Multislice CT Angiography Assessment of Coronary Artery Bypass Graft (CABG) Patients

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Abstract: Objective: The aim of this study was to use multi-detector computed tomography coronary angiography (MDCT-CA) for assessment of coronary bypass grafts (CABG), distal runoffs and coronary native arteries. **Methods:** 128 multislice CT-CA was performed for 30 patients (28 men with a mean age 66.6 ± 13.2 years and 2 women with a mean age 58.5 ± 12 years), post-CABG patients. The mean passed time from CABG surgery to multislice CTA was 5.2 ± 4.8 yrs. The mean heart rate during CTA examination was 64.5 ± 13.2 beats / min. Significant stenosis was determined as ≥50% lumen narrowing. **Results**: An overall accuracy of MDCT-CA to detect or exclude a significant stenosis on a segment-per-segment analysis was 100%. Sensitivity, specificity, positive predictive value and negative predictive value of MDCT-CA in detection of a remarkable stenosis were 95%, 98%, 97%, 99% in distal runoffs respectively; 99%, 97%, 98%, 100% in bypass grafts respectively; and 95%, 93%, 84%, 97% in native coronary arteries, respectively. **Conclusions:** Multislice CT coronary angiography is a potentially safe, non-invasive and valuable modality in assessment of coronary bypass grafts in post-CABG patients, and can replace conventional coronary angiography as a follow up imaging modality for post-CABG symptomatic patients.

[Esam M. Hemat; El-Sayed H. Zidan; Ahmed A. Ismail and Wael A. Khalil. **Multislice CT Angiography Assessment of Coronary Artery Bypass Graft (CABG) Patients.** *J Am Sci* 2016;12(8):92-98]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 13. doi:10.7537/marsjas120816.13.

Keywords: Coronary disease; Coronary bypass grafts; MDCT angiography; Post-CABG

1. Introduction

Coronary artery disease is the most common reason for hospitalization and mortality in the industrial countries and its prevalence is increasing in urbanic Eastern countries[(1)]. Advanced coronary artery disease often requires bypass surgery to ensure myocardial perfusion. Coronary artery bypass graft (CABG) surgery is the standard care in the treatment of advanced coronary artery disease. The long term outcome of coronary artery bypass grafting is closely related to the type of graft, venous or arterial [(2-4)]. Post-CABG surgery recurrent symptoms may be due to disease progression, commonly in native coronary arteries, in the venous grafts, or less commonly in an arterial grafts [(5,6)]. Thereby, evaluation of symptomatic patients after CABG, is an important thing, and must include arterial bypass grafts, venous bypass grafts, and coronary native arteries. Conventional angiography (CCA) is the gold standard tool to assess the native coronary arteries and bypass grafts status of post-CABG surgery patients, it is invasive, risky and cost procedure [(7, 8)]. MDCT-CA with a retrospective electrocardiogram gating increasingly accepted as a diagnostic imaging tool of the heart, allowing assessment of coronary bypass graft patency with a high temporal and spatial resolution [(9)]. In 2005, introduction of 64-MDCT technology gave a higher temporal and a higher spatial resolution, that improving visualization of bypass grafts and distal runoffs[(10)]. Improved diagnostic accuracy in detection of stenosis greater than 50% [(11)], particularly in vessels larger than 1.5 mm caliber [(11, 12)], has been found and registered. Results of a three recent studies [(12-14)] stated that 64-multislice CT coronary angiography had a high diagnostic accuracy in the assessment of bypass graft patency and narrowing. However, the prevalence of marked lumen narrowing (without complete occlusion) was low in those studies. Pache et al., 2006 [(15)] found that 64-slice MDCT could detect coronary bypass graft stenosis or occlusion with a sensitivity of 97.8% and a specificity of 89.3%, but lacked the data about native coronary arteries. Recently, developed CT scanners enabled a retrospective MDCT-CA with a low patient radiation exposure by lowering the tube current to 4% during the non-reconstructed phase in all scanned phases [(16)]. The introduction of 128 and 256-multislice CT, gave high temporal and spatial resolution with a less cardiac and respiratory motion, improving assessment of bypass graft patency, stenosis, or occlusion with a promising results [(17)]. In addition, 3D image reconstruction and advanced volumetric visualization techniques allow multi-planer assessment of coronary bypass grafts [(18)]. Our study aimed to assess the diagnostic accuracy of a noninvasive, 128-multislice CT coronary angiography in follow up of coronary bypass grafts in post-CABG patients.

