Detection of deep venous thrombosis on CT venography: Comparison of dose of contrast material

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Purpose

Pulmonary embolism and deep venous thrombosis (DVT) should be considered parts of the same pathologic process \(^1\). More than 90\% of pulmonary emboli arise from deep veins of the leg and pelvis, and the primary risk factor for recurrent pulmonary embolism is the presence of residual proximal venous thrombosis \(^2\). Combined CT venography (CTV) and pulmonary CT angiography is a novel diagnostic strategy in which radiologists can check both the pulmonary arteries for pulmonary embolism as well as the deep veins of the abdomen, pelvis, and lower extremities for thrombosis in a single study \(^3\)-\(^7\).

Various scanning protocols and contrast materials for CTV to exclude DVT have been reported \(^3\)-\(^9\). In previous reports, investigators who used various combinations of quantities and concentrations of contrast material described a range in mean venous attenuation of 91-112 hounsfield units (HU) in CTV \(^3\), \(^4\), \(^8\), \(^9\). Arakawa et al. reported that patient age, body weight, and the amount of contrast material were important factors associated with vessel enhancement in CTV \(^10\).

We have evaluated whether body weight was an accurate indicator for determining contrast load using 300 mg I/ml of contrast material in CTC \(^11\). In our previous study CTV for DVT started 180 s after the start of infusion of contrast material of injection rate of 3 ml/s have produced high mean levels of venous enhancement, however, there was a poor correlation between donages of contrast material per body weight \(^11\). Therefore, we suggested that the dosage of contrast material in CTV to detect DVT should not be considerably increased, in particularly on lower body weight of Asian patients. **The purpose of this study to prospectively compare the vascular attenuation achieved with 120ml of contrast material for lower body weight patients with that achieved with 150 ml contrast material for middle body weight patients.**

Methods and Materials

Informed consent was not required because this was a retrospective study approved by our institutional review board.

Between May 2006 and October 2008, 171 patients were performed CTV. We used in Group A: 150mL of isohexol (Omnipapue 300; iodain 300 mg/lmL, Dai-ichi-Sankyo, Tokyo) on 100 patients (mean body weight: 60.3±9.49kg) and in Group B: 120 mL the same contrast material on 71 patients (mean body weight: 50.3±3.62kg). Group A of patients (79 females, 31 males; mean age, 52.8 years; age range, 25-80 years) and Group
B of patients (51 females, 20 males; mean age, 56.3 years; age range, 22-84 years) underwent CTV to exclude the possibility of pulmonary thrombosis and/or DVT. Most of the study participants comprised of females because the CT protocol was performed as a part of the preoperative gynecological examination. Patients with heart failure were excluded. We used the same administration rate of 3 ml/sec and scanning delay was 25 s and 180 s. The first set of scans was performed in the chest area to exclude pulmonary embolism and the second set of scans was performed to exclude DVT in the lower extremity. Second scans were performed in caudal-to-cranial direction from the ankle joints. Examinations were carried out using a 64-slice MDCT scanner (Somatom Cardiac Sensation 64, Siemens, Germany) with 0.6 mm collimation and reconstruction interval of 5 mm.

A radiologist (J.K), with more than 20 years of experience in interpreting vascular CT images, reviewed the CT images. Regions of interest (ROI) were set to measure CT attenuation at representative points in bilateral common femoral and popliteal veins (Fig. 1).

Fig. 1

Fig.: Measurement of points of vessels a: Common femoral veins in inguinal region (white arrow) b: Popliteal veins at level of upper edge of patella (black arrow). References: T. Ichikawa; radiology, university, Isehara, JAPAN
The ROIs were observed on a workstation using an oval area, approximately two-third of the target vessel in cross-sectional images. When a clot occupied the vein, CT attenuation of the vein was not measured; however Hounsfield unit (HU) of the thrombus was recorded. CT attenuations of the common femoral and popliteal veins were compared on both groups. A p value of < 0.05 was considered significant in statistical analysis. Assuming a venous enhancement of 80 HU as cut-off value for accurate diagnosis of DVT, prevalence of venous enhancement of less than 80 HU was evaluated in bilateral common femoral and popliteal veins on both groups. Statistical analyses were carried out using the unpaired t test using SPSS version 15.0 (SPSS, Chikago, IL, USA) statistical package. Comparisons with a p value less than 0.05 were considered statically, significantly different.

Images for this section:

Fig. 1: Measurement of points of vessels a: Common femoral veins in inguinal region (white arrow) b: Popliteal veins at level of upper edge of patella (black arrow).
Results

Demographic data for each group are listed in Table 1.

