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Transarterial computed tomography angiography before and after endovascular aortic repair in patients with chronic kidney disease

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ABSTRACT

Objectives: In this study, we aimed to evaluate the accuracy of transarterial computed tomography angiography (TA-CTA) in treatment planning and follow-up and to identify the contrast-induced nephropathy (CIN) risk of this procedure in patients with chronic kidney disease (CKD).

Patients and methods: Between November 2012 and November 2013, a total of 14 patients (13 males, 1 female; mean age 73.8±7.2 years; range, 58 to 90 years) with CKD and an aortic aneurysm who underwent TA-CTA were included in this study. A flush catheter was placed in the aorta and CTA images were obtained by 64-slice multidetector computed tomography (MDCT). For the thoracoabdominal TA-CTA, a mixture of 16 mL contrast + 84 mL saline was used, while for the abdominal TA-CTA, 8 mL of contrast + 42 mL of saline mixture was used. These mixtures were injected with an automatic injector without delay in time. The image quality scores (IQS) were between 1 and 4. Serum creatinine and estimated glomerular filtration rate (eGFR) values were obtained before the procedure, and on Days 2-5 and at Months 1-3 after the procedure.

Results: None of the patients developed CIN. The mean creatinine levels were as follows: 2.35 mg/dL before the procedure, 2.27 mg/dL on Days 2-5, and 2.28 mg/dL at Months 1-3 (p=0.084 and 0.109, respectively). The mean eGFR values were as follows: 32.2 mL/min/1.73 m^2 before the procedure, 34.2 mL/min/1.73 m^2 on Days 2-5, and 34.6 mL/min/1.73 m^2 at Months 1-3 (p=0.061 and 0.017, respectively). The Hounsfield unit (HU) values were as follows: 184 to 251 HU (mean: 230 HU) on the distal ascending aorta, 104 to 430 HU (mean: 198 HU) on the renal artery level of the abdominal aorta, 104 to 430 HU (mean: 198 HU) at the terminal aorta, 88 to 406 HU (mean: 183 HU) on the common iliac arteries, and 103 to 274 HU (mean: 171 HU) on the common femoral arteries The HU value was measured in a non-enhanced area as 22 to 45 HU (mean: 32 HU). The mean IQS of Observer 1 and Observer 2 was 3.52 and 3.47, respectively. Only one TA-CTA procedure was scored differently. The mean IQS was 3.495 with an intra-observer agreement of 94%.

Conclusion: Despite its invasive nature, diluted, low-contrast enhanced TA-CTA is an easy-to-use and safe method which provides sufficient anatomical details without causing any nephropathy risk.

Keywords: Chronic kidney disease, computed tomography angiography, contrast-induced nephropathy, contrast material, endovascular aortic repair.

Computed tomography angiography (CTA) is a standard imaging method used in endovascular aortic aneurysm repair (EVAR) planning and follow-up.[1,2] The side effects on kidney functions of the non-ionic contrast material used in this procedure are well known. Among the risk factors of contrast-induced nephropathy (CIN), there are increased creatinine levels, dehydration, congestive heart failure, particularly for individuals over the age of 60, and using nephrotoxic drugs.[3,4] Aortic aneurysm is frequently observed in elderly and is often accompanied by renal dysfunction and diabetes.[5] Therefore, non-ionic contrast materials should be used more carefully in this group of patients.

Frequent abdominal CTA may be needed before and after EVAR. Also, during the endovascular treatment, a high amount of contrast material can be used. Subsequent use of contrast agent may particularly increase the risk of contrast nephropathy in patients with renal insufficiency.

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In the present study, we, for the first time, aimed to evaluate the effectiveness of TA-CTA in treatment planning and follow-up with low-dose non-ionic contrast agent and to identify the CIN risk of this procedure in patients with chronic kidney disease (CKD).

