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DynaCT during EVAR – A Comparison with Multidetector CT

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Abstract *Objectives:* We have explored the usefulness of an on-table, cross-sectional radiological imaging (DynaCT) in endovascular aortic repair (EVAR). DynaCT images were compared to images from a regular multidetector (16 slice) CT. In the comparison, we tested the accordance of firstly 5 relevant clinical measurements and secondly the visibility of 9 anatomical areas in the two different types of images. This imaging was carried out in addition to the usual angiographic imaging.
Design, material and method: 20 patients with infrarenal abdominal aortic aneurysm (AAA) were prospectively enrolled in the study. We compared Images from DynaCT with two different doses of contrast medium to MDCT-images in two different ways. Firstly relevant arterial diameters and lengths and secondly, 9 anatomical areas were evaluated regarding visibility which was scored on a 4-point scale.
Results: There were no significant differences in the measured arterial diameters and lengths. MDCT had a significantly higher visibility score than both DynaCT investigations. However, with the highest contrast medium dose we found acceptable diagnostic quality in 78–94% of the cases for 8 of the 9 investigated anatomical areas.
Conclusion: Our findings indicate that on-table DynaCT are of sufficient quality to give relevant information of arterial measurements, needed in endovascular repair of infrarenal aortic aneurysms.

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Introduction

The incidence of infrarenal abdominal aortic aneurysm (AAA) has increased during the last decades and so has the number of open, as well as endovascular procedures to treat this condition.[1] Improvements in stent-graft material and implantation technique over the years have broadened the indications for treatment of AAA.[2] Endovascular aortic aneurysm repair (EVAR) could be particularly beneficial for haemodynamically unstable patients with ruptured aneurysms.[3–5] Randomised studies have also shown lower early mortality and morbidity for EVAR versus open surgery.[6,7] On the other hand there has been some scepticism against EVAR based on lack of long term results, the necessity of having a follow-up program and a higher number of secondary procedures compared to open repair.[8] Furthermore, in our current practice about 50% of patients with AAA are unfit for EVAR because of anatomical limitations.

Since anatomical complexity sets limitation to EVAR, satisfactory imaging facilities are mandatory to make relevant measurements for supporting the EVAR.[9] Cross-sectional imaging is especially useful, and multidetector computed tomography (MDCT) represents the standard procedure at our hospital for diagnostic imaging as well as post-treatment imaging in patients with AAA.[10] Today MDCT has to be done in a CT-laboratory, but it might be advantageous to get cross-sectional imaging on-table in the operating room before the procedures is finished. A modified angiographic C-arm with an optional functionality, Axiom Artis dTA with DynaCT® (Siemens, Erlangen, Germany) enables on-table, cross-sectional images and 2- and 3-dimensional reconstructions similar to the CT images. The combination of the C-arch design and the DynaCT functionality enables both traditional angiographic imaging, and soft tissue differentiation. Previous experience has indicated that angiographic CT is feasible in various medical contexts.[11–16] A potential advantage is that one can save time and in some cases avoid risky transfer of the patient to a dedicated CT-laboratory. In a pre-treatment situation, the medical team could make the decision between open surgery and EVAR in a combined operating room and angiography laboratory during preparation of the patient and save valuable time in a critical situation. If necessary, conversion to open surgery during the procedure can be done quickly without moving the patient to another room. In the post-treatment setting one has the possibility of on-table control before the procedure is ended. As an extra advantage, we expect DynaCT to be more cost-effective as a separate MDCT examination can be saved. However, the benefit of this type of cross-sectional images depends on the ability to provide satisfactory information, relevant to the procedure, and this needs to be explored.

The main purpose of the present study was to explore to which extent the images of DynaCT were satisfactory in connection with EVAR and to compare the image information from this new functionality to MDCT. We compared image quality in terms of visualisation of important anatomical landmarks in similar kind of slice images, produced by two different imaging techniques. We defined arterial diameters and lengths from the two sets of images (DynaCT and MDCT), and in addition we addressed image quality in terms of ability of reproducing important details from DynaCT compared to MDCT. We also assessed to what extent the visibility of specified anatomical details reproduced in the DynaCT images reached the minimum score for clinical usefulness. Finally, the significance of the dose and concentration of contrast material was investigated.

