Right arm injection of contrast medium reduces venous artifacts in head and neck multislice spiral computed tomography angiography

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Abstract. – **OBJECTIVE:** We tested whether injection of contrast medium via right or left arm would affect venous artifacts on head and neck multislice spiral computed tomography (CT) angiography.

PATIENTS AND METHODS: 326 patients were enrolled. Each patient was injected with 10 ml of contrast medium at 5 ml/sec. Time of peak contrast value plus an additional 1 sec was defined as delay time. Another 40 ml of contrast medium were injected with the same injection speed. The scanning area ranged from the aortic arch to the top of the head. Left and right forearms were used for intravenous injections of contrast medium in, respectively, 151 and 175 patients. Comparative analyses of image quality included determining contrast medium residues remaining in the superior vena cava, brachiocephalic vein, or subclavian vein, and comparisons of quality of three-dimensional CT angiography.

RESULTS: In 75% of head and neck angiographies, the delay time of the common carotid artery ranged from 16 to 22 sec. In 60% of the images, the quality was graded as excellent, with the left arm injection resulting in delay time of > 23 sec and the right arm delay time of > 18 sec. The CT imaging quality after contrast injections via left or right arms was statistically significant ($p < 0.05$). The image quality after right arm injection was better than after left arm injection.

CONCLUSIONS: Intravenous injection of contrast medium via right arm reduces artifacts from contrast medium residues and improves the image quality of head and neck CT angiography.

Key words:
    Computed tomography, X-ray, Angiography, Head and neck artery, Image quality, Contrast medium.

Introduction

Computed tomography (CT) has become an indispensable examination method to study blood vessels. CT shows blood vessels through sectioning, bone removal and three-dimensional reconstruction, and displays vascular lumens, vascular walls and perivascular tissue structures. These structures play an important role in the examination of the head and neck vascular lesions[1-3]. Image artifacts are the main limitation affecting the quality of CT imaging. They convolute the reconstructed data of the image and affect the attenuation coefficient of the object. Notably, image artifacts arise because of machine- and operator-related factors.

During the head and neck CT angiography, artifacts in the superior vena cava, subclavian vein and brachiocephalic vein affect the image quality. Currently, the causes of these artifacts are mostly attributed to breathing, heartbeat, and to concentration and dosage of contrast medium. The solutions proposed by many studies are a decrease of the volume of contrast medium, change of scanning direction, or a rapid injection of contrast medium[4,5]. However, head and neck CT angiography is also determined by the site of contrast medium injection (i.e., via veins of left or right arm)[6,7]. Up to now, very few studies with large sample sizes have evaluated the effects of administration routes of contrast medium on the distribution characteristics of the cervical arteries, and the results have not been clearly stated. Previously, in a small group of patients, we have demonstrated that artifact formation in clinical head and neck CT angiography significantly correlates with the route of contrast medium administration. In the present study with a large group of patients we further evaluated the effects of different routes of contrast medium administration on artifact formation during the head and neck angiography using the multislice spiral CT.

Patients and Methods

Patients

A total of 342 patients who had undergone head and neck dual-source spiral CT angiography (Siemens Definition, Munich, Germany) at the

Department of Magnetic Resonance Imaging, Air Force General Hospital, were enrolled in our study from September 2008 to November 2012. The patient ages ranged from 50 to 65 years. Sixteen patients with thoracic neoplasms, cardiac insufficiency, or postoperative chest diseases were excluded from this study as they might have affected the carotid angiography. Intravenous injections of contrast medium in the left or right arms were respectively performed in 151 and 175 patients.

Equipment

The imaging was done using the SOMATOM Definition Dual-Source spiral CT (Siemens, Munich, Germany), Extravasation Detection Accessory double-syringe power injector, and contrast medium Ultravist 370 (370 mg/ml, Schering AG, Berlin-Wedding, Germany).

