ORIGINAL

Visualization of Lumbar Artery Variations by Contrast-Enhanced Multi-detector Row Computed Tomography

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Abstract : Purpose : This study was designed to identify the anatomical variations of lumbar arteries on contrast-enhanced multi-detector row computed tomography (MDCT). Materials and Methods : Consecutive 100 colon cancer patients underwent preoperative 3-dimensional navigation studies, which include CT colonography (CTC) and CT angiography (CTA) for evaluation of anatomical relationship between the colon cancer and mesenteric vasculatures. After exclusion of inappropriate cases, 84 cases (33 women and 51 men ; mean age, 64 years) were finally analyzed. The visualization of lumbar arteries from the CTA was scored based on the agreement of two radiology specialists. Also the presence or absence of left and right common trunk of each lumbar artery was evaluated. Results : Visualization scores on both sides of L1 were significantly lower than those of L2-L4. No significant difference could be found on visualization of L1 lumbar arteries between the young and the elderly group. The common trunk tended to be in the lower lumbar levels (L1 in 2.4%, L2 in 9.5%, L3 in 11%, and L4 in 23%). Conclusion : The development and variation of lumbar arteries can be evaluated with CTA. Furthermore, CTA can provide sufficient anatomical information on variations of the lumbar arteries prior to surgery or catheterization. J. Med. Invest. 63 : 45-48, February, 2016

Keywords : *lumbar region, CT colonography, CT angiography, interventional radiology*

INTRODUCTION

Anatomical variations in lumbar arteries should be identified to avoid the risk of damage during surgery or catheterization. In addition, this information is required for embolization of the lumbar arteries to treat vertebral body tumors and aortic stent graft placement-in which serious complications such as postoperative endoleak are sometimes reported (1-7).

Some of the variations are anastomoses, presence of a common trunk of the right and left lumbar arteries, and association with the main feeding vessels of the spinal cord. In addition, prior knowledge of these variations is essential for fast and safe procedures. Decades ago, detailed vascular anatomy was difficult to grasp, except during autopsy. However, since the performance of multi-detector row computed tomography (MDCT) has progressed in recent years, the capability of visualizing thin blood vessels has dramatically improved.

CT colonography (CTC) has been recently used as one of the colon imaging modalities. It permits detection and evaluation of diseases of the large intestine by 3-dimensional (3D) reconstruction and computed imaging including virtual endoscopy using digital CT data, without the need for invasive real endoscopy. Compared with other colon tests, this study enables fast and painless inspection of the colon and has been recommended for patients in whom insertion of the endoscope is difficult, such as the elderly. A combination CTC with CT angiography (CTA) is applied to preoperative 3D navigation studies for evaluation of anatomical relationship between the site of the colon cancer and mesenteric vasculatures. The flow rate of intravenous administration of contrast agent for CTA imaging is higher (5 ml/s) than other contrast CT examinations. Hence, CTA (i.e. CT arterial phase) can be used for evaluation of arterial anatomy and preoperative simulation.

The visualization of vasculatures in CTA may be useful for evaluation of lumbar arteries, but there has been no report on lumbar arteries with CTA. Since there is a possibility that blood vessels can be evaluated in more detail and by minimally invasive means, we tried to assess the imaging data in this method. We aimed to identify the anatomical variations of lumbar arteries with CTA and evaluate its use for assessment before operations or interventional radiology procedures.

MATERIALS AND METHODS

We recruited consecutive 100 colon cancer patients underwent preoperative 3D navigation studies which include CT colonography (CTC) and CT angiography (CTA) for evaluation of anatomical relationship between the site of the colon cancer and mesenteric vasculatures from April 2012 to April 2013.