PATIENTS AND METHODS

Between November 2012 and November 2013, a total of 14 patients (13 males, 1 female; mean age 73.8±7.2 years; range, 58 to 90 years) with CKD and an aortic aneurysm who were admitted to the interventional radiology clinic of Ankara Atatürk Training and Research Hospital and underwent TA-CTA were included in this study. Kidney function tests before and after the procedure were performed, and the effectiveness of the procedures before and after EVAR were prospectively evaluated. Newly diagnosed or patients with EVAR due to aortic aneurysm with a baseline serum creatinine level of >1.2 mg/dL and baseline estimated glomerular filtration rate (eGFR) of <60 mL/min/1.73 m^2 with Grade ≥3 renal insufficiency were included in the study. None of the patients had a history of contrast-related allergies or asthma. None of the patients underwent imaging studies of the aorta within the last three months before TA-CTA which was performed for EVAR planning of. A written informed consent was obtained from each patient. The study protocol was approved by the Ankara Atatürk Training and Research Hospital Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Operative technique

Before the TA-CTA procedure, a 5F sheath was placed in the brachial or femoral artery of all patients. Afterwards, a 5F flush catheter (Boston Scientific, Global Park, Heredia, Costa Rica) was placed into the proximal descending thoracic aorta of the patients with a thoracoabdominal aortic aneurysm (TAAA), and into the 8 to 10 thoracic vertebrae level in the patients with an abdominal aortic aneurysm (AAA). The patients were taken to the CT unit immediately after 2,500 IU of heparin anticoagulation was injected through the flush catheter. The CT scans were obtained with a 64-slice multidetector computed tomography (MDCT) (Aquillion, Toshiba Medical System, Nasu, Japan) device with 0.5-mm slice thickness. For AAAs, 8 mL contrast agent + 42 mL normal saline mixture was injected, while for TAAAs, 16 mL contrast agent + 84 mL saline mixture was injected through the flush catheter. Iso-osmolar iohexol, a third-generation contrast agent, was used. The diluted contrast was injected with an automatic injector, through the flush catheter at a speed of 7 mL/sec with a pressure of 600 mmHg (Medrad Avanta, Pittsburgh, PA, USA). The MDCT scanning was started with the contrast injection simultaneously, and no delay time was used.

Two radiologists with four and 12 years of experience evaluated the CT scans separately. The Hounsfield unit (HU) values were measured at the non-enhanced proximal aortic region, distal thoracic aorta, at the renal artery level of the abdominal aorta, terminal aorta, common iliac arteries, and common femoral arteries. The image quality scores (IQS) was graded from 1 to 4, such that the TA-CTA parameters to be met (Table 1). Then, the intra-observer agreement was evaluated regarding the given IQS. The IQS of TA-CTA of 8 mL and of 16 mL contrast agent were compared separately. The patients who underwent TA-CTA after EVAR were evaluated with color Doppler ultrasound (CDUS) (Logic E9; GE, Milwaukee, Wl, USA) for endoleak by a third

TABLE 1
TA-CTA parameters of image quality scores

Image quality score	TA-CTA parameters
1. Poor	Only proximal segments of visceral arteries and iliac arteries are seen as well as aorta on the axial images
2. Adequate	Distal branches of visceral arteries and femoral arteries are seen as well as aorta on the axial images
3. Good	Only proximal segments of visceral arteries and iliac arteries are seen as well as aorta on the axial and volume rendered images
4. Excellent	Distal branches of visceral arteries and femoral arteries are seen as well as aorta on the axial and volume rendered images

TA-CTA: Transarterial computed tomography angiography.

experienced radiologist. Any difference between the TA-CTA and CDUS in terms of endoleak detection was evaluated.