Material and Methods

During the period December 2005 until March 2007 altogether 37 patients were selected for endovascular aneurysm repair based on clinical evaluation, blood tests and pre-treatment MDCT.

Process of inclusion

Of the 37 possible cases, 4 patients were not asked to participate in the investigation, due to organisational errors. Thirty-three gave informed consent. The EVAR was conducted as a normal routine with angiographic imaging to support the insertion of stent graft, in addition we performed the DynaCT imaging.

Because of ethical considerations in this early stage of research we decided to inject the extra dose of contrast that was needed for the DynaCT examinations as the last contrast injection after insertion of the stent graft. In that way we had the opportunity to evaluate the total examination time and dose of contrast injected so far, in combination with the serum creatinine before the extra injection, made only for research. Based on these considerations, 13 were excluded by the medical team. For these 13, the extra dose of contrast was regarded unjustified. Thus, we were left with 20 patients with informed consent who had DynaCT imaging performed. The study was conducted according to the principles of the declaration of Helsinki and approved by the local Ethics Committee (Regional Committee for Medical and Health Research Ethics (REK)). The investigation is registered in Clinical Trials.gov no: NCT00264862.

The study was carried out prospectively; all 20 patients were treated with Zenith® (Cook, Inc., Bloomington, IN, USA) stent grafts, according to the hospital's standard protocol for endovascular stent-grafting of AAA.

Technique of EVAR

All EVAR procedures were performed in a dedicated operating suite combining an angiography laboratory with DynaCT and facilities for open surgery; The Operating Rooms of the Future (ORF) at St. Olavs Hospital, Trondheim, Norway. The procedures were thus carried out under fluoroscopic guidance by a team of experienced surgeons and radiologists. A combination of epidural and spinal anaesthesia was used in all cases. Access to the aortic aneurysm was made by surgical exposure of both the common femoral arteries, in one case with unilateral iliac extension of only one of the femoral arteries. Modular stent grafts were deployed from the aortic neck below the renal arteries to the iliac arteries. Bifurcated stent grafts were applied in 16 cases (aorto-biiliac). In 2 cases the stent graft was inserted

from the aorta to the iliac artery on one side (aorto-uni-iliac) and supplemented with femoro-femoral cross-over bypass. One aortic stent graft without iliac extension (custom made for one patient with a saccular aneurysm) and one extension of a previously implanted aorto-biiliacal stent graft were also included. 5000 IU of heparin was administered during the procedure. Cefalotin (Cefalotin®, ACS Dobfar Generics, Luxembourg) was given as a prophylactic antibiotic, 2 g immediately before the procedure and 1 g every 24 h for 48 h postoperatively The staff used standard radiation protection during intervention.

Imaging

The standard imaging protocol at our hospital included pre-treatment planning with a 16 channel MDCT before insertion of the stent graft, and post-treatment MDCT control within three days after the procedure. In the present study we also performed an additional on-table DynaCT run after the stent graft was deployed. The DynaCT image data sets were compared with the post-treatment MDCT images to perform the scientific comparison The cross-sectional images from DynaCT were made from 248 projections obtained during 200 degrees rotation of the C-arm after processing in a Leonardo workstation (Siemens Medical Solutions). The acquisition time was 10 s for the DynaCT images, it took 7 min until the reconstructed axial CT-like slices and an automatic 3D model was ready. After that it took about 3–5 min to make axial slice images, MPR (Multi-Planar Reformatting) and MIP (Maximum Intensity Projection) in a Voxar® (Barco, Belgium) workstation. The Voxar workstation is a plugin to our PACS (picture and communication system) and was preferred by the radiologists because of its easy accessibility. The image volume data was processed into four different image series from DynaCT and MDCT respectively: (1) Source images which were axial slice images, (2) reconstructed axial slice images, (3) coronal MPR and (4) five mm coronal MIP images with 50% overlap.