Tests

Patients fasted before the CT angiography exam. The injection was done as follows. The patient' left or right forearm was used for a superficial venipuncture using 20-gauge disposable trocars. Then, the patient underwent CT angiography scanning while positioned in the posterior-anterior and lateral position. After marking the position, scanning of the scout layer began from approximately 1 cm above the shoulder to approximately 5 cm from the head to define the monitoring layer in the clear layer of the common carotid artery and common jugular vein. We first used test bolus for the scan, then 10 ml of contrast medium were injected at 5 ml/sec, and a monitoring scan was performed to observe the monitoring. The scan was stopped immediately after enhancement was detected. The monitoring scan sequence was entered into the time-density curve (DnYEL). The analyzing window was used to obtain the time to peak-density curve as a function of the delay time of the artery and vein. The scanning direction was as follows: arterial phase was scanned from distal to proximal (head), whereas venous phase was scanned from proximal (head) to distal direction. After monitoring scan, the initial layer of CTA scan, parameters and delay times were defined. This was followed by injection of 40 ml of contrast medium at 5 ml/sec, after which another scan was started to complete the exam.

Phase optimization was done as follows. The peak value of the common carotid artery time-density curve and an additional 1 sec were defined as the delay time of head and neck angiography. The monitoring scan parameters were axial scan mode, tube current 20 mAs, tube voltage 120 kV, 10 sec delay time from contrast medium injection to the beginning of monitoring scan, monitoring scan at every 0.33 sec (scan time), 1.16 sec cycle time, 1 x 10 mm acquisition mode, and 10 mm layer thickness (slice). The scanning parameters were: spiral pattern (Helical à Spiral), tube current of 200 mA, tube voltage of 120 kV, minimum 3 sec delay time from the axis scan mode of monitoring scan changing to helical scan mode, 0.33 sec tube ball rotation speed, 1.2 pitch, 300 mm scan field of view, 64 x 0.6 mm acquisition mode, 5 mm layer thickness slice, 5 mm layer spacing increment, and 5-6 sec scan time.

Image post-processing

The 5-mm scanned images were overlaid and reconstructed using 0.75-mm thick slices and 0.5 mm layer spacing. The reconstructed images were transferred to a workstation for post-processing.

The arterial phase and unenhanced phase images with 0.75 mm layer thickness were placed into Neuro Dynamic System Analysis (DSA) window. The software processed the silhouettes automatically. The silhouette sequences went through the head and neck CT angiography reconstruction and were used for vascular analysis with application of volume rendering, maximum intensity projection, curve planar reconstruction, multiplanar reconstruction, and InSpace software methods.

Table I. Demographic data of 326 study patients.

Parameters	Contrast medium injection via left arm	Contrast medium injection via right arm	*p*
Age (full years)	54.7 ± 0.8	55.5 ± 0.9	> 0.1
Male/female gender	16/14	15/15	
Body weight (kg)	60.5 ± 9.1	59.2 ± 8.2	
Body height (cm)	167.9 ± 9.2	166.3 ± 9.0	
Body mass index, BMI	21.9 ± 2.0	22.5 ± 3.0	
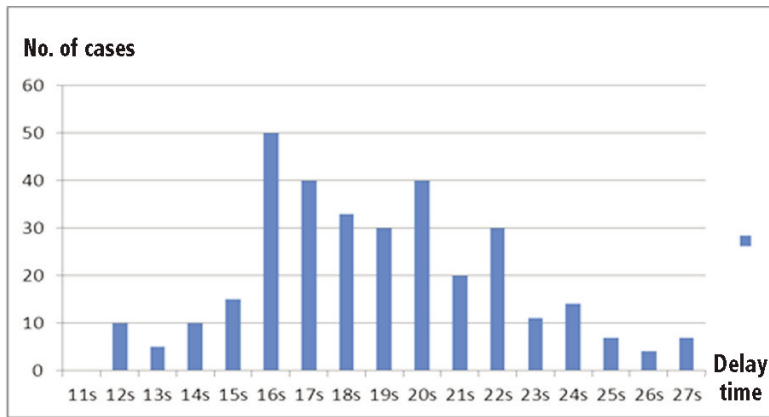
Figure 1. Distribution of delay time in the common carotid artery in 326 patients during head and neck CT angiography.

