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# Virtual Angioscopy in the Assessment of Vascular Invasion: Is it More Reliable than CT Angiography?

# Vasküler İnvazyonların Değerlendirilmesinde Sanal Anjioskopi:BT Anjiografiden Daha Güvenilir midir?

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## ABSTRACT

**Background:** Vascular invasion is possible with bone-and soft tissue tumors like in the other malignant neoplasms. Anymore, it is possible to search the vascular bundle encasement or invasion by conventional axial sections and reconstructed MPR-3D images (MDCT-angiography). It is important to notice the early findings of any invasion. Prompt recognition of the invasion, early operation (stent-graft application or re-anastomosis) can reduce morbidity rate significantly. The aim of this study was to report the different findings that can be visualized with three-dimensional (3D) image, virtual angioscopy in the evaluation of the tumor and vessel relationship.

**Material and Method:** Four patients with different tumors were evaluated with CT angioscopy to demonstrate their relationship with vessels.

**Results:** CT angioscopy images were demonstrative with adequate quality and did not show occlusion of a major vessel. However displacement of vessel due to compressinn and wall irregularity in apatient was apparent.

**Conclusion:** 3D imaging with virtual angioscopy will be helpful to evaluate the relation of the tumor and vessels. It can lead to surgeons before surgery.

**Key words:** *Virtual Angioscopy, Multi-detector row CT, Vasculary invasion*

## ÖZET

**Amaç:** Vasküler invazyon diğer tümörlerde olduğu gibi kemik ve yumuşak doku tümörlerinde de görülür. Damarların yaşlanması, yakınlığı ya da invazyonu konvansiyonel aksiyel kesitlerde ve rekonstrükte edilen MPR-3D görüntülerle

(MDCTanjiyografi) araştırılabilir. Erken invazyon varlığı önemlidir. İnvazyonun erken tanısı, erken ameliyat (stent-greft uygulaması ya da yeniden anastomoz) morbidite oranını düşürür. Çalışmamızın amacı tümör-damar ilişkisini sanal anjioskopi, 3 boyutlu görüntüleme ile değerlendirmesi ile değişik bulguların da ortaya konulabilirliğini göstermektir.

**Gereç ve Yöntem:** Tümör damar ilişkisi olan 4 tümörlü hasta değerlendirildi.

**Sonuçlar:** Tüm hastalarda CT raporları tümör va damar ilişkisi hakkında bilgi yoktu. Vakalarda büyük damar tıkanıklığına rastlanılmadı.

**Yorum:** Sanal anjioskopi ile 3D görüntüleme damar tümör ilişkisini belirlemede yardımcı olacaktır. Bu durumda ameliyat öncesi cerrahlar için yol gösterici olabilir.

**Anahtar Sözcükler:** *Sanal anjioskopi, Multidedektör CT, Damar invazyonu*

## INTRODUCTION

Computed tomographic angioscopy (CTA) has gained wide clinical acceptance as a powerful diagnostic tool in the non-invasive evaluation of vascular disorders. Virtual angioscopy can be also used as a supplemental technique for a better definition of anatomic details according to the conventional angiography and CT angiography (1,2). This technique allows exploration of the inner surfaces of the lesion and related vessels. It may add important and useful details for the final diagnosis.

We evaluated usefullness of virtual angioscopy in demonstrating vascular invasion, wall integrity in tumoral lesions.

## MATERIAL AND METHODS

We retrospectively reviewed four patients (2 male, 2 female) who had tumor lesions (tibial osteosarcoma, undifferentiated chondrosarcoma, ulcerated duodenal adenocarcinoma, locally agressive and malignant feocromocytoma) images for this study.

All patients were studied with multidedector CT scanners (two patients with 16 slice and two patients with 64x2 slice MDCT) using the following parameters: detector collimation, 0.625 mm; pitch, 1.75 and 1.75; slice thickness, 1.25 mm; reconstruction interval, 1 mm; gantry rotation time, 0.5 sec; injection to scanning delay was determined using bolus tracking method. A 20-gauge intravenous catheter was placed into an antecubital vein for all patients. A 110-mL bolus of iodinated contrast medium (350 mg I/mL) was injected with an automatic power injector at the rate of 4.5 mL/s. CT acquisition of image data was initiated after determining the bolus arrival (bolus tracking method). All data and CT angiograms, reconstructed thin section axial images and data transferred to 3D post-processing special workstation (Philips, Extended Brilliance TM Workspace, and Release 2.0.11).