The 11 first patients received 33 ml of radiographic contrast medium Omnipaque® 200 mg I/ml at 3 ml/s (GE Healthcare, Oslo, Norway), through a 4F UniFlush catheter (Cordis, The Netherlands) placed at the supra-celiac level of aorta. The dose of contrast was chosen according to the vendor's recommendations. Based on the experience from the 11 first patients, we decided to increase the volume and injection rate of contrast medium for the last 9 cases for a more optimal visualisation of the vessels. After ethical and methodological considerations, we decided it was right to increase the dose of contrast up to 50 ml of Omnipaque 200 mg I/ml (GE Healthcare, Norway). The contrast was mixed with 50 ml of 0.9% NaCl and injected at 8 ml/s, Thus the volume was increased from 33 ml to 100 ml with an increased iodine dose from approximately 7 g to 10 g at an unchanged injection time. The mean total amount of contrast medium through the treatment procedure was 7,8 g iodine (min: 5,0 max: 11,9).

MDCT data were obtained with a MDCT scanner (Sensation 16, Siemens Erlangen, Germany), the collimation was 16×0.75 mm, average total dose-length-product (DLP) was 379 mGycm (min 209, max 616).

We reconstructed axial and coronal MPR and Thin slice MIP (5 mm images with 50% overlap) series in Voxar® 3D software. For MDCT, the contrast medium was injected according to our standard protocol. Eighty ml of Omnipaque 350 mg I/ml (mean total dose of iodine 28,000 mg) followed by 30 ml of NaCl was injected at 4 ml/s in an antecubital vein.

All image series were de-identified prior to the comparison between DynaCT and MDCT.

Image analysis

All image preparation was performed by one of the investigators (AØ) after all of the patients had been included. From the image data from MDCT and DynaCT respectively, the four image series (previously described) were stored in the PACS system after de-identification. Image data from DynaCT and MDCT were compared by two different methods: Firstly 5 relevant arterial diameters and lengths were measured in suitable planes (Table 1). Secondly a graded evaluation of anatomical details was performed in all four series of images from DynaCT and MDCT respectively (Table 2). The criteria employed in the evaluation of visibility were derived from the European Guidelines for Quality Criteria for Computed Tomography.[17] Two experienced radiologists (AØ, SH), blinded to each others results evaluated both sets of images.

All four series of images from each examination were assessed in terms of visibility of important anatomic areas and details in the stent graft according to a 4-point scale (4 = perfect imaging, 3 = clear reproduction, diagnosis possible without restrictions, 2 = acceptable, relevant diagnosis possible and 1 = poor, relevant diagnosis impossible). For point C (the whole stent graft in the visualised volume), a different point-scale was used (see Table 2, point C).

Because the contrast injection protocol was changed for DynaCT during the study period, we defined 3 imaging techniques for the analysis: DynaCT 1 (original contrast medium dose), 11 patients, DynaCT 2 (increased contrast medium dose), 9 patients, and MDCT, 20 patients.

Statistics

Statistical analyses were performed using a linear mixed model with patient and radiologist as random factors, and imaging technique as a fixed factor. The linear mixed model is an extension of the Bland–Altman approach for comparing clinical measurements.[18] One of the useful features of a linear mixed model is proper use of all available data, also when the number of patients differs between the groups. The dependent variables were firstly the diameter or length, and secondly visibility of the score points. 95% confidence intervals (CI) are given where appropriate. Two-sided p-values <0.05 were considered significant.

Results

Clinical characteristics of the patient sample

20 consecutive patients were enrolled during a period from December 2005 through April 2007. The clinical characteristics of the patients are summarised in Table 3.

Table 1 Comparing DynaCT 1, DynaCT 2 and MDCT. Measured lengths and diameters in mm (±95% CI)

	DynaCT 1	DynaCT 2	MDCT	*p*-Value
1. Max. diameter of the aneurysm	60.8 (±1.5) $n = 22$	59.6 (±1.7) $n = 18$	60.5 (±0.9) $n = 40$	0.67
2. Diameter neck of aneurysm	19.3 (±0.47) $n = 22$	19.1 (±0.58) $n = 16$	19.4 (±0.29) $n = 40$	0.74
3. Length of aneurysm neck	25.6 (±2.5) $n = 18$	27.8 (±2.9) $n = 15$	26.8 (±1.4) $n = 40$	0.60
4. Renal artery − bifurcation	111.8 (±2.9) $n = 20$	115.3 (±3.5) $n = 15$	115.5 (±1.7) $n = 40$	0.11
5. Top stent-to-stent bifurcation	96.5 (±3.6) $n = 12$	103.0 (± 4.4) $n = 9$	100.6 (±1.9) $n = 33$	0.11

DynaCT 1: Original contrast protocol, DynaCT 2: After change of contrast protocol, MDCT: Multi detector CT. n = The total number of observations made for each measurement. For example, 22 for DynaCT 1 means 11 patients all observed by two radiologists. Total n for two investigators are: DynaCT 1 = 22, for DynaCT 2 = 18 and for MDCT = 40. Smaller n means that some points could not be evaluated by one or by both investigators, because they were judged outside the image volume.