In addition to the renal insufficiency risk, the patients were evaluated for additional risk factors such as old age, diabetes, use of nephrotoxic drugs, and hypertension regarding CIN. Possible nephrotoxic drugs were discontinued in all patients 24 h prior to the procedure. At least three days before the procedure, the patients were put on minimum 3 liters of oral fluid intake. After the procedure, 1 to 1.5 mL/kg/h of intravenous hydration was administered for 6 h. All patients received 600 mg of oral n-acetylcysteine twice daily for one week, starting two days before the procedure. The highest serum creatinine levels on Days 2-5 and at Months 1-3 after the procedure, and the lowest eGFR values at the same period of time were recorded. These laboratory values were evaluated regarding CIN. Changes in kidney function tests were compared in patients receiving 8 mL and 16 mL of contrast agent.

Statistical analysis

Statistical analysis was performed using the SPSS version 13.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. The Wilcoxon signed-rank test was used to compare significant differences between baseline creatinine and eGFR values on Days 2-5 and at Months 1-3. The Mann-Whitney U test was used for the comparison of the changes in kidney function tests and the differences in TA-CTA IQS in the patients receiving 8 mL and 16 mL of contrast agent. A p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 14 patients, four thoracoabdominal TA-CTA procedures were performed in three patients with TAAAs, and 13 abdominal TA-CTA procedures were performed in 11 patients with AAAs. In total, 17 TA-CTA procedures were performed. Brachial artery catheterization was performed in seven procedures, and femoral artery catheterization was performed in 10 procedures. A pigtail catheter as a flush catheter was used in all 17 procedures. None of the patients developed complications such as hematoma or pseudoaneurysm.

Besides renal insufficiency, all patients had hypertension, eight had diabetes mellitus, and two had congestive heart failure. Twelve of the patients were above 60 years of age. Also, five of the patients using angiotensin-converting enzyme inhibitors were

TABLE 2
Baseline demographic and clinic characteristics of patients

No	Age/Sex	Diabetes mellitus	Hypertension	Congestive heart failure	Hospitalization day	Intensive care unit	Post intervention complication
1	69/M	Yes	No	No	1	No	No
2	74/F	Yes	No	No	1	No	No
3	90/M	Yes	Yes	No	1	No	No
4	77/M	Yes	Yes	No	1	No	No
5	58/M	Yes	Yes	Yes	1	No	No
6	71/M	Yes	No	No	1	No	No
7	67/M	Yes	Yes	Yes	1	No	No
8	81/M	Yes	No	No	1	No	No
9	59/M	Yes	Yes	No	1	No	No
10	72/M	Yes	Yes	No	1	No	No
11	78/M	Yes	Yes	No	1	No	No
12	80/M	Yes	No	No	1	No	No
13	75/M	Yes	No	No	1	No	No
14	82/M	Yes	Yes	No	1	No	No

Number 5, Number 6, and Number 9 had two interventions at different times before and after endovascular aortic aneurysm repair.

TABLE 3
Hounsfield unit values measured from different anatomical sites with TA-CTA

Unenhanced aortic area		Distal descending thoracic aorta		Abdominal aorta at renal artery level		Terminal aorta		Common iliac artery		Common femoral artery	
HU	Range	HU	Range	HU	Range	HU	Range	HU	Range	HU	Range
32	22-45	230	184-251	207	104-410	198	104-430	183	88-406	171	103-274

HU: Hounsfield unit; TA-CTA: Transarterial computed tomography angiography.

prescribed a different class of antihypertensive drugs by the treating nephrologist. In three patients using metformin, the drug was discontinued 48 h prior to the procedure to prevent the peril of lactic acidosis. After the procedure, serum creatinine levels were measured, and the drug was re-initiated. Baseline demographic and clinical characteristics of the patients are presented in Table 2.