Three-dimensional images were obtained using volume rendering and maximum intensity projections. With the guidance of the MPR images virtual angioscopy examinations also has done with using the same software. 3D postprocessing techniques (CT angiography techniques) were used to produce images that simulate conventional angiograms. Also these CT data sets were also used to create intraluminal images (by fly-through technique), thereby generating virtual vascular endoscopic studies.

## RESULTS

The tumors of the four patients we studied were tibial osteosarcoma, undifferentiated chondrosarcoma, ulcerated duodenal adenocarcinoma, and a locally agressive malignant feocromocytoma.

CT angioscopy of the patients did not reveal any occlusion of the neighbouring arteries near the tumors. All features and

images of the cases were demonstrated in figures (Figure 1-4).

## DISCUSSION

Technological revolution allows progress of medicine. Invasive technique starts give place to non-invasive. Virtual colonoscopy was used in 1994. Since its description in 1994, CT colonography is rapidly evolving as a method of colorectal evaluation. It has been proposed as an alternative, minimally invasive procedure. It found that useful to evaluate for screening of colorectal cancer (3). On the other hands, virtual angioscopy was started to use in radiology department. Recent advances in CT technology improve the image quality and diagnostic performance of the procedure in the vascular system. In our study, we evaluated to explain tumor-vessel relation which extracts boundary region between the contrast media filled in the vascular lumen and lesion.

Helical CTA generated virtual intravascular endoscopy (VIE) is a rapidly evolving technology that permits interactive two-dimensional (2D) and three-dimensional (3D) visualization techniques (4,5). But the final image quality is determined by several factors including slice thickness, pitch and image reconstruction interval. However, the acquisition step of CTA sets fundamental limits on the entire process (6). Virtual angioscopy is useful for detection of ulcerations, the assessment of the origin of visceral arteries, as well as the lumen of the aorta and its branches This method usually used to view of vessels in brain, liver, pancreas and heart (7,8,9,10,11). With this technique, endoluminal and vessel fly-through views can be created by using the data sets obtained by multislice computed tomography and MR scans (12). The technique is similar to using a camera to look inside vessels (Fig 1-6).

This non-invasive method is available for screening inoperability or operability in suitable patients and it improved our surgical results by improving visualization and increasing surgical orientation. It can be very helpful to surgeons during surgery and may reduce post-surgical complications. The use of 3D vascular reconstructions gives the surgeons a volumetric picture of the surgical area and a more detailed vascular map in comparison to conventional angiography. Brennan et al (13) show that, three-dimensional reconstructed angiographic images are used to identify arterial variants for the surgeon as part of the preoperative radiologic assessment of pancreatic and ampullary tumors in Whipple operation. In addition to displaying vascular anatomy, it is possible to evaluate the soft tissue and osseous anatomy with MDCT-angioscopy which is important for surgical planning (14). In our pediatric patient who have trouble with right tibial osteosarcoma. There is contrast enhancement through the posterior deep compartment muscle groups. No sign of vasculary invasion was seen. Also CT angioscopy images show the tibioperoneal bifurcation and posterior tibial arteries have excellent endoluminal surfaces.

Abdominal computed tomographic angiography (CTA) is increasingly performed since the development of helical computed tomography (CT) and this technique has proved to be greatly valuable for various conditions such as pre-operative evaluation for liver, pancreas, and abdominal aorta, vena cava and portal vein (2,15). When it use to evaluate aorta and iliac artery, it usually helpful to the explain complications such as endoleak, graft migration, thrombosis, or angulation of the endograft component in Abdominal aorta and iliac arteries. Slow endoleaks are mostly detected on delayed scans. Many authors have proposed that MD-CTA is the imaging modality of choice for the pre- and post-operative assessment of abdominal aortic aneurysms, thus replacing digital angiography (16,17).

This virtual method should contribute to preoperative planning to achieve safe, curative resection in HCC patients, whose hepatic function is compromised. Assessments of portal vein, inferior cava vein and suprahepatic veins anatomies are necessary for planning the best liver resection technique. It has become the imaging modality of choice as pre-operative planning for hepatic resection, liver transplantation (18). The use of sophisticated rendering methods as a tool in preoperative imaging is well established in the field of solid-organ transplantation imaging, particularly of the liver (19) and kidney (20). On the other hand, we know that, invasion of the superior mesenteric artery is one of the contradictions for surgery in pancreatic cancer and we cannot see SMA clearly ever time in abdominal tomography (21). Surgical resection is recommended for this group of patients and provides the best option for long-term survival (22). Preoperative knowledge of the anatomic variability variants in the arterial supply to this region is important. Although conventional axial imaging has been used in preoperative planning, the use of 3D reconstruction augments the ability to evaluate arterial anatomy (13). 3D reconstructions are better than axial images for prediction of successful pancreatic resection (23).