2. Materials and methods

2.1. Research design and ethics

Our retrospective study carried out at radiology department of Zagazig University hospitals, and included 30 patients who had symptoms of ischaemic heart disease and had coronary artery bypass graft (CABG) surgery. Coronary CT angiography (CCTA) and coronary conventional angiography (CCA) were done for all patients, after informed consent approved by research ethics committee of faculty of medicine-Zagazig University, between March 2014 and November 2015. Patients were reviewed by comparing their CCTA results with the conventional angiography results. Patients with hypersensitivity to contrast, had impaired renal function (GFR less than 30ml) or had severe arrhythmia and also with extensive coronary calcification (more than 400) according to Agagstone score are excluded from the study.

2.2. Patient preparation

Avoid caffeine and atropine with proper hydration , on the night before examination, patient were asked to take beta blocker medication and in patient who do not routinely take beta-blocker, administration of 20 mg 2-3 hours before time of scanning is essential.

2.3. Data collection

Examination were performed with 128-multi-detector row CT scanner (Phillips Inguinity Core 128 TM). Patient position were supine with elevated arms throughout the examination. Retrospective ECG gating refers to the simultaneous acquisition of both the patient ECG tracing and the CT data by acquiring both pieces of information. In contrast enhanced CT, a total volume of 120 ml of Ultravist was administered through 18-gauge needle in the right anticubital vein by using automatic injector at a rate of 4ml/sec by test bolus technique in which for test bolus, contrast volume was 20 ml and injection was at rate of 4ml/sec and for main angiographic study, contrast volume was 100 ml at rate of 4ml/sec. The scanning was done during patients breath hold. Scanning parameters are summarized in table (1). Regarding the image display, once scan was complete, we evaluated the volume data set at the workstation, the axial images are considered the source images providing the basic information in CT, scrolling through these images in cranio-caudal direction allows interpretation of cardiac structures. Reconstruction from volume sets during any phase of cardiac cycle, to enable better visualization of entire coronary arteries tributaries, the following techniques are most commonly employed: maximum intensity projection (MIP), multi-planer reformation (MPR), and three-dimensional volume rendering (3D-VR). For interpretation, stenosis degree according to luminal narrowing whether significant or not is divided into three grades (1) free of stenosis, (2) non significant stenosis in which luminal narrowing ≤ 50 and (3) significant stensios in which luminal narrowing >50.

3. Results

All 30 patients could be examined successfully. Patients' demographic data are summarized in Table 2. We analyzed, 102 grafts (42 left IMA, 8 right IMA, 6 radial artery, 46 great saphenous vein grafts). Forty grafts anastomosed to RCA, 42 to left anterior descending artery (LAD), and 20 to circumflex artery (CX), resulting in a total of 380 vessel segments (Table 3). A segment-per- segment analysis was used more than a per-patient analysis to get accurate information about bypass grafted segment, distal runoffs and native arteries. Sensitivity, specificity, positive predictive , and negative predictive values in detection of a remarkable lumen narrowing were 95%, 98%, 97%, 99% in distal runoffs respectively; 99% , 97% , 98%, 100% in bypass grafted segments respectively; and 95%, 93%, 84%, 97% in non-grafted native coronary arteries, respectively (Tables 4,5).

Table 1. Scanning parameters of multislice-CTA.