The mean HUs of the aorta measured during the TA-CTA procedures on different anatomical localizations are shown in Table 3. All TA-CTA procedures were separately evaluated by two observers according to the IQS TA-CTA criteria. None of the procedures received 1 (negative) IQS score. Observer 1 graded 11 procedures with IQS 4, four procedures with IQS 3, and two procedures with IQS 2. Observer 2 graded 10 procedures with IQS 4, five procedures with IQS 3, and two procedures with

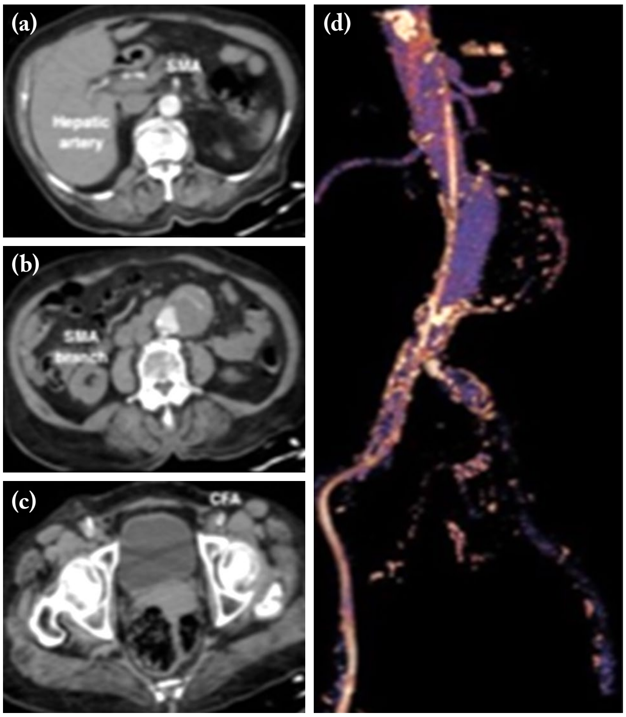

Figure 1. An example for IQS 2. TA-CTA images performed on an 86-year-old woman with an abdominal aortic aneurysm and chronic kidney disease before EVAR. On axial images, distal branches of visceral arteries and femoral arteries can be seen, as well as aorta. **(a)** Superior mesenteric artery and hepatic artery can be seen. **(b)** Superior mesenteric artery branch can be seen. **(c)** Common femoral arteries can be seen. **(d)** Not an enough quality for volume rendered image.

TA-CTA: Transarterial computed tomography angiography; EVAR: Endovascular aortic aneurysm repair.

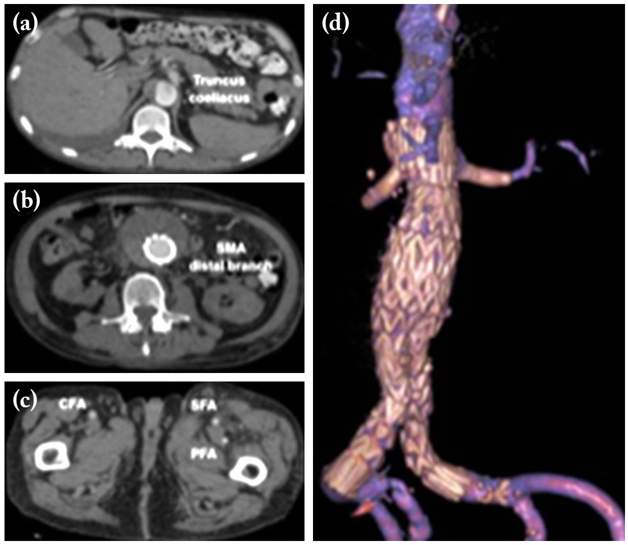

Figure 2. An example for IQS 3. TA-CTA images which was performed on a 65-year-old man with an abdominal aortic aneurysm and chronic kidney disease after EVAR. On axial images, distal branches of visceral arteries and femoral arteries can be seen, as well as aorta, but only proximal segments of visceral arteries and iliac arteries are seen, as well as aorta, on the axial and volume rendered images. **(a)** Truncus coeliacus and its branches can be seen. **(b)** Superior mesenteric artery and its distal branches can be seen. **(c)** Common femoral arteries and its branches can be seen. **(d)** Only proximal segments of visceral arteries and iliac arteries can be seen on volume rendered images.

