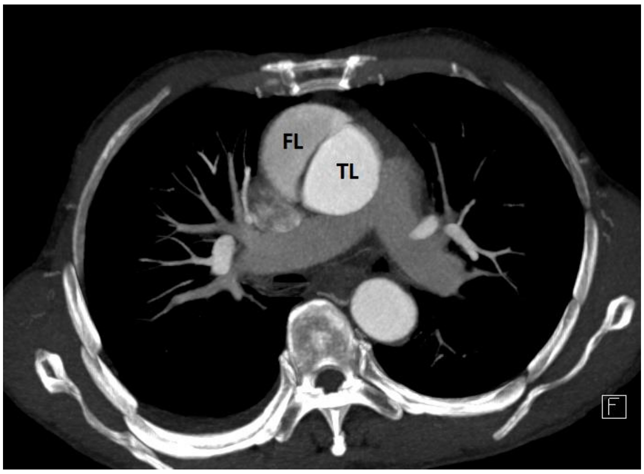



A




B

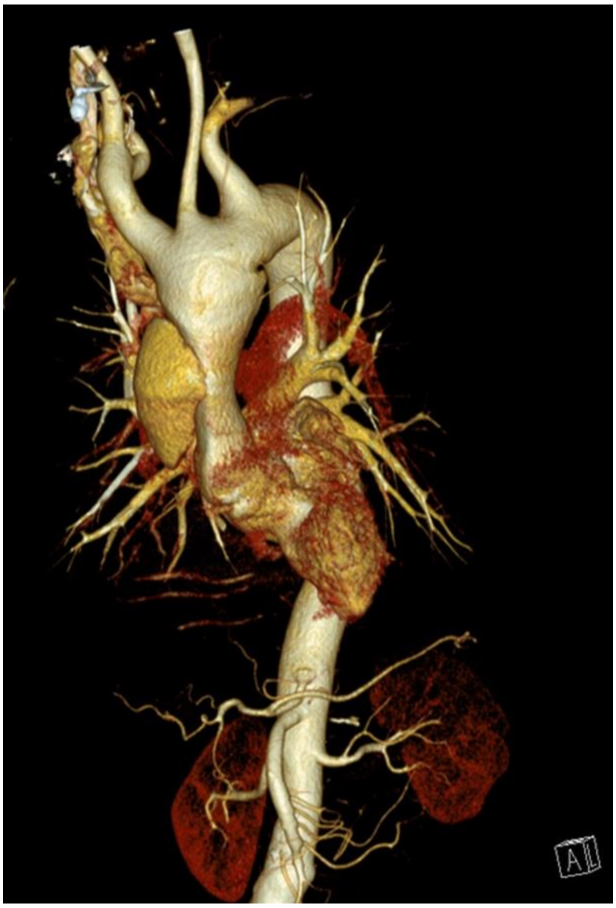
**Figure 4: Stanford type A aortic dissection in a 55-year-old man with chest pain symptom. A: 2D axial image shows dissection in the ascending aorta with high CT attenuation in the true lumen (TL) compared to relatively low attenuation in the false lumen (FL). B: Coronal maximum-intensity projection (MIP) shows the location of aortic dissection in the ascending aorta with these two lumens displayed clearly. C and D: 3D volume rendering images demonstrate the dissection in relation to aortic arch and other aortic branches**




A


B


C




D

**Figure 5: Stanford type B aortic dissection in a 48-year-old man with chest pain symptom. A: sagittal reformatted CTA image shows the dissection distal to the left subclavian artery, with narrowed true lumen. B and C: 3D volume rendering images demonstrate the dissection arising from descending aorta with extension to abdominal aorta and iliac arteries**