Image evaluation

After the image silhouettes were prepared, superior vena cava, brachiocephalic vein, and subclavian vein were observed for contrast medium residues that could lead to artifacts on the angiograph. The image quality was classified as follows: excellent (no artifacts appear in the superior vena cava, brachiocephalic vein and only slight residues are seen in the subclavian vein), good (no artifacts are detected in the superior vena cava, but artifacts are present in the brachiocephalic and subclavian veins), and poor (artifacts present in the superior vena cava, brachiocephalic vein and subclavian vein).

Statistical Analysis

The findings were evaluated by two experts, and statistical analysis was performed according to the medical information. The SPSS17.0 statistical software (SPSS Inc., Chicago, IL, USA) was used to analyze the data. Differences between groups were assessed by the Wilcoxon rank-sum test. The $p < 0.05$ was considered as indicating statistically significant difference.

Results

This study included 326 patients: 179 male and 147 female patients, ages ranging from 50 to 65 years ([mean ± SEM] age of 55.16 ± 0.93 years). There was no significant difference between the patients who received contrast medium via the left or right arm (Table I). The delay time of the common carotid arteries in these patients showed that this parameter in most (75%) patients) ranged from 16 to 22 sec (Figure 1). The distribution of the image quality in patients who received contrast medium via left or right arm is shown in Figures 2 and 3. Sixty percent of the images were graded as having excellent quality, with left arm delay time of >23 sec (Figure 2) and right arm delay time >18 sec (Figure 3). These differences were statistically significant (Table II).
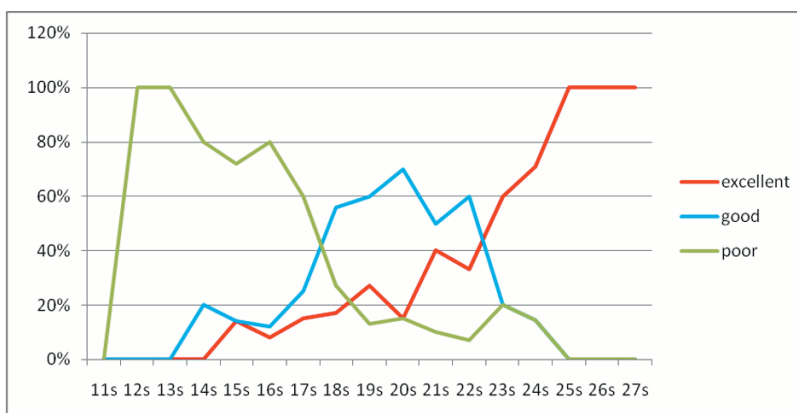
Figure 2. Imaging quality in patients after contrast medium injection via left arm. Sixty percent of images achieve excellent quality grade with the left arm delay time of > 23 sec.

Figure 3. Imaging quality in patients after contrast medium injection via right arm. Sixty percent of the images achieve excellent quality grade with the right arm delay time of > 18 sec.
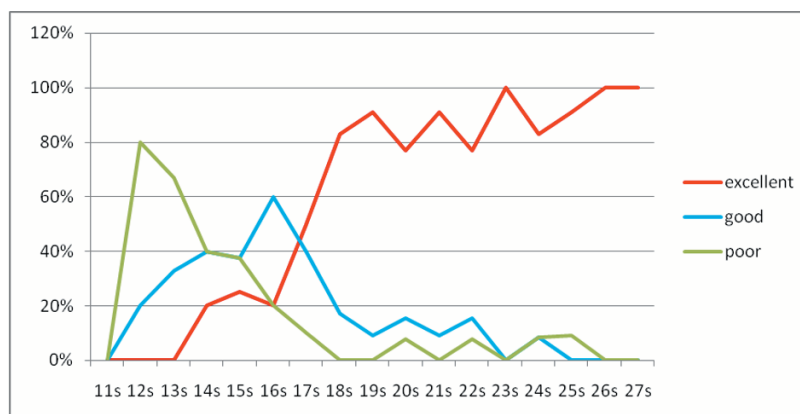
Discussion

We performed a comparative analysis of image quality of neck multislice spiral CT angiography in 326 patients. Our findings indicated that intravenous injection of contrast medium via right arm led to a shorter delay time to reach excellent grade images. In some patients, delay times were quite stable, with a large proportion ranging from 16-22 sec. This could significantly reduce the occurrence of venous artifacts in neck angiography.