TA-CTA: Transarterial computed tomography angiography; EVAR: Endovascular aortic aneurysm repair.

IQS 2. The mean IQS of Observer 1 was 3.52 and of Observer 2 was 3.47. Only one TA-CTA procedure was scored differently. The intra-observer agreement was 94% (Figure 1 and 2).

Among four thoracoabdominal TA-CTA procedures, in which 16 mL of contrast agent was used, three had IQS 4 and one had IQS 2. Among 13 abdominal TA-CTA procedures, in which 8 mL of contrast agent was used, six had IQS 4, five had IQS 3, one had IQS 2, and one had IQS 3.5. There was no statistically significant difference in the mean IQS between the 8 mL and 16 mL groups. The IQS of both observers, the mean IQS, the amount of contrast agent used, and aneurysm types are summarized in Table 4.

Of nine TA-CTA procedures performed for control purposes after EVAR, only one procedure had type 2 endoleak, which was detected by both observers. On CDUS performed after EVAR, type 2 endoleak was detected in the same patient. No endoleak was detected on TA-CTA or CDUS in the remaining procedures.

The mean baseline serum creatinine values were 2.35 (range, 1.34 to 4) mg/dL and the mean baseline eGFR values were 32.2 (range, 16.1 to 56.3) mL/min/1.73 m^2. The highest serum creatinine levels on Days 2-5 and at Months 1-3 was 2.27 (range, 1.2 to 4.4) mg/dL and 2.28 (range, 1.3 to 4.1) mg/dL, respectively. The lowest eGFR values on Days 2-5 and at Months 1-3 were 34.2 (range, 14.4 to 64) mL/min/1.73 m^2 and 34.6 (range, 15.6 to 58.3) mL/min/1.73 m^2, respectively. No significant difference was found in the baseline serum creatinine and eGFR values between the highest serum creatinine values on Days 2-5 and at Months 1-3 and the lowest serum eGFR values on Days 2-5. However, there was a statistically significant difference in the baseline eGFR values and the lowest eGFR values at Months 1-3 and this difference was also seen in the eGFR values. All kidney function test results before and after the procedures are presented in Table 5.

None of the patients had a serum creatinine level of ≥25% on Days 2-5 compared to baseline

TABLE 4
Aneurysm types, amount of contrast material used, and image quality scores

No	Type of aneurysm	Contrast amount used (mL)	Observer 1 Image quality score	Observer 2 Image quality score	Mean image quality score
1	Abdominal	8	4	4	4
2	Abdominal	8	4	4	4
3	Abdominal	8	3	3	3
4	Thoracoabdominal	16	2	2	2
5	Thoracoabdominal	16	4	4	4
6	Abdominal	8	2	2	2
7	Thoracoabdominal	16	4	4	4
8	Abdominal	8	4	4	4
9	Abdominal	8	4	4	4
10	Abdominal	8	4	3	3.5
11	Abdominal	8	3	3	3
12	Thoracoabdominal	16	4	4	4
13	Abdominal	8	4	4	4
14	Abdominal	8	3	3	3
15	Abdominal	8	4	4	4
16	Abdominal	8	3	3	3
17	Abdominal	8	4	4	4
Mean	-	9.88	3.52	3.47	3.495

TABLE 5
Lowest serum creatinine and eGFR values before the procedure, on Days 2-5, and at Months 1-3 after the procedure