Radiation dose

DynaCT imaging was performed with fixed mA (milliampere) at 162 and automatic KV (kilovolt), average 85 (min 76, max 95), dose-areal-product (DAP) for the DynaCT imaging was average 3027 μGym^2 (min 2308, max 3668) and for the total procedure it was average 24864 μGym^2 (min 8340, max 55229). Average fluoroscopic time was 24 min (min 13, max 38).

To compare average effective radiation dose for the patient we made an estimate, based on conversion factor from the Norwegian Radiation Protection Authority.[19] This indicates that average approximately effective dose to the patient was: one single DynaCT series is 6−8 mSV (millisievert) and the dose from the whole EVAR procedure is 50−70 mSV. Average effective dose from MDCT is approximately 6 mSV.

DynaCT compared to MDCT for relevant measurements and visibility scores

The results are based on the combined data from the two independent investigators and are presented in Table 1. For the arterial measurements, there were no significant differences between DynaCT 1 versus MDCT or between DynaCT 2 versus MDCT.

When we compared the score points for visibility of the anatomical areas for both types of images, (20 patients and two investigators), there were significant differences between DynaCT 1 versus MDCT and between DynaCT 2 versus MDCT in the favour of MDCT (Table 2), all p-values <0.001. Change of contrast dose seemed to have a positive effect on visibility of all the evaluated anatomical areas, except C (the whole stent graft in the volume), but positive effect reached significance for only the points B and G.

These data were also analysed to find out to what extent the visibility score of the DynaCT images indicated that DynaCT were diagnostic relevant, defined as score 2 or more on the visibility scale. Firstly we found that the overall visibility score for the 9 anatomical areas (points A−I) improved after the change of contrast protocol from average 2.3 for DynaCT 1 (original contrast protocol) to mean 2.5 for DynaCT 2 (new contrast protocol), $p = 0.014$. Eight of the 9 anatomical areas were reproduced in a diagnostic relevant way, which is score 2 or better on the visibility scale. The percentages of diagnostic relevant scores in the DynaCT 2 readings after for each of the 9 anatomical areas were: A: 78%, B:78%, C:83%, D:89%, E:83%, F:33%, G:78%, H:78% and I:94%.

Table 2 Comparing DynaCT 1, DynaCT 2 and MDCT. Score-points on a scale from 1−4 for visibility of anatomical areas (±95% CI)

Anatomic area	DynaCT 1 $n = 22$	DynaCT 2 $n = 18$	MDCT $n = 40$
A. Renal artery on the right side: separation of orifice and the proximal segment from the aorta and surrounding tissue	2.1 (±0.3)	2.5 (±0.3)	3.9 (±0.2)
B. Renal artery on the left side: Separation of orifice and the proximal segment from the aorta and surrounding tissue	1.9 (±0.3)	2.5 (±0.3)	3.9 (±0.2)
C. Is the whole stent-graft recorded in the volume? 4; yes with good margin 3; just barely 2; <10% is missing, and 1; > 10% is missing	2.9 (±0.3)	2.1 (±0.3)	4.0 (±0.2)
D. Markers in the stent graft: number and positions are assessed.	2.6 (±0.2)	2.9 (±0.3)	3.7 (±0.1)
E. Both kidneys: renal border can be separated from surrounding tissue	2.8 (±0.3)	3.1 (± 0.4)	4.0 (±0.2)
F. The whole lumen of the abdominal aorta above the proximal end of the stent graft: separation of aortic wall from surrounding tissue	1.8 (±0.3)	1.8 (±0.3)	4.0 (±0.2)
G. Iliac arteries distal to the stent graft: separation from surrounding tissue	1.7 (±0.3)	2.8 (±0.4)	3.9 (±0.2)
H. Vena cava inferior below the renal veins: separation from surrounding tissue and aorta	2.0 (±0.2)	2.1 (±0.3)	3.6 (±0.1)
I. Differentiation of the psoas muscle from the neighbouring structures	3.0 (±0.2)	3.0 (±0.3)	4.0 (±0.1)