Patient who has ulcerated duodenal adeno-carcinoma is evaluated by abdominal CT, and showed the arterial and venous mesenteric vessels as normal, invasion was not found. After then, invasion and calibration lost was found in 3D images (Fig 3-4). CT angioscopy of the SMA was normal, but venous CT angioscopy targetted through the SMV well delineated the invasion by showing progressive luminal narowing and increasing endoluminal surface irregularity. VR-3D portovenous phase image points the heterogenous tumor area hiding invasion location. Retrospectively created saggital MIP image reveals all of the abnormally encased SMV. Surgeons made diagnostic laparotomy and they found invasion in this patient. Like this case, axial continuous arterial phase sections show the normal luminal enhancement of the SMA in evaluation of a patient who has malign and locally aggressive feocromocytoma. Perivasculary fat strands and increased density represents the infiltration. At the virtual angioscopy images, we can see the deterioration of the endoluminal surface regularity through the SMA in contrast to celiac artery (Fig 5). Although MRI, sonography, and endoscopic sonography have been used to assess for local resectability, MDCT allows a prompt recognition of the vascular invasion and different computerized reconstruction techniques as maximum intensity projection (MIP), multiplanar reformatting (MPR) and virtual angioscopy (VA) added imaging information for treatment (13). Moreover, we think that, MDCT renders the possibility of searching the endoluminal contours of hollow organs by virtual angioscopy technique. So, physicians can evaluate inner vessel fly-through views and may discuss to operability of tumor. In first patient, he was undifferentiated chondrosarcoma. There is an elongation of femoral artery near the tumor, but arterial phase axial section shows the infiltrative soft tissue mass (encircled area) with encasement of the common femoral artery at posterior site. 3D view was marked tumor infiltration by arrows for the guidance of fly-through virtual angioscopy images. It shows obvious luminal surface irregularity and vegetation to the endoluminal space (Fig 1, 2).

In conclusion, the results of this study support that MDCT-based virtual angioscopy may be helpful for delineation the tumor-vessel relationship in clinic evaluation. Using a 3-D imaging method by multidedector CT virtual angioscopy views of various conditions were compared preoperatively with this study.