No	Basal Cre and e-GFR values (mg/dL; mg/min/1.73 m^2)	Lowest Cre and highest e-GFR values on Days 2-5 (mg/dL; mg/min/1.73 m^2)	Lowest Cre and highest e-GFR values on Months 1-3 (mg/dL; mg/min/1.73 m^2)
1	2.80/22.7	2.76/23.1	2.80/22.7
2	2.86/23.1	2.81/23.6	2.41/24.2
3	2.52/27.4	2.18/32.3	2.93/25.8
4	2.47/28.7	2.82/24.7	2.44/29.1
5	3.00/23.0	2.88/24.1	2.57/27.5
6	1.96/27.3	1.98/25.4	1.62/32.0
7	1.38/55.0	1.40/54.4	1.30/58.9
8	2.00/33.3	1.70/42.4	1.67/43.3
9	1.67/43.3	1.49/49.1	1.53/54.9
10	2.19/31.5	1.82/39.0	2.05/34.0
11	2.46/27.4	2.30/29.6	2.11/32.7
12	1.84/37.4	1.68/41.5	1.79/38.6
13	1.37/53.3	1.44/50.3	1.35/54.0
14	2.84/22.9	2.64/24.9	3.40/18.7
15	3.39/18.7	3.22/19.8	3.40/18.7
16	4.00/16.1	4.40 /14.4	4.10/15.6
17	1.34/56.3	1.20/64.0	1.30/58.3
Mean	2.35/32.2	2.27/34.2	2.28/34.6

eGFR: Estimated glomerular filtration rate.

indicating CIN. A mild decrease was detected in the mean serum creatinine values of 12 procedures. Also, there was a statistically significant difference in the comparison of baseline eGFR values with the lowest eGFR values at Months 1-3. The decrease in serum creatinine values and the difference in eGFR levels was related to the hydration before and after the procedure, NAC treatment, discontinuation of possible nephrotoxic drugs, and the precautions taken to prevent CIN.

Furthermore, there was no statistically significant difference in the evaluation of 8 and 16 mL of contrast agents on the kidney function tests at four different time points (on Days 2-5 and at Months 1-3). All measurements are given in Tables 6 and 7.

DISCUSSION

Radiological imaging studies are needed for follow-up and treatment decision of an aortic aneurysm, which is a disease with a high mortality rate.[5] These radiological imaging modalities should be three-dimensional with a high spatial resolution and contrast enhancement to be used in the decision making of surgical or endovascular treatment methods. In particular, the morphological eligibility criteria of the aneurysms for EVAR procedure should be evaluated, which has been increasingly preferred recently to surgical procedures.

The CTA is a worldwide approved standard method used in the planning and follow-up of endovascular treatment.[1,2] It is well known that contrast agents used in CTA are nephrotoxic and tend to lead to CIN; therefore, morbidity and mortality rates increase leading to longer hospitalization duration and increased medical expenses.[6,7] Patients with aortic aneurysms are more often elderly having other comorbidities. Diabetes mellitus and renal injury are the most common comorbidities in these patients.[5]

TABLE 6
P values obtained from the comparison of baseline serum creatinine and eGFR values with highest serum creatinine and lowest e-GFR values on Days 2-5 and at Months 1-3

1. Parameter	Basal serum creatinine values	Basal serum creatinin values	Basal e-GFR values	Basal e-GFR values
2. Parameter	Highest serum creatinine values on Days 2-5	Highest serum creatinine values on Months 1-3	Lowest e-GFR values on Days 2-5	Lowest e-GFR values on Months 1-3
P value	0.084	0.109	0.061	0.017

eGFR: Estimated glomerular filtration rate.

TABLE 7
P values obtained from the comparison of the changes on renal function of 8 mL and 16 mL of contrast material

1. Parameter	The effect of 8 mL contrast material on creatinine at Days 2-5	The effect of 8 mL contrast material on creatinine at Months 1-3	The effect of 8 mL contrast material on e-GFR at Days 2-5	The effect of 8 mL contrast material on e-GFR at Months 1-3
2. Parameter	The effect of 16 mL contrast material on creatinine at Days 2-5	The effect of 16 mL contrast material on creatinine at Months 1-3	The effect of 16 mL contrast material on e-GFR at Days 2-5	The effect of 16 mL contrast material on e-GFR at Months 1-3
P value	1.00	0.624	0.785	0.412

eGFR: Estimated glomerular filtration rate.