DynaCT 1: Original contrast protocol, DynaCT 2: DynaCT after change of contrast protocol, MDCT: multi detector CT. n = The total number of observations for each measurement, 40 for MDCT means 20 patients observed by 2 investigators. All comparisons DynaCT 1 versus MDCT and DynaCT 2 versus MDCT have $p < 0.001$. Comparisons between DynaCT 1 and DynaCT 2 have p-values A:0.080, B:0.014, C:0.001, D:0.20, E:0.21, F:0.88,G: <0.001, H:0.20, and I:0.88 for the respective anatomic areas.

Table 3 Patient characteristics and co-morbidity in 20 patients treated for AAA by EVAR

Characteristic	
Male gender	16 (80%)
Mean age, years (range), SD	73 (61–84), 6
Weight (range) SD	81,4 (60–104), 13
Preoperative maximum aneurysm diameter in mm (range), SD	59 (40–92), 11
Symptomatic aneurysm	2
Coronary heart disease	10
Chronic obstructive pulmonary disease	3
Renal insufficiency (serum creatinine > 140 μmol/L)	0
Carotid artery disease	2
Diabetes	2
Lower limb arterial insufficiency	2
Hypertension	12

For all MDCT readings, the visibility score were as expected, in the upper end of the scale (mode = 4).

Inter-investigator difference

For measured maximum diameter of the aneurysm, there were no significant differences between the two investigators. For the other four measurements, there were small, but significant inter-investigator deviations: The upper aortic neck diameter deviated with approximately 1 mm, the length of the upper aortic neck with approximately 3 mm. There was a significant difference between the two investigators within approximately ±5 mm regarding the distance from the lowest renal artery to the aortic bifurcation and from the top of the stent graft to the graft bifurcation (Table 4).

For all 9 anatomic areas, one investigator gave higher mean visibility scores than the other investigator (Table 5). These disagreements were statistically significant for all landmarks except F (the whole lumen of abdominal aorta above the proximal end of the stent graft).

In 7 cases it was impossible for technical reasons (potential collision between C-arm and patient or surgical equipment) to place the region of interest in the centre of the imaging volume (the images were off centre between approximately 20 and 45 mm). This resulted in low scores for some objects that in these cases tended to be outside the image field. Point F (lumen of the abdominal aorta above the stent graft) was in some cases above the 20 cm long image field. This is demonstrated in Fig. 1, images A and B.

Discussion

Measurements of diameters and lengths of anatomical structures made in DynaCT images were not significantly different from those obtained by MDCT. Our results indicate that DynaCT gives an image quality sufficient for evaluation of patients with AAA.

MDCT is superior in differentiation of low contrast details and is able to scan much larger anatomical volumes. However most of the relevant anatomical structures could be acceptably reproduced also with DynaCT as long as they were located within the examined volume. The image quality improved after the change in the dose of contrast medium and with the highest contrast medium dose we found diagnostic quality in 78–94% of the cases for 8 of the 9 investigated anatomical areas.

The comparison between the two evaluation methods indicates that although the visibility score in DynaCT is lower, it is good enough for measurements necessary for stent-graft planning.

Our estimate of effective dose to the patient indicate that DynaCT tend to give a higher radiation dose, compared to MDCT. However considered the age of this group of patients the risk of developing diseases as consequence of radiation is regarded rather low.

To our knowledge, little research has been presented regarding the application of DynaCT during EVAR. Technical image quality is inferior to MDCT, especially in terms of low contrast resolution.[20] However clinical experience from other centres has demonstrated the usefulness of DynaCT imaging for detection of complications during both EVAR and neuroendovascular procedures. The on-table management of such complication can improve the clinical outcome.[21,22]

Our experience indicates that use of DynaCT was sometimes a little cumbersome and includes several manual procedural steps. The distance between the C-arm parts and the surgically prepared patient is narrow, and it is difficult to centre the region of interest optimally. The limited diameter (25 cm) and length (20 cm) of the DynaCT image volume is also a limitation. Therefore, the technique is difficult to apply for evaluation of pathology in a large anatomical volume, as in thoracic and thoracoabdominal aneurysms.