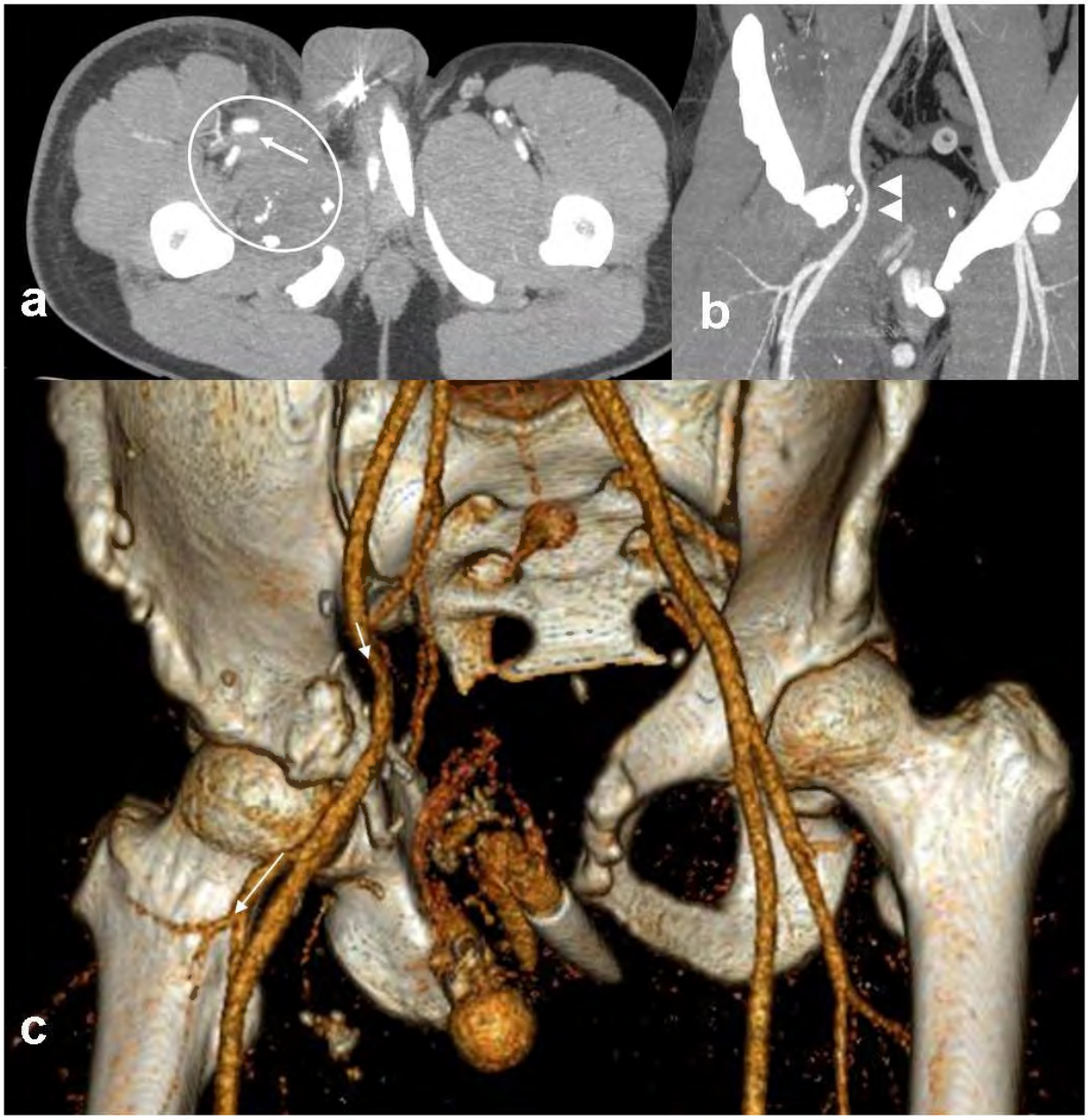


***Figure 1:*** *Undifferentiated chondrosarcoma (male, 34 years, with 16 slice MDCT). a) Arterial phase axial section shows the infiltrative soft tissue mass (encircled area) with encasement of the common femoral artery, posteriorly (arrow). b) Coronal plane thick section MIP image delineates the narrowed segment of the same artery (arrowheads). c) 3-Three-dimensional VR image of the pelvic arteries. Points of view were marked by arrows for the guidence of fly-through virtual angioscopy images.*

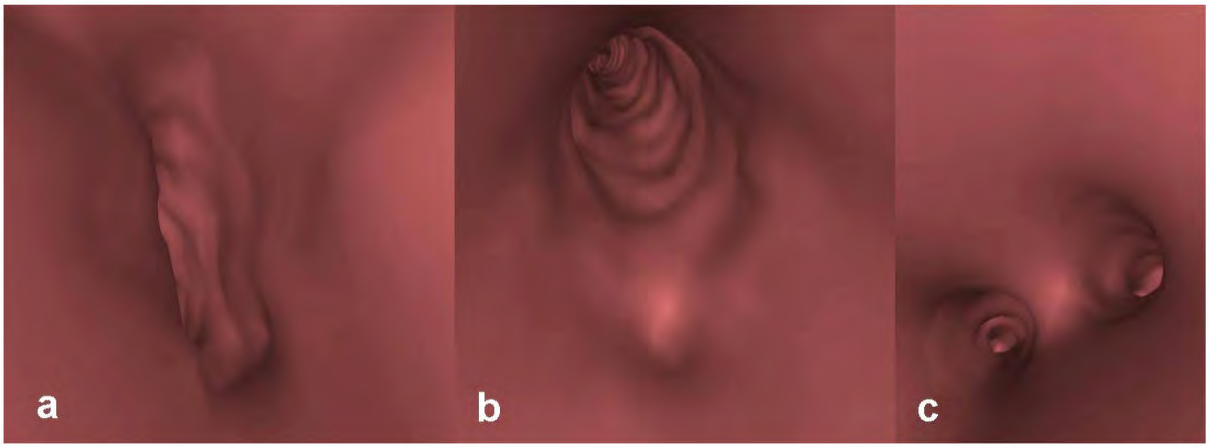


***Figure 2:*** *Virtual CT-angioscopy images of the same patients at figure 1 a) View from the narrowed segment (short arrow at figure 1c) shows obvious luminal surface irregularity and vegetation to the endoluminal space. b) Distal to the affected narrow segment also shows less obvious irregularity of the endoluminal surface. c) View from the deep femoral artey at bifurcation of this vessel (long arrow at figure 1c), shows the excellent sharp and regular vessel endoluminal surface.*