The main factor to determine this difference may be related to anatomy. During the forearm intravenous injection, the route of contrast medium consists of superficial veins of the upper limb. The injection site was either cephalic, median, or basilic veins of the forearm. Contrast medium moves along these vessels and reached the axillary vein to enter the subclavian vein to continue through the brachiocephalic vein and superior vena cava to finally enter into the heart. Then, it further goes through the pulmonary circulation into the left ventricle. The pumping of the left ventricle allows the contrast medium to enter the aortic arch. The aortic arch generally has the following three main branches: (1) brachiocephalic trunk, which bifurcates into right subclavian artery and right common carotid artery, (2) the left common carotid artery, and (3) the left subclavian artery[8,9]. We combined the knowledge from the circulation route of the contrast medium with the information from literature and compared the anatomical structures of the left and right sides to determine whether there were significant differences between the two sides[10]. The right brachiocephalic vein is approximately 2.5 cm long and straight, and originates after the convergence of the right subclavian vein with the right internal jugular vein. The right brachiocephalic vein is almost vertically anterior to the brachiocephalic trunk, drains into the superior vena cava, and does not intersect with other vessels. The flow direction of the left brachiocephalic vein is diagonally towards the right, with approximately 6 cm of length, where it crosses the left brachiocephalic vein and the front of the aortic arch and intersects with other vessels. The diameter of the left brachiocephalic vein is significantly smaller than that of the right brachiocephalic vein. Therefore, when the contrast medium is administered into the right arm, larger diameter, and short and straight flow direction prevent residue formation and thereby reduce the occurrence of the artifacts. In addition, reflux occurs less often. The main branches of the subclavian vein are the external jugular vein and the dorsal scapular vein. Some people have only a few venous valves in the subclavian and external jugular veins. In addition, the function of venous valves declines with age[8]. Moreover, the left brachiocephalic vein is longer.

Table II. CT imaging quality.

	Poor quality (number)	Good quality (number)	Excellent quality (number)
Contrast medium injection via left arm	58	57	36
Contrast medium injection via right arm	24	42	109

p = 0.002

It crosses diagonally between the sternum and the innominate artery and forms an angle with the superior vena cava. At this angle, the left brachiocephalic vein is easily compressed, resulting in a narrowed vein. The high-pressure contrast medium injection easily refluxes, which hardly occurs when the injection is done through the right brachiocephalic vein[11,12].

Studies have reported that the left brachiocephalic vein is located in the anterior space of the anterior mediastinal vessels. During thoracic breathing or postural changes, this space narrows down. With the large dose and high-speed intravenous injection, the contrast medium may be retained in the distal ends of the left subclavian and brachiocephalic veins. The intravenous contrast medium may also reflux and produce artifacts that affect the image quality[13]. Another study[14] on the reflux conditions of left arm intravenous injection demonstrated that intravenous injection in the upper left arm had significantly more frequent reflux episodes than in the upper right arm, and this is consisted with our conclusions. In addition, time is a key factor to the success of CT imaging. In this study, the test bolus scanning technology was used to monitor and compare the delay time of the patients. The results suggest that intravenous injection via the right upper arm may fulfill the image requirement earlier, which improves the success rate of CT scanning. In addition, excluding the shoulders from the scanning may show a clear level in the monitoring layer of the CT angiography scan in the common carotid artery and common jugular vein. Due to low mA of the monitoring scan, thick shoulder tissue may diminish x-ray penetration. This may also cause artifacts and inaccurate peak-density detection, resulting in the failure of CT scan.

Conclusions

In the absence of other special circumstances, the use of the right upper arm for intravenous injection of contrast medium significantly reduces artifacts in the superior vena cava, brachiocephalic vein and subclavian vein during head and neck CT angiography.

Conflict of Interest

The Authors declare no conflicts of interest.

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