The most important reason for CIN is impaired kidney functions, and another significant risk factor is the amount of contrast agent used.[3,4] Patients with aortic aneurysms are exposed to large amounts of contrast agent during treatment planning, during EVAR, and during follow-up after EVAR. This condition also carries a high risk for the development of CIN in patients with CKD and aortic aneurysms. Thus, alternative imaging methods to CTA are needed to consider in these patients.

All these limitations led us to seek an easy applicable, operator-independent technique which can be used in CKD patients before and after EVAR with a high resolution and sufficient anatomical details and without aggravating the already impaired renal functions or causing new renal injuries. In the present study, we used the TA-CTA technique to overcome these limitations. We obtained sufficient IQS (mean: 3,495) from all 17 TA-CTA procedures. None of the patients developed procedure-related contrast material nephrotoxicity or complications. In 12 procedures, the mean creatinine levels on Days 2-5 after the procedure were lower than the baseline levels, which can be related to the precautions taken to decrease CIN, particularly adequate hydration (saline, sodium bicarbonate infusions) before and after the procedures, erythropoietin treatment in patients with renal anemia (hemoglobin values below 11 g/dL, erythrocyte suspension was replaced), avoiding the unnecessary use of loop diuretics, antibiotics and nonsteroidal anti-inflammatory drugs, discontinuation of angiotensin-converting enzyme inhibitors and/or angiotensin II receptor blockers 24 h before the procedure, preventing hypotension and dehydration, and continuation of regular statin use. There are many studies suggesting that, beside the use of low-dose contrast material, hydration is the most important measure in the protection from CIN.[8] The comparison of baseline serum creatinine and eGFR values with post-procedural short- and long-term serum creatinine and eGFR values showed a significant difference in favor of eGFR values only between baseline and at Months 1-3.

To the best of our knowledge, there is no study similar to ours concerning EVAR planning and follow-up with the use of very low contrast material. However, in a similar study including eight patients with CKD, Isaacson et al.[9] reported that that low-dose iodine TA-CTA was a feasible option for EVAR planning. Also, Joshi et al.[10] used an intra-arterial low-dose contrast agent with CTA in the evaluation of pelvic blood vessels of patients with renal insufficiency

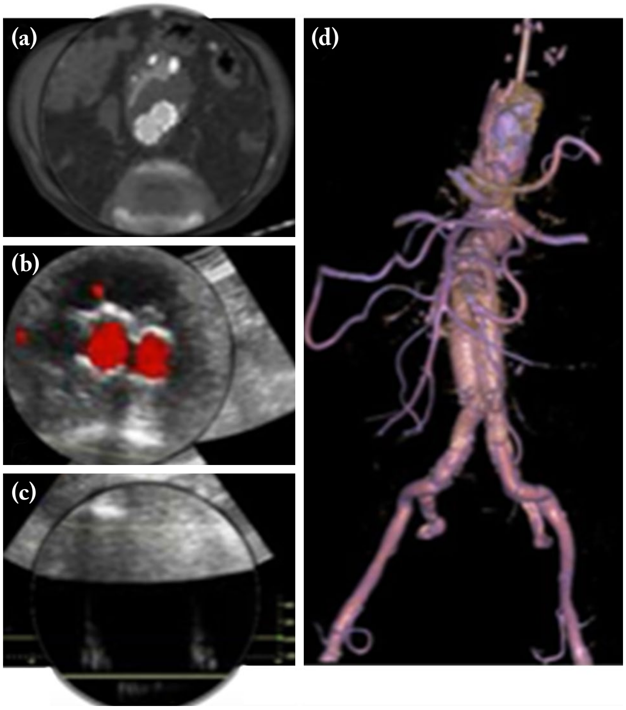

Figure 3. An example for type 2 endoleak and IQS 4. TA-CTA and CDUS images performed on an 80-year-old man with an abdominal aortic aneurysm and chronic kidney disease after EVAR. **(a-c)** Type 2 endoleak can be seen easily in both of axial images, CDUS images, and its spectral analysis. **(d)** Distal branches of visceral arteries and femoral arteries are seen, as well as aorta on the axial and volume rendered images.