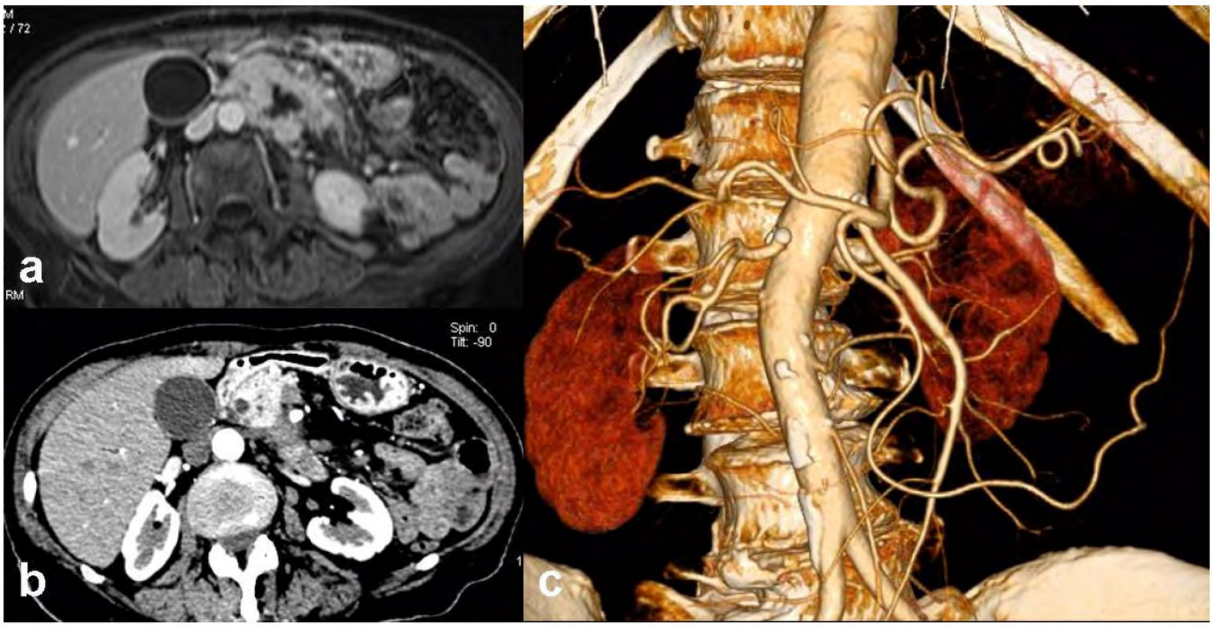


***Figure 3:*** *Ulcerated duodenal adenocarcinoma (female, 68 years, with 64x2 slice MDCT). Contrast enhanced T1w axial sequence (a) and contrast enhanced axial CT (b) section and also VR-3D image (c) show the arterial and venous mesenteric vessels as normal.*