The presence of the following factors were set as exclusion criteria because of the difficulty of vascular evaluation : metastatic lesions affecting the lumbar arteries, abdominal aortic aneurysm greater than 50 mm in diameter, vascular malformation of lumbar lesion, and lumbosacral transitional vertebra (i.e., if the vertebral body at the top level is defined as the first lumbar vertebra with no rib and the artery originates from this level to the first lumbar artery). To account for the possible effect of age in the progression of blood vessel stenosis from atherosclerotic changes, the study population was divided into two groups : young (36-65 years) and elderly (66-89 years). The study was conducted with prior approval of the university ethics committee. The CTA examination consisted an arterial phase series and a portal phase series. The data from the arterial phase series were evaluated for the visualization of lumbar arteries and middle sacral artery in this study. Imaging

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was carried out using Toshiba Medical Systems Co., Ltd (*Tochigi, Japan*) on 16 columns of MDCT (Aquilion16), with 300-370 mg/ml of iodinated contrast agent given at 100-150 ml boluses at 5 ml/s and make the injection of boost in 50 ml saline. The arterial phase images (0.5 mm thickness) were captured by the bolus tracking method (Real Prep). Interpretation of lumbar arteries was done by using the coronal interactive sliding slab maximum intensity projection (MIP) method (window width 600±50 HU, window levels 100±50 HU, slab thickness 5 mm, level from the anterior aspect of the aorta to the posterior aspect of vertebral bodies).

Based on the agreement of two radiology specialists, We scored the visualization of lumbar arteries (L1-L4) as follows : 3 points= good appearance : visible arterial course with a large caliber, 2 points=fair appearance : visible arterial course with a moderate caliber, 1 point=poor appearance : visible arterial course with a small caliber , 0 point=absent : invisible arterial course (Figures 1-a, b, and c). In addition, the presence or absence of left and right common stems of each lumbar artery was also evaluated. For branches that were difficult to assess, the axial slab MIP method and the original axial images were added in the evaluation. Figure 2 shows a case which had a common trunk of the lumbar arteries. Student's t-test was performed to compare the average visualized scores of each artery at different sites and the age groups. We've used Excel as a statistical software.

RESULTS

Among 100 consequent patients, one patient was excluded for having vascular malformation and fifteen patients were excluded for having lumbosacral transitional vertebra. The final evaluation included 84 cases : 51 men, 33 women, with a mean age of 64 years (range 36-89, median 65 years) ; there were 47 in the young age group, and 37 in the elderly age group. Evaluations of lumbar arteries (L1-4) were carried out without any major discrepancies between the two observers in all 84 cases. There was no case with severe scoliosis which made the interpretation difficult. Also there were no obvious calcifications or calcified plaques in the lumbar arteries examined. Mean visualization scores for each lumbar artery are presented in Table 1. The scores for arteries on both sides of L1 were significantly lower compared with those of L2-L4. There were no significant differences between the two age groups in terms of lumbar artery visualization score (Table 2). There was almost no correlation between age and visualization score except for right L2 artery (Table 3). Table 4 shows the number of cases that had no lumbar arteries visualized. Significant deviation was

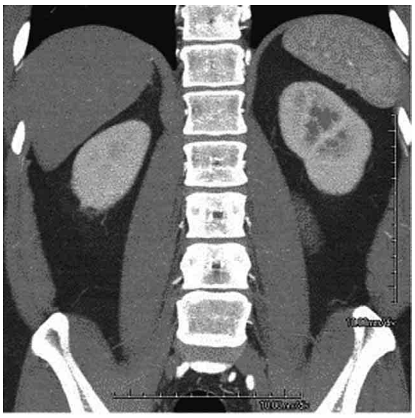

Figure 1-a A 44-year-old man
3 points (good) : Bilateral L1-4 arteries

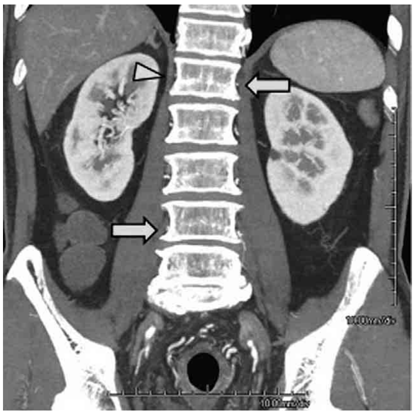

Figure 1-b A 68-year-old man
2 points (fair) : Lt. L1 and Rt. L4 arteries (Arrows)
1 point (poor) : Rt. L1 artery (Arrow head)