TA-CTA: Transarterial computed tomography angiography; EVAR: Endovascular aortic aneurysm repair; CDUS: Color Doppler ultrasound.

undergoing percutaneous aortic valve replacement and they mixed normal saline and 10 to 15 mL of contrast agent with a ratio of 3:1 and 4:1 and, then, injected the mixture through a pigtail catheter which was inserted into the abdominal aorta at the infrarenal level. Prior to the intraarterial CTA, they performed pelvic digital subtraction angiography to ensure the catheter level. The mean baseline eGFR values before the procedure was 54.8±3.9 mL/min/1.73 m^2. The authors conclude that there was no significant difference in the eGFR values before and 72 h after the procedure. In our study, we successfully scanned a larger area with the use of less contrast material (8 and 16 mL) after we placed the flush catheter and also lowered the additional contrast load by avoiding angiography. Furthermore, the mean baseline eGFR value in our patient group was 32.2 mL/min/1.73 m^2, indicating a much lower value.

For the thoracoabdominal and abdominal TA-CTA, we used 16 mL and 8 mL of contrast agent, respectively. There was no statistically significant difference in the renal functions or the IQS between the two doses. However, the non-significant difference between 8 mL and 16 mL contrast agent can be attributed to the length of the area scanned. The non-significant difference on renal functions between the two doses suggests that 16 mL of contrast agent can be safely used in TA-CTA with a better image quality.

The insufficient amount of contrast used in the detection of type 2 endoleak caused by retrograde reflux after EVAR in control patients may be a limitation to the present study. To eliminate this deficit, we performed additional CDUS on the control group after EVAR. Type 2 endoleak was detected in only one patient by CDUS. The endoleak detected on CDUS was also clearly visible on TA-CTA (Figure 3).

In general, the amount of contrast agent used during EVAR is very high. It would be appropriate to lower the use of contrast during imaging methods and to use techniques that would lower the amount of contrast used during procedures in CKD patients, as in our study. For this purpose, among the endovascular abdominal aortic repair methods, stenting and renal artery catheterization technique with carbon dioxide (CO_2) has come to the forefront.[11] The CO_2 is a gas with negative contrast features. Aortic stent procedure with CO_2 is a safe and successful method. Due to the low contrast resolution of CO_2, special post-processing software and automatic gas injectors providing continuous gas infusion are necessary.[12] Aortic stent procedure takes longer; therefore, the amount of radiation received increases. The most important theoretical risks are stroke and ischemia of the spinal cord in supradiaphragmatic use.[13] In addition to being an inexpensive negative contrast material, there is no CO_2 tube regulator system for pressure regulation during injection in Turkey and, therefore, its use is not widespread in our country.

In a study conducted by Canyigit et al.,[14] the renal artery catheterization technique was used in 16 patients with impaired renal functions, and no significant difference was found in the serum creatinine and eGFR values before and 72 h after the procedure. The technique is based on catheterization of the renal artery with Simmons catheter without the use of contrast and the renal artery level is localized without the use of aortography. Thus, the use of high amount of contrast material for the detection of renal artery level during EVAR and the repeated use of aortographies for distance determination while first placing the stent is not required. In the aforementioned study, the lowest possible amount of contrast material was used and the procedure was completed. The risk of CIN was minimized by intravenous hydration before and after the procedure. Of note, in CKD patients with aortic aneurysms, the use of lowest possible contrast dose is of utmost importance during diagnosis, treatment, and follow-up to minimize the risk of CIN.

Main limitation in our study was the low number of patients.

In conclusion, the TA-CTA obtained with diluted low-dose contrast material in CKD patients with an aortic aneurysm is an invasive, but safe and easy-to-use method which provides sufficient anatomical details without causing CIN risk. Further large-scale, prospective studies are needed to confirm these findings.

Declaration of conflicting interests

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