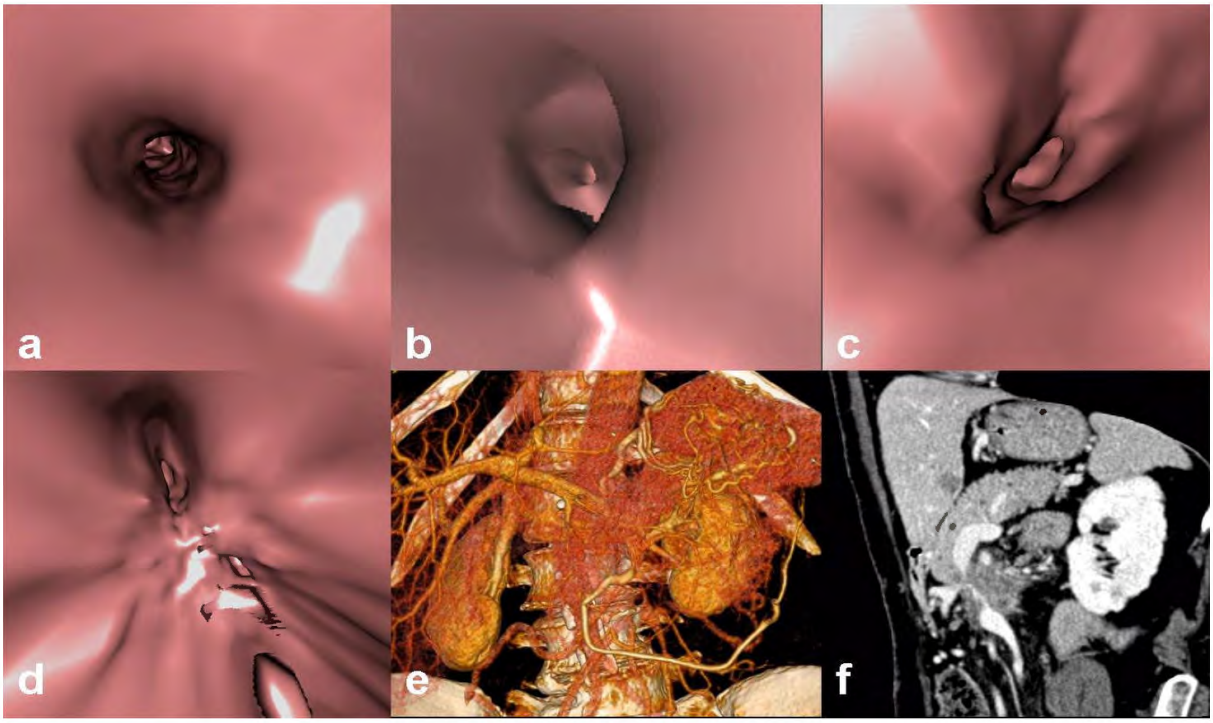


***Figure 4:*** *In the same patient at figure 3, CT angioscopy of the SMA was normal (a). But venous CT angioscopy targetted through the SMV well delineated the invasion (b, c, d) by showing progressive luminal narowing and increasing endoluminal surface irregularity. VR-3D portovenous phase image (e) points the heterogenous tumor area hiding the invasion location. Retrospectively created saggital MIP image (f) reveals all of the abnormally encased SMV.*

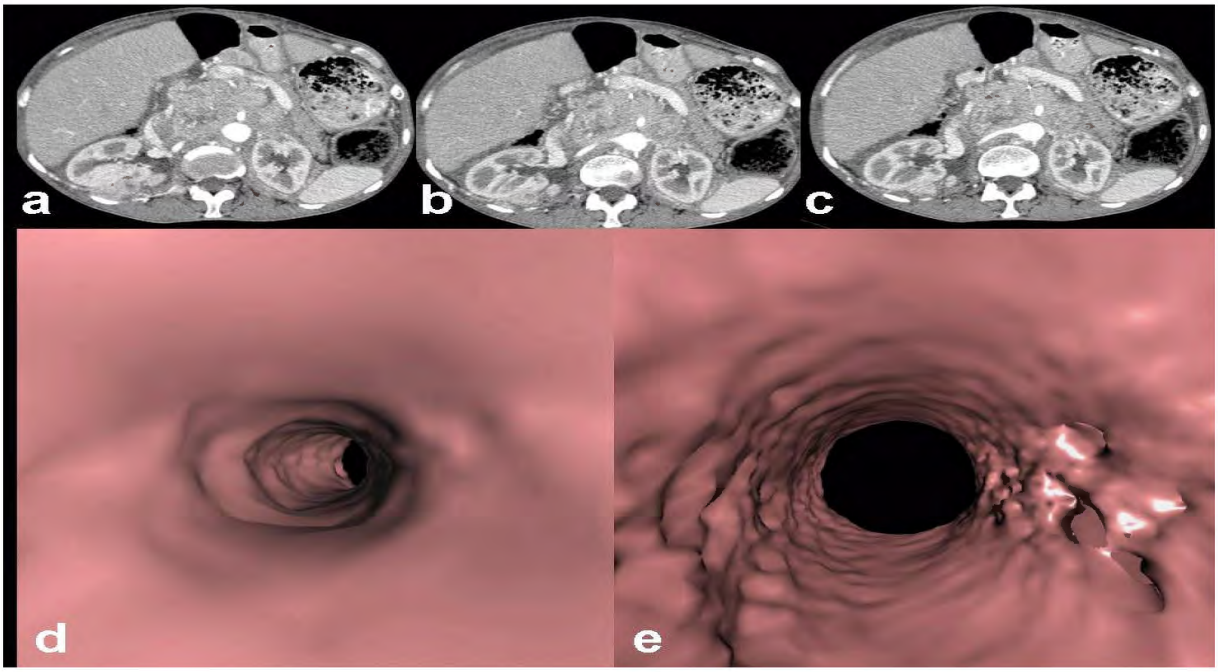


***Figure 5:*** *Locally agressive and malignant feocromocytoma (female, 59 years, with 64x2 slice MDCT). Axial continuous arterial phase sections (a, b, c) show the normal luminal enhancement of the SMA. Perivasculary fat strands and increased density represents the infiltration. At the virtual angioscopy images, we can see the deterioration of the endoluminal surface regularity through the SMA in contrast to caeliac artey (d, e).*