Parameter	Recommendation for 128 detector row CT
x-ray tube power	120 Kv.
X-ray tube current x-ray tube rotation	430 mAs 300 ms gantry rotation time
Patient with heart rate > 65 beat/minute	Administer B-Blocker
Contrast volume	120ml
Contrast administration rate	4ml/sec.
Scanning delay	10-18s.
Detector collimation	12x0.75 mm or 16x0.75mm
Slice thickness	0.6 mm
ECG gating	Retrospective
Sector reconstruction	0.42 sec rotation; Single for HR < 70; Multiple for HR >70
Scanning time (sec)	16.09 s
Pitch	0.25
Section increment	0.4 mm

Table 2. Characteristics of the study patients.

Patients (n)	30
Age (years) (SD)	66.6 (13.2)
Male (n) (%)	28 (93%)
Mean heart rate during scan (n) (SD)	64 (11)
Mean radiation dose for MDCT (msv) (SD)	17 (1.3)
Duration post-CABG (years) (SD)	5.2 (4.8)
Total number of bypass grafts (n)	102
Arterial grafts (n)	54
Venous grafts (n)	48
Hypertension (n)	16
Hypercholesterolaemia (n)	12
Smoking history (n)	20
Diabetes mellitus (n)	9
Family history (n)	13
Obesity (n)	7

Table 3. Graft types (n = 102)

Graft Type		n
Arterial (n = 54)	Left internal mammary artery	42
	Right internal mammary artery	8
	Radial artery	4
Venous		48
Saphenous graft	to left anterior descending artery	19
	to diagonal branch	6
	to circumflex artery	10
	to right coronary artery	13

Table 4. Diagnostic Accuracy of 128-multislice CTA.

Variables	50-70 graft stenosis (%)	>50-70 graft stenosis (%)
Sensitivity	95	98
Specificity	97	98
PPV	87	96
NPV	97	99
Diagnostic accuracy	96	98

Table 5. Diagnostic performance of multi-slice CTA per patient.

Variables	TP	TN	FP	FN	Accuracy (95% CI)
Graft disease	36	15	1	0	98.1% (94.4–100%)
Distal runoff disease	7	38	6	1	86.5% (77.2–95.8%)
Native coronary disease	28	11	8	0	84.0% (73.3–93.7%)

True positive (TP); true negative (TN); false positive (FP); false negative (FN). Confidence interval (CI)