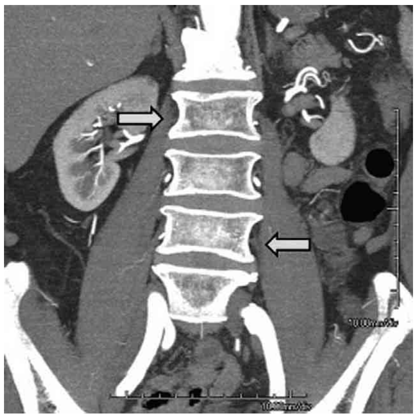

Figure 1-c A 79-year-old man
0 point (absent) : Rt. L2 and Lt. L4 arteries (Arrows)

Figure 1 Visualized scores of lumbar arteries

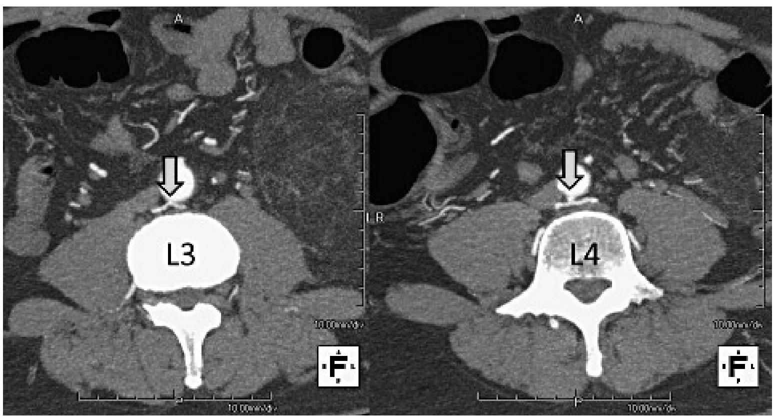

Figure 2 Common trunk in axial MIP image A 54-year-old man
L3 and L4 arteries had a common trunk. (Arrows)

not observed. The number of lumbar arteries with a common trunk (Table 5) was relatively different by 2.38-22.62% at each lumbar artery level. The proportion of arteries with a common trunk was less at a upper level ; L1 arteries had significantly fewer common trunks compared with L2-L4 arteries ($p < 0.05$), and L2 and L3 arteries had significantly fewer common trunks compared with L4 arteries ($p < 0.05$).

Table 1 Visualized scores of lumbar arteries

Region	Mean score±SD (N : 84)	Significant difference of the mean score for the other sites of the artery
Lt. L1 a.	2.44±0.62	*
Rt. L1 a.	2.55±0.68	*
Lt. L2 a.	2.84±0.39	
Rt. L2 a.	2.77±0.50	
Lt. L3 a.	2.94±0.28	
Rt. L3 a.	2.95±0.21	
Lt. L4 a.	2.82±0.56	
Rt. L4 a.	2.83±0.53	

* $P < 0.05$ for both sides L2-4 arteries

Table 2 Visualized scores of lumbar arteries (2 groups divided)

Region	Mean score (younger group)	Mean score (elderly group)	Significant difference between 2 groups
Lt. L1 a.	2.49	2.38	NS (P : 0.43)
Rt. L1 a.	2.60	2.49	NS (P : 0.47)
Lt. L2 a.	2.83	2.86	NS (P : 0.69)
Rt. L2 a.	2.85	2.68	NS (P : 0.13)
Lt. L3 a.	2.98	2.89	NS (P : 0.20)
Rt. L3 a.	2.96	2.95	NS (P : 0.81)
Lt. L4 a.	2.85	2.78	NS (P : 0.61)
Rt. L4 a.	2.77	2.92	NS (P : 0.16)