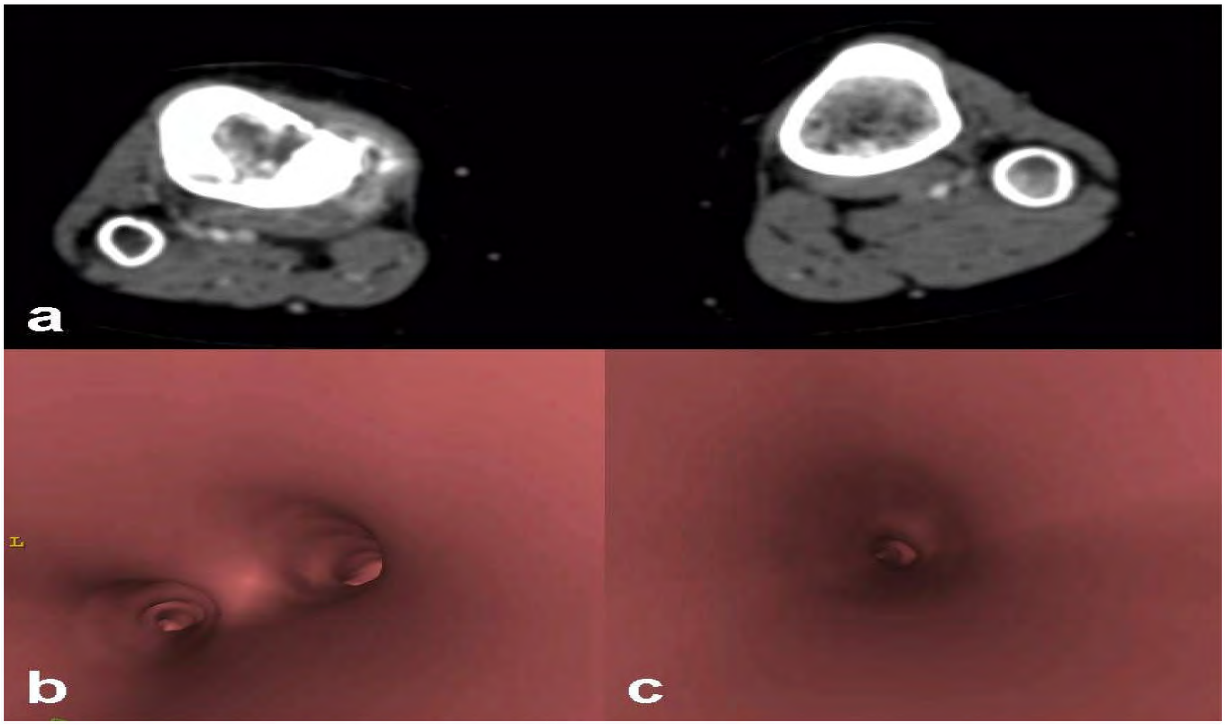


***Figure 6:*** *Pediatric patient who have trouble with right tibial osteosarcoma (female, 14 years, with 16 slice MDCT). a) There is contrast enhancement through the posteromedial deep compartment muscle groups in axial section. No sign of vasculary invasion was seen. b) Also CT angioscopy images show that the tibioperoneal bifurcation and posterior tibial arteries have excellent endoluminal surfaces.*

## REFERENCES


*1) Armerding MD, Rubin GD, Beaulieu CF, Slonim SM, Olcott EW, Samuels SL, Jorgensen MJ, Semba CP, Jeffrey RB Jr, Dake MD. Aortic aneurysmal disease: assessment of stent-graft treatment-CT versus conventional angiography. Radiology 200;215:138– 46.*

*2) Brink JA. Spiral CT angiography of the abdomen and pelvis: interventional applications. Abdom Imaging 1997;22:365–372.*

*3) Ekçi B, Gökçe Ö. Kalın barsağın değerlendirilmesinde sanal kolonoskopinin yeri. Klinik Aktuel Tıp, Gastroenteroloji Forum 2008;2: 46-50.*