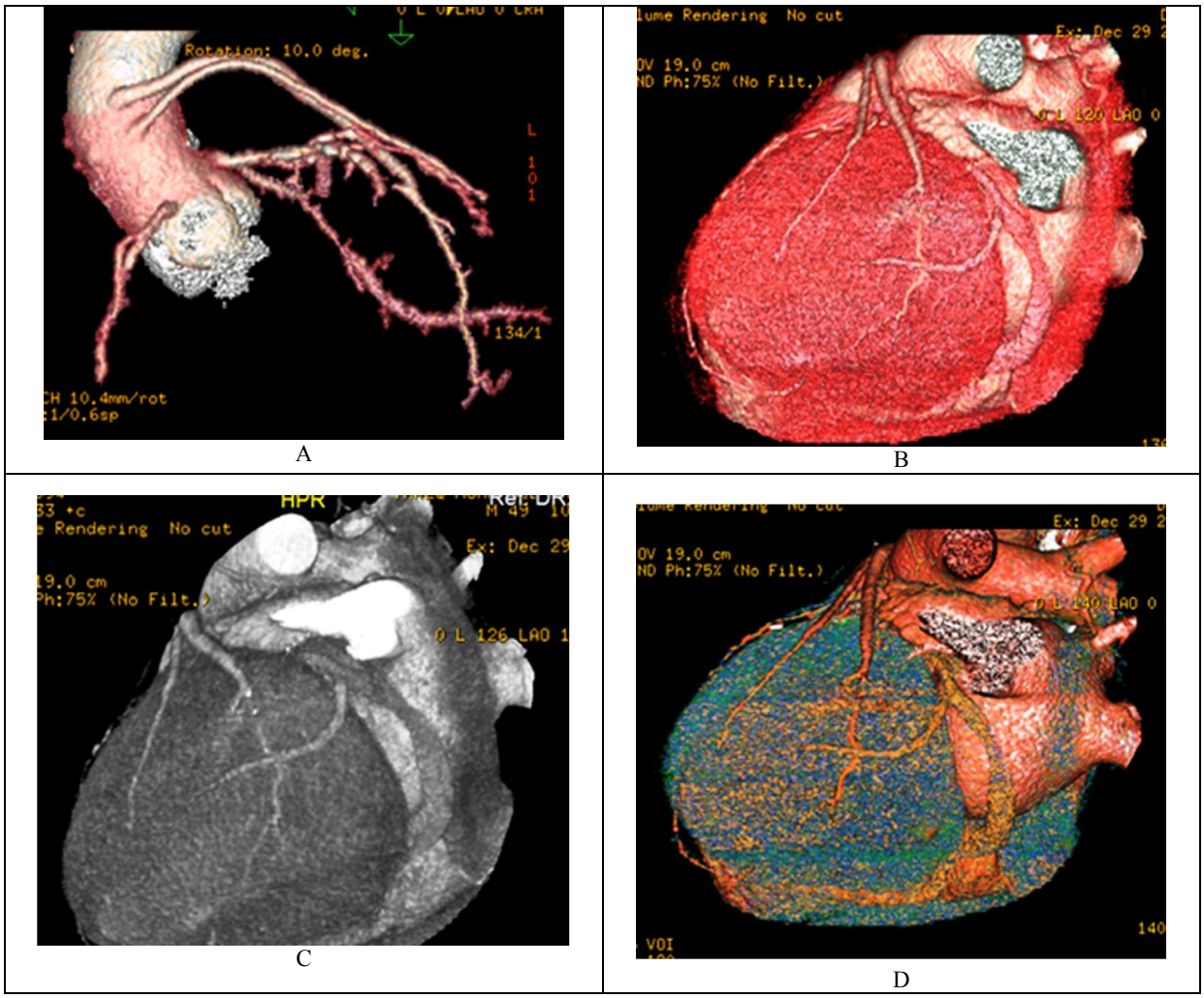


Figure 1. Volume-rendering reconstruction. Saphenous grafts to the obtuse marginal artery (superior) and left anterior descending artery (inferior) with metal artifact and a reduced diameter without visualization of the distal anastomosis of inferior graft in multiplaner reconstruction, the saphenous graft was therefore considered occluded.