Table 4 A comparison between two investigators. Measured lengths and diameters in mm (± 95% CI)

	Investigator 1	Investigator 2	Difference	*p*-value
1. Max. diameter of the aneurysm	60.6 (±1.0) $n = 40$	60.0 (±1.0) $n = 40$	0.5 (±1.3)	0.46
2. Diameter neck of aneurysm	18.7 (±0.3) $n = 39$	19.8 (±0.3) $n = 39$	−1.1 (±0.4)	<0.001
3. Length of aneurysm neck	28.3 (±1.5) $n = 38$	25.2 (±1.6) $n = 35$	3.0 (±2.1)	0.006
4. Renal artery − bifurcation	116.7 (±1.9) $n = 38$	111.6 (±1.9) $n = 37$	5.1 (±2.5)	<0.001
5. Top stent-to-stent bifurcation	97.6 (±2.1) $n = 29$	102.5 (±2.5) $n = 25$	−4.9 (±2.9)	0.002

n = The total number of observations for each reader. For example, $n = 40$ for investigator 1, means 20 observations from DynaCT (both 1 and 2) and 20 observations from MDCT. Maximum n for the two investigators are: DynaCT = 40 and for MDCT = 40. Smaller n means that the same points could not be evaluated by the reader.

Table 5 A comparison between two investigators. Comparing score-points on a scale from 1–4 for visibility of anatomic areas (±95% CI). For all structures, all $n = 40$ observations were available for DynaCT and for MDCT

Anatomic area	Investigator 1	Investigator 2	Diff 1 versus 2	*p*-Value
A. Right renal artery	3.0 (±1.7)	2.7 (±1.7)	0.3 (±0.2)	0.031
B. Left renal artery	2.9 (±0.2)	2.6 (±0.2)	0.3 (±0.2)	0.017
C. The whole stent-graft in the visualised volume.	3.1 (±0.2)	2.8 (±0.2)	0.3 (±0.2)	0.011
D. Markers; number and positions	3.7 (±1.4)	2.4 (±1.4)	1.3 (±0.2)	<0.001
E. Renal borders; separation from surrounding tissue	3.5 (±0.2)	3.1 (±0.2)	0.4 (±0.3)	0.007
F. Lumen abdominal aorta proximal to stent graft.	2.6 (±0.2)	2.5 (±0.2)	0.2 (±0,3)	0.25
G. Iliac artery distal to stent graft	3.0 (±0.2)	2.6 (±0.2)	0.4 (±0,3)	0.004
H. Vena cava inferior distal to renal veins	2.7 (±0.1)	2.4 (±0,2)	0.3 (±0.2)	0.009
I. Visible psoas contour	3.5 (±0.1)	3.2 (±0.1)	0.3 (±0.2)	0.004

n = The total number of observations for each measurement, for example, 40 for MDCT means 20 patients observed by 2 investigators.

The system has been upgraded after this investigation. The upgrading has reduced the 3D volume reconstruction time from about 7 to 2 min and is claimed to give better image quality. The time consumed for the reconstructions will depend on how experienced the operator is, but we estimate approximately 5 min for a beginner after necessary introduction to the software. In further research, these aspects will be investigated more systematically.

In our opinion DynaCT might represent a valuable adjunct to the standard equipment that is normally available in an operating room for vascular procedures. One potential advantage with the DynaCT modality could be for imaging of acute cases. The patients can then be taken directly to the operating suite where decision about therapy can be performed while preparing the patient. Cross-sectional imaging can be done without transferring the patient to the department of radiology. Should open surgery become necessary, or be the treatment of choice after DynaCT imaging, it can be done in the same environment. In our opinion EVAR is best carried out in a hybrid operating room where both endovascular treatment and open surgery can be performed in sterile environments.[23]