*4) Sun Z, Allen YB, Nadkarni S, Knight R, Hartley DE, Lawrence-Brown MM. CT virtual intravascular endoscopy in the visualization of fenestrated stent-grafts. J Endovasc Ther. 2008;15:42-51.*

*5) Bartolozzi C, Neri E, Caramella D. CT in vascular pathologies. Eur Radiol 1998;8:679–84.*

*6) Whiting BR, McFarland EG, Brink JA. Influence of image acquisition parameters on CT artifacts and polyp depiction in spiral CT colonography: in vitro evaluation. Radiology 2000;217:165–72.*

*7) Rosahl SK, Gharabaghi A, Hubbe U, Shahidi R, Samii M. Virtual reality augmentation in skull base surgery.Skull Base. 2006 May;16(2):59-66.*

*8)Raabe A, Beck J, Rohde S, Berkefeld J, Seifert V. Three-dimensional rotational angiography guidance for aneurysm surgery. J Neurosurg. 2006;105:406-11.*

*9) Uchida M, Ishibashi M, Sakoda J, Azuma S, Nagata S, Hayabuchi N. CT image fusion for 3D depiction of anatomic abnormalities of the hepatic hilum. AJR Am J Roentgenol. 2007;189:184-91.*

*10) Endo K, Sata N, Shimura K, Yasuda Y. Pancreatic arteriovenous malformation: a case report of hemodynamic and three-dimensional morphological analysis using multi-detector row computed tomography and post-processing methods.JOP. 2009;10:59-63.*

*11) Hu XH, Huang GY, Pa M, Li X, Wu L, Liu F, Jia B, Li GP. Multidetector CT angiography and 3D reconstruction in young children with coarctation of the aorta.Pediatr Cardiol. 2008;29:726-31.*

*12) Carrascosa P, Capuñay C, Vembar M, Ciancibello L, Carrascosa J. Multislice CT virtual angioscopy of the abdomen. Abdom Imaging 2005;230:249–58.*

*13) Brennan DD, Zamboni G, Sosna J, Callery MP, Vollmer CM, Raptopoulos VD, Kruskal JB. Virtual Whipple: preoperative surgical planning with volume-rendered MDCT images to identify arterial variants relevant to the Whipple procedure. AJR Am J Roentgenol. 2007;188:451-5.*

*14) Kato Y, Sano H, Katada K, Ogura Y, Kanaoka N, Yokoyama T, Kanno T. Clinical usefulness of 3-D CT endoscopic imaging of cerebral aneurysms.Neurol Res. 1996;18:98-102.*

*15) Guven K, Acunas B. Multidetector computed tomography angiography of the abdomen. Eur J Radiol 2004;52:44–55.*

*16) Willoteaux S, Lions C, Gaxotte V, Negaiwi Z, Beregi JP. Imaging of aortic dissection by helical computed tomography (CT). Eur Radiol 2004;14:1999–2008.*

*17) Rydberg J, Kopecky KK, Lalka SG, Johnson MS, Dalsing MC, Persohn SA. Stent grafting of abdominal aortic aneurysms: pre- and postoperative evaluation with multislice helical CT. J Comput Assist Tomogr 2001;25:580–586.*

*18) Yamanaka J, Saito S, Fujimoto J. Impact of preoperative planning using virtual segmental volumetry on liver resection for hepatocellular carcinoma. World J Surg. 2007;31:1249-55.*

*19) Kamel IR, Kruskal JB, Keogan MT, Goldberg SN, Warmbrand G, Raptopoulos V. Multidetector CT of potential right-lobe liver donors. AJR 2001;177:645–651.*

*20) Kawamoto S, Montgomery RA, Lawler LP, Horton KM, Fishman EK. Multidetector CT angiography for preoperative evaluation of living laparoscopic kidney donors. AJR 2003; 180:1633–1638.*

*21) Brugel M, Rummeny EJ, Dobritz M. Vascular invasion in pancreatic cancer: value of multislice helical CT. Abdom Imaging 2004;29:239–245.*

*22)Yeo CJ, Cameron JL, Sohn TA, Lillemoe KD, Pitt HA, Talamini MA, Hruban RH, Ord SE, Sauter PK, Coleman J, Zahurak ML, Grochow LB, Abrams RA. Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. Ann Surg 1997; 226:248–257*

*23)Raptopoulos V, Steer ML, Sheiman RG, Vrachliotis TG, Gougoutas CA, Movson JS. The use of helical CT and CT angiography to predict vascular involvement from pancreatic cancer: correlation with findings at surgery. AJR 1997;168:971–7*