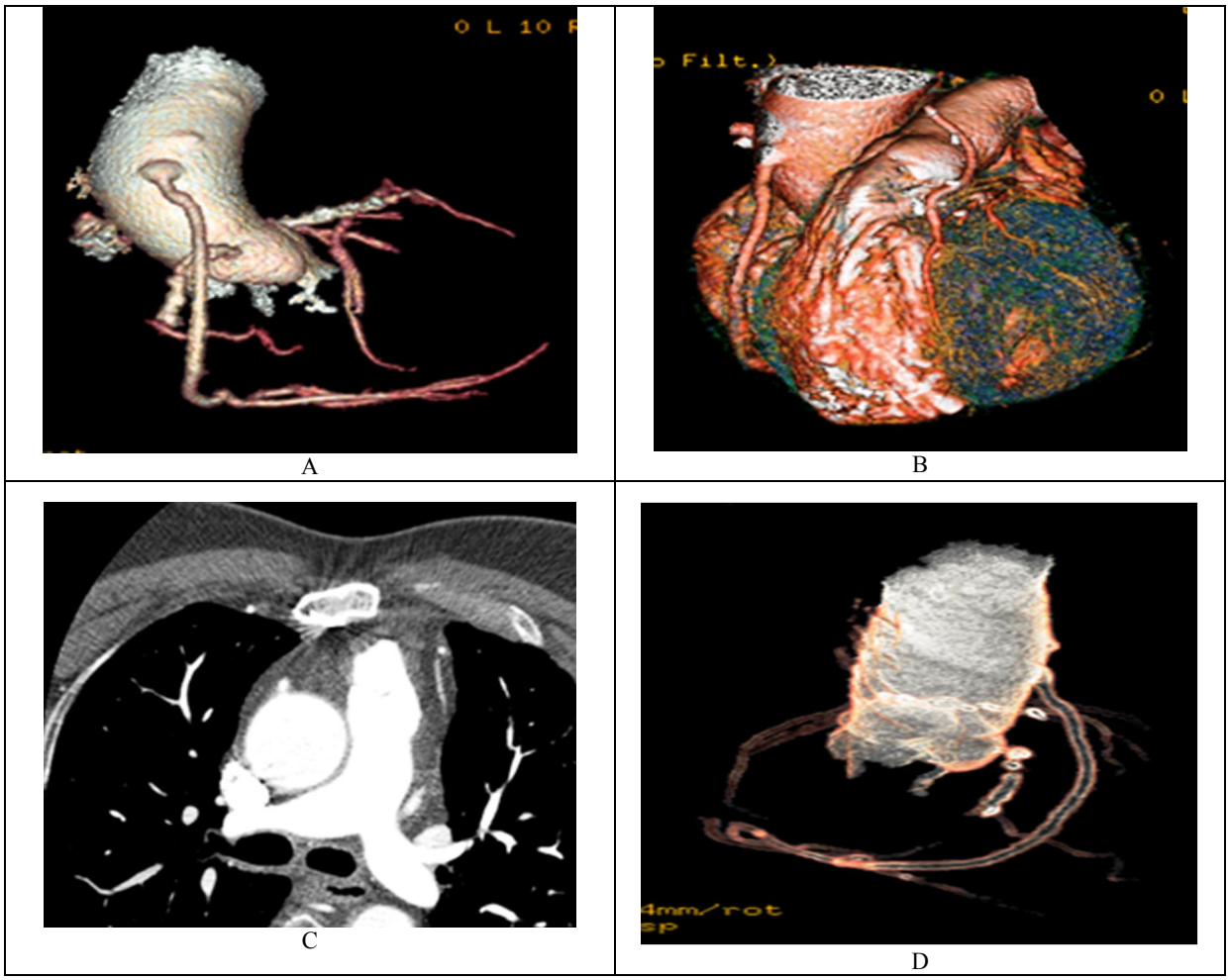
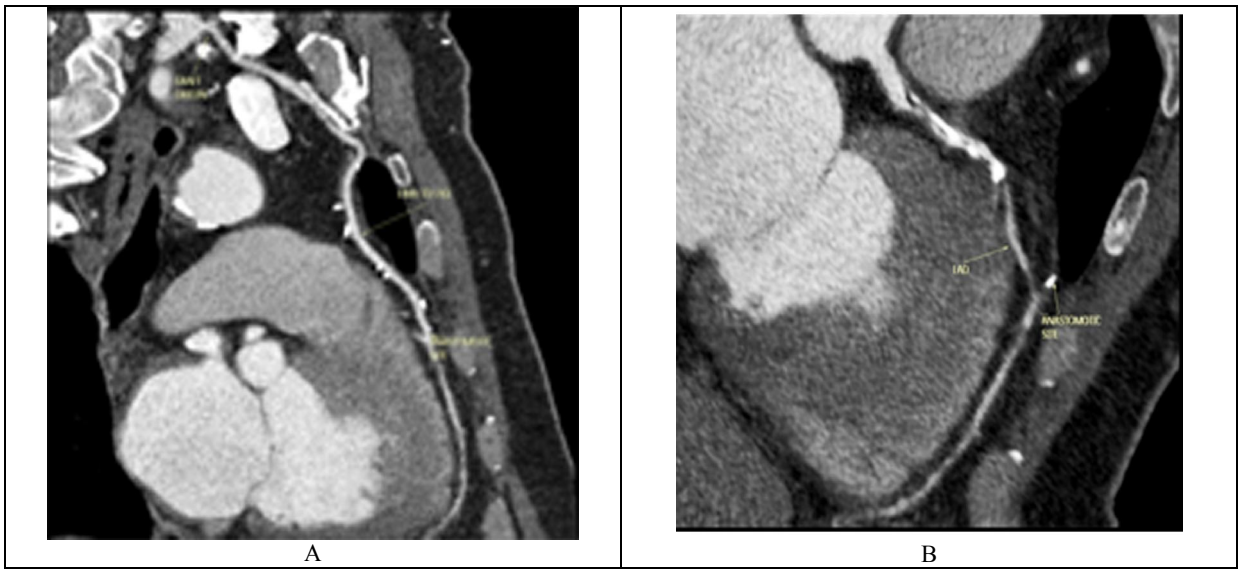