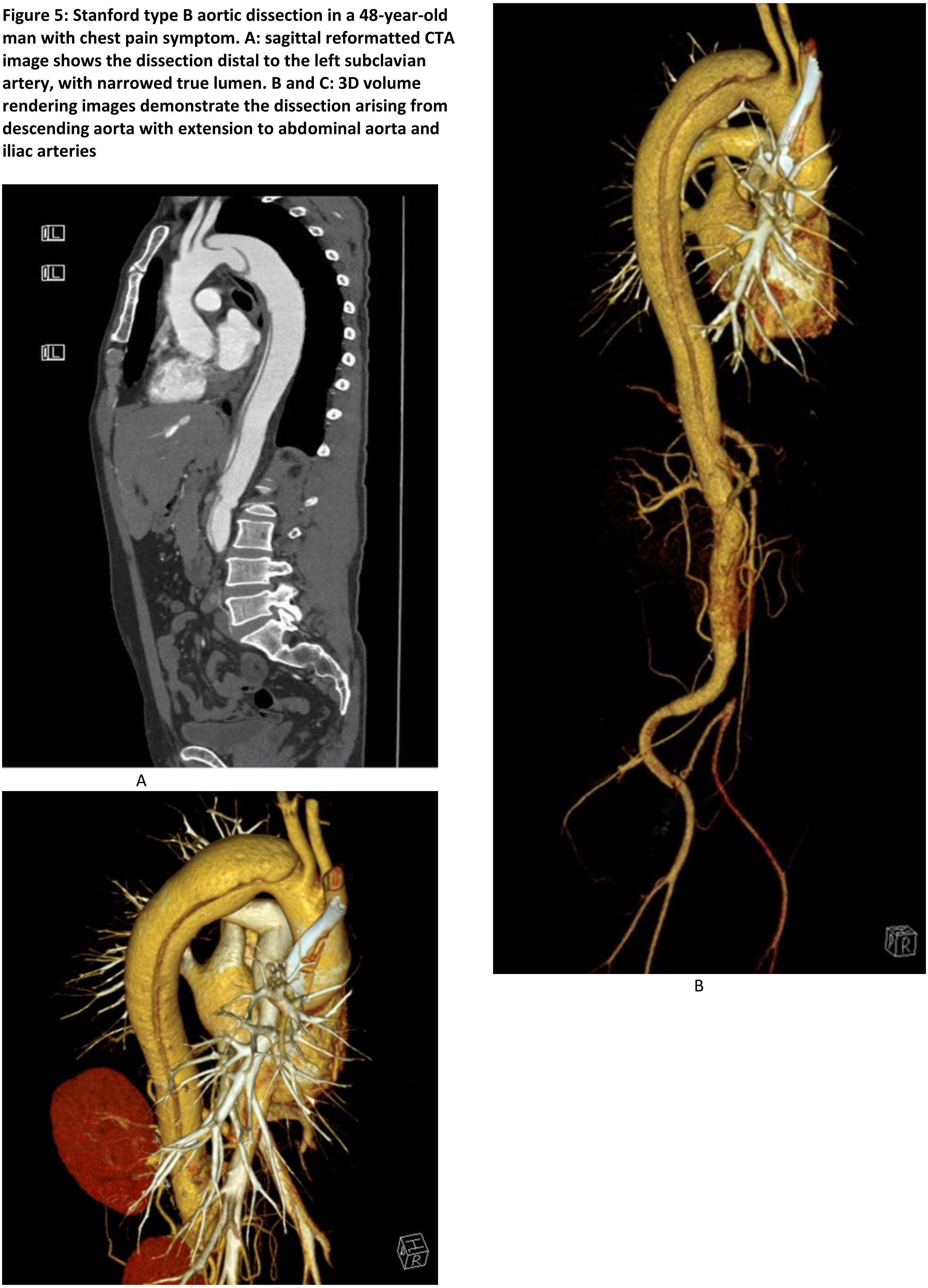


**Table 1: Study characteristics of patients with suspected aortic dissection**

| Parameters assessed | All cases | <30 yrs | 31-40 yrs | 41-50 yrs | 51-60 yrs | 61-70 yrs | >70 yrs |
|---|---|---|---|---|---|---|---|
| | **204** | **4** | **9** | **55** | **49** | **56** | **31** |
| Gender (M/F) | 142/62 | 01/3 | 7/2 | 49/6 | 31/17 | 34/22 | 19/12 |
| Age (yrs) | 57.08±12.47 | 26.7±4.5 | 36±3.1 | 45.5±2.8 | 55.5±3.1 | 64.8±2.9 | 73.8±13.4 |
| CTDI vol (mGy) | 10.66±6.25 | 11.37±2.68 | 15.25±9.07 | 11.18±7.18 | 10.94±6.71 | 10.31±5.27 | 8.49±3.70 |
| DLP (mGy.cm) | 657.85±343.22 | 664.75±346.60 | 975.66±458.93 | 674.22±369.92 | 671.66±321.69 | 661.75±326.15 | 506.78±259.43 |
| Effective dose (mSv) | 11.18±5.83 | 11.30±5.89 | 16.58±7.80 | 11.46±6.28 | 11.41±5.48 | 11.24±5.54 | 8.61±4.41 |

CTDIvol-volume CT dose index, DLP-dose length product. Values are presented as mean and SD