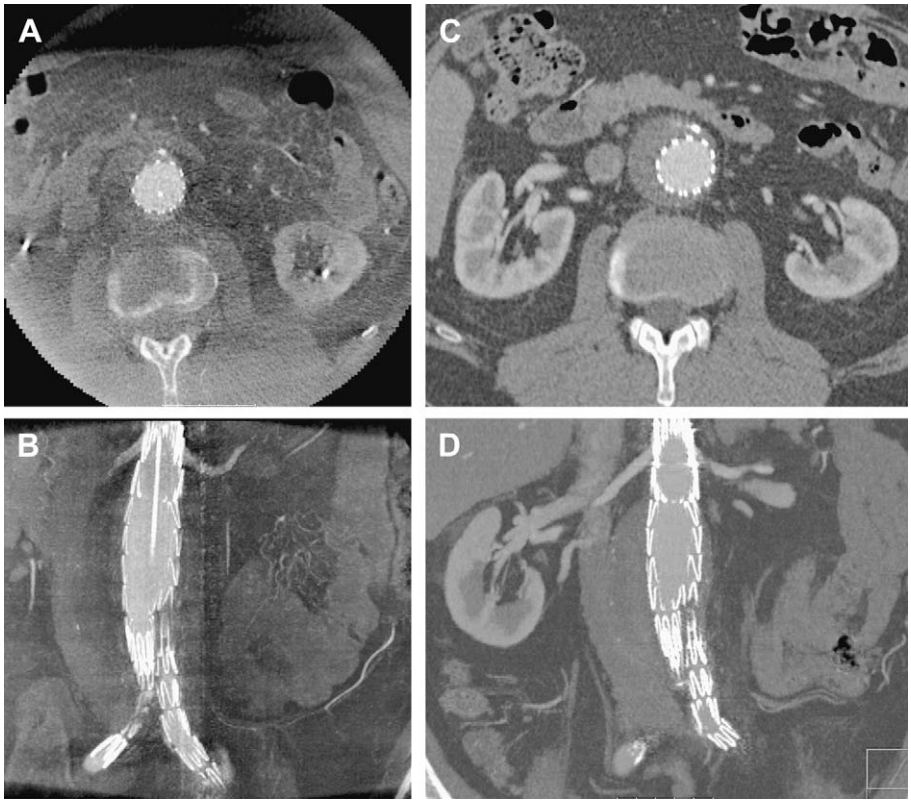

Figure 1 Four images from one patient at the same anatomical position comparing DynaCT with multidetector CT. The patient had been treated with EVAR for abdominal aortic aneurysm. A: DynaCT, axial slice image. B: DynaCT, coronal thin slice maximum intensity projection (MIP). C: Multidetector CT, axial slice image. D: Multidetector CT, coronal thin slice MIP. The images A and B also illustrate the centring problem as the region of interest is out of centre because of technical reasons.

With the DynaCT readily available, on-table CT-like images can be provided within a few minutes. This might be an advantage in patients with symptomatic or ruptured aneurysms, and might also replace an early postoperative follow-up CT-scan. We also believe that fewer separate CT-procedures contribute to a more cost-effective process from diagnosis to treatment and follow-up as the cost of personnel recourses and occupied time in a CT-laboratory is an important economic factor.

Study limitations

There are several limitations with the present investigation. A disadvantage is that we had to change the contrast dose during the study period. However, it became obvious as the investigation proceeded that the amount of contrast was suboptimal in some patients, and we regarded it unethical to continue with the low contrast volume. The analysis showed a significant improvement in visibility of some anatomical areas, especially in the iliac arteries, after the change of contrast protocol. This fact was unknown during planning of the investigation since DynaCT had not been used for patients with AAA before. We therefore decided to include an evaluation of two different contrast doses in the present investigation. However in future studies, a uniform contrast dose will be applied.

Furthermore, it was decided to do the DynaCT examination after deployment of the stent grafts. If the extra contrast medium to make DynaCT for research had been injected prior to stent-graft insertion, we considered it might be an unnecessary and unethical risk for some of the patients as the total amount of contrast in the whole procedure in some cases might exceed the advisable dose.

Conclusion

Comparison between DynaCT and the standard imaging procedure MDCT shows that on-table DynaCT images are of sufficient quality to give relevant information for arterial measurements despite a significantly poorer visibility score. Further investigations are necessary to explore the potential of this imaging modality in the clinical routine, especially in emergency endovascular AAA repair.

Conflicts of Interest

Siemens AG has provided free upgrading of the software for the DynaCT and for the Leonardo workstation.

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