Figure 2. Volume-rendering reconstruction. Saphenous graft to the left anterior descending artery, which is patent with fusiform dilatation at proximal anastomosis denotes aneurismal dilatation.



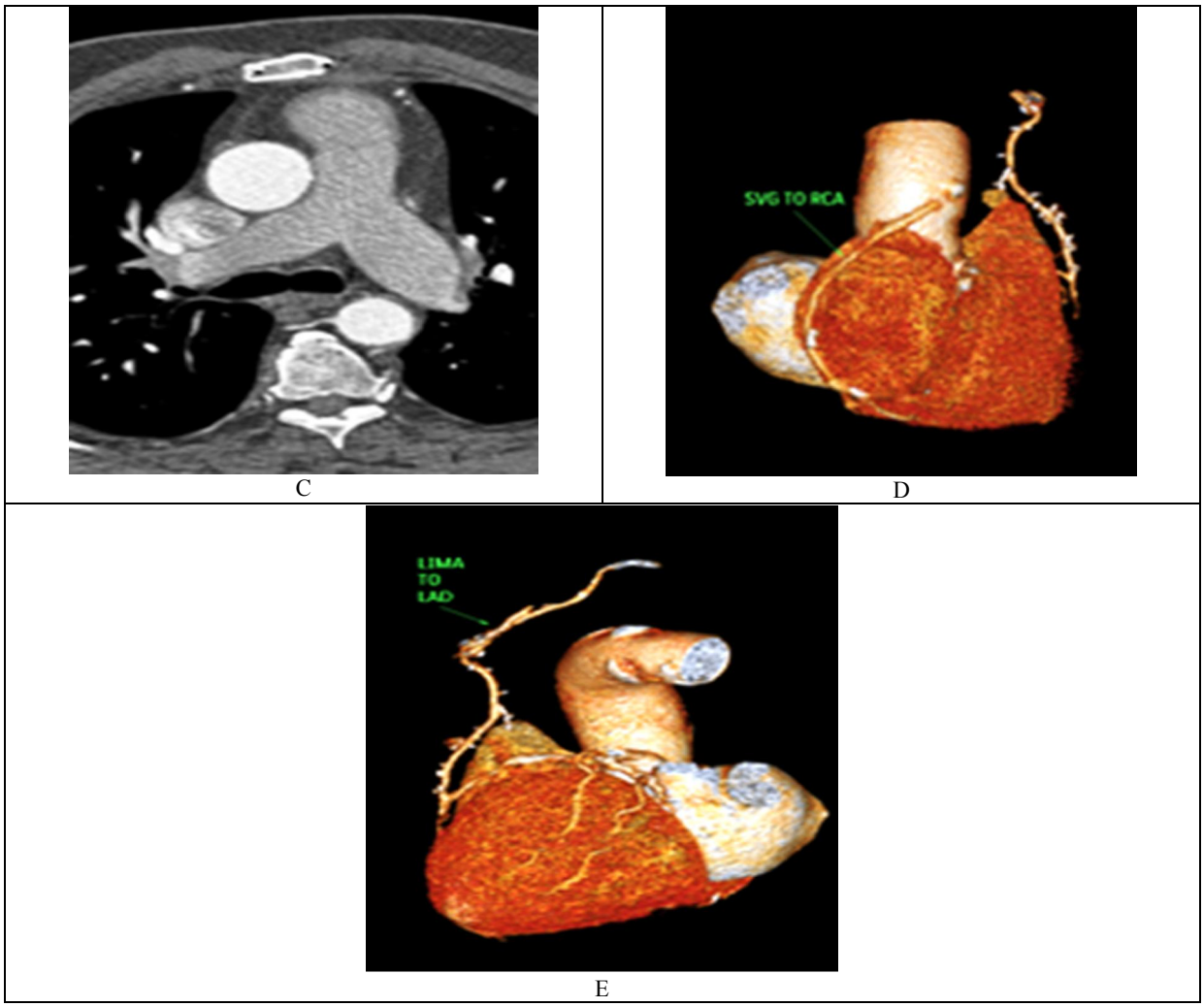


Figure 3. Arterial and venous by-pass grafts in 64-year old man, images obtained with contrast enhanced 128 MCCT. (a, b, c) curved multiplanar reconstruction and axial MPR image show completely thrombosed, occluded proximal saphenous graft and LIMA is patent, note the distal anastomotic site of LIMA with occluded native LAD at (b, d, e) volume rendering reconstruction. Patent LIMA to left anterior descending artery and saphenous graft to RCA is completely occulded along proximal segment (arrow).

4. Discussion

Computed tomography coronary angiography as a noninvasive procedure, has become popular in recent years as a result of advances in multi-slice CT. MDCT has a faster gantry rotation, a high X-ray tube potential, and wider detector area coverage. Therefore, MDCT gives a short scanning time, better image quality, and lower patient radiation dose [17,19,20]. Accurate diagnosis of post-CABG recurrent angina patients stills complex, so full assessment of coronary bypass grafts, distal runoffs and native coronary arteries is necessary [19]. MDCT-CA as a noninvasive tool, showed excellent diagnostic ability for the detection of obstructive graft disease, with sensitivity of 100% for occluded grafts and sensitivity ranged from 80% to 95% for the detection of a significant stenosis (≥50%) [21-24]. Few data about the diagnostic work-up of multislice CTA in detection of significant stenosis of the native coronary arteries are available. Feuchtner et al., reported a sensitivity of 86% and 89% in distal runoffs stenosis; 86% and 97% in non-grafted arteries stenosis, respectively and their specificity was 90% and 93% in distal runoffs and 76% and 86% in non-grafted arteries, respectively [25]. The 128-slice