Table 3 Correlation coefficient between age and visualized score

Region	Correlation coefficient between age	Remarks
Lt. L1 a.	-0.05	almost no correlation
Rt. L1 a.	0.11	almost no correlation
Lt. L2 a.	0.08	almost no correlation
Rt. L2 a.	-0.23	weak correlation
Lt. L3 a.	-0.11	almost no correlation
Rt. L3 a.	-0.05	almost no correlation
Lt. L4 a.	-0.13	almost no correlation
Rt. L4 a.	0.05	almost no correlation

Table 4 Number of cases having no lumbar arteries visualized

Region	Number of cases	Remarks
Lt. L1 a.	1	All other arteries were 3 points in this case.
Rt. L1 a.	2	
Lt. L2 a.	0	
Rt. L2 a.	1	Lt. L4 artery was also 0 point in this case.
Lt. L3 a.	0	
Rt. L3 a.	0	
Lt. L4 a.	2	
Rt. L4 a.	2	

Table 5 Number of cases having a common trunk

Region	Number of cases having a common trunk (percentage of the total)	Significant difference
L1 a.	2 cases (2.38%)	*
L2 a.	8 cases (9.52%)	**
L3 a.	9 cases (10.71%)	**
L4 a.	19 cases (22.62%)	

* Significantly less in $p < 0.05$ for the L2-4
** Significantly less in $p < 0.05$ for the L4

DISCUSSION

Lumbar artery branches come in pairs, the left and right, and the distance between branches correspond to the length of the corresponding vertebral body interval. These arteries run diagonally upward first before traveling obliquely across and branching out to the psoas, abdominal muscles, and around the kidney (8). In this study, the visualization score of the upper lumbar arteries was significantly lower than that of the lower lumbar arteries, regardless of age. Arslan *et al.* (9) observed under a surgical microscope 80 lumbar arteries of 10 male cadavers fixed in formalin. They reported that upper lumbar arteries were slightly narrower than the lower lumbar arteries, findings that were consistent with the results of the present study. The possible influence of the body weight on contrast enhance effects in arteries was compensated for by adjusting the volume of contrast media used according to patient's weight (100 ml if less than 60 kg, 125 ml if 60 kg to less than 70 kg, and 150 ml if 70 kg or more). Also, the time for the contrast agent to reach the lumbar arteries from the start of injection varies among subjects. To address this problem, we used automated bolus tracking method, which monitored the temporal change in CT values of the aorta to determine the scan timing for the arterial phase.

Baniel *et al.* (10) have reported the variation in number of lumbar arteries. Also previous autopsy, operation or angiography studies (8-14) are consistent with the results in the present study. These variation in lumbar arteries may be secondary to arteriosclerosis and other factors. A lumbar level without a corresponding lumbar artery may be covered by branches of other lumbar arteries. In this study, the Adamkiewicz branch of the lumbar arteries was not observed. According to previous studies (15, 16), identification of this artery is sufficient by CTA. There was continuity at the thoracic level in many cases and it is presumed that there was no anatomic association with lumbar artery level.

A prior knowledge of the presence or absence of a lumbar artery common trunk is crucial for any lumbar artery catheterization. In the case of the common stem of lumbar arteries, catheterization of each right or left branch needs careful and shallow insertions. In addition, the prior knowledge of the presence or absence of a lumbar artery common trunk allows quick selection and identification of the vessel in the catheterization, short procedure time and reduced radiation exposure.

In conclusion, CTA is sufficient in the delineation of lumbar arteries, and anatomical characteristics were comparable with past reports on autopsy cases. CTA provide useful information prior to surgery and catheterization.

CONFLICT OF INTEREST

For all authors : No conflicts of interest are declared.

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