MDCT scanner allows images acquisition during a heart cycle shorter time window (83 ms), producing an image of good quality with a less coronary motility and more accurate delineation of stenosis, specially at bypass graft distal anastomotic site and smaller distal runoffs [26]. We evaluate the role of 128 multi-slice CTA in follow up of coronary bypass grafts patients to assess bypass graft patency, distal runoffs and native coronary arteries to obviate the need for invasive conventional coronary angiography. Our study

revealed 100% sensitivity, for detection of bypass graft occlusion on a per-segment analysis, and 96% sensitivity for detection of ≥50% stenosis in distal runoffs. The majority of distal anastomotic sites and distal runoffs showed good image quality and could be evaluated well. Moreover, on a per-patient analysis, we noticed that, all stenotic or occluded graft bypass segments were accurately detected. Our results state that an accurate, reliable, noninvasive assessment of coronary bypass grafts with MDCT-CA can markedly decrease and limit the need of invasive coronary angiography. MDCT coronary angiography evaluation of bypass grafts provide accurate bypass graft origin, shorting procedure time, saving contrast load, and patient exposure to radiation [(28)]. But, ICA may still required to confirm MDCT angiography accuracy in assessment of distal runoffs and native arteries obstructive disease [(29)].

5. Conclusions

It is concluded that, 128-multislice CTA has a high accuracy in detection or exclusion of bypass grafts, distal runoffs and native coronary arteries significant stenosis. Multislice-CTA should be considered as a noninvasive, reliable, accurate procedure and can replace ICA in follow-up of a post-CABG patients.

Acknowledgements:

The authors acknowledge the support of radiology department of Zagazig University hospitals in this study.

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8/26/2016