### Table 1: Demographic Date of Group A and B

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=100)</th>
<th>Group B (n=71)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean age (y)</strong></td>
<td>55.3 (13.7)</td>
<td>52.9 (14.1)</td>
<td>0.278</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td>0.692</td>
</tr>
<tr>
<td><strong>Male</strong></td>
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<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>69</td>
<td>51</td>
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<td><strong>Mean body weight (kg)</strong></td>
<td>60.9 (8.9)</td>
<td>50.3 (3.7)</td>
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**Fig.**: Demographic data of Group A and B

**References**: T. Ichikawa; radiology, university, Isehara, JAPAN

There was no significant difference between the both groups in terms of patient age and six. The mean HU of the common femoral and popliteal veins were 115.4 ±16.6 HU and 113±16.6 HU in Group A, and 115.6 ±13.2 HU and 115.7 ±16.6 HU in Group B. There was no significant difference on the common femoral venous enhancement on both groups (P=1.29). There was no significant difference on the popliteal venous enhancement on both groups (P=0.91). On femoral veins, DVT was detected 6 points in group A and DVT was detected in included 10 points in group B. On popliteal veins, DVT was detected 10 points in group A and DVT was detected 10 points in group B. The mean CT attenuation of DVT was 45.7 ±11.6 HU (range; 34-57 HU). Table 2 listed the percentage of vessels with HU levels less than 80 in both groups.
Table 2: Percentage of venous enhancement of 80 HU as the cut-off value

<table>
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<th>Vessel</th>
<th>Group A: 150ml</th>
<th>Group B: 120ml</th>
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<tr>
<td>Femoral vein</td>
<td>2.1% (4/194)</td>
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Fig.: Percentage of venous enhancement of 80 HU as the cut-off value

References: T. Ichikawa; radiology, university, Isehara, JAPAN

On femoral veins, CT attenuation of 4 vessels was less than 80HU (2.1%: 4/194) in group A and there was no vessel with less than 80HU in group B. Percentage of CT attenuation of less than 80HU in group A is higher than that in group B on femoral veins (p=0.045). On popliteal veins, CT attenuation of 5 vessels (2.6%: 5/190) was less than 80HU in group A and CT attenuation of 2 vessels (1.5%: 2/136) with less than 80HU in group B. There was no significant difference between the both groups in vessels with HU levels less than 80 on popliteal veins (p=0.48).

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*Fig. 2: Percentage of venous enhancement of 80 HU as the cut-off value*
Fig. 3: A 61 year-female with acute thrombophlebitis. CT image showed thrombi (white and black arrows) in both popliteal veins with wall enhancement and dirty fat around the vein. These findings are severe on right popliteal vein compared with left side. CT attenuation of thrombus (white arrow) was 68 HU.
Conclusion

Pulmonary embolism and DVT have been described as different manifestations of the same disease process\textsuperscript{1}. DVT is often asymptomatic and is associated with recurrent DVT and pulmonary embolism when treated inadequately\textsuperscript{12,13}. Therefore, accurate detection of DVT is necessary for prompt treatment. CT has now become the initial diagnostic examination of choice for pulmonary embolism in many institutions. Combined CTV and pulmonary CT angiography was first reported by Loud et al. in 1998\textsuperscript{5}. Combined CT angiography and CTV can be used to evaluate pulmonary embolism and DVT in a single examination, providing the radiologist with a useful road map for planning interventional procedures (e.g., placement of vena caval filter and thrombolysis)\textsuperscript{14}. Various scanning protocols and contrast materials in combined CTV have been used to exclude DVT\textsuperscript{3-9}. To exclude or detect DVT in CTV, scanning delay of 3 min after injecting the contrast material was chosen to allow time for uniform venous opacification\textsuperscript{3,5,7}.

The degree of venous enhancement is important in evaluating DVT\textsuperscript{3,6,8,9}. Arakawa et al. reported that patient age, body weight, and the amount of contrast material were important factors associated with vessel enhancement in CTV\textsuperscript{10}. In our previous study, there was a low correlation between the dose of contrast material per patient weight and CT attenuation of veins. Therefore, we suggest that the dosage of contrast material in CT venography to detect DVT should not be considerably increased\textsuperscript{11}. Since there is no consensus about the adequate venous opacification to diagnose DVT in CT, the difference in attenuation between the vein and the clots should be large enough for confident diagnosis. Clot attenuation has been reported to be variable. Loud et al. reported an average attenuation of 31 HU and Cham et al. reported an average attenuation of 51 HU\textsuperscript{6,8}. In present study, the average CT attenuation of DVT was 45.7 ± 11.6 HU, which was similar to that reported in the literature\textsuperscript{6,8}. If a clot has an attenuation of 31 HU, venous attenuation in the range of 60-70 HU is probably adequate for detection. Moreover, as Cham et al. reported an average attenuation of 51 HU, if the median attenuation of a clot is 55 HU, half the clots will have an attenuation that is greater than 55 HU\textsuperscript{8}. A clot can be possibly diagnosed when the venous attenuation is in the range of 60-70 HU and cannot be completely excluded. Clot images obtained within 8 days of disease onset showed an average attenuation of 66 ± 7 HU (Fig. 2), whereas those that had been present for more than 8 days showed an average attenuation of 55 ± 11 HU\textsuperscript{15}. Goodman et al. reported that a reasonable but unproven attenuation of 80 HU or more would provide adequate contrast differentiation between the clot and opacified vessels\textsuperscript{9}. In present study, less than 2.5% of patients had venous attenuation of less than 80 HU when not only 150ml used but also 120ml used. Based on these data, we suggest that optimal venous attenuation that provides adequate contrast differentiation
between the clot and veins should be more than 90 HU. When Arakawa et al. used 100 ml of contrast material (300mg I/ml) with the same scanning protocol for patients with a body weight less than 50 kg, an average CT attenuation of the femoral veins was 104 ± 21 HU. The prevalence of patients with less than 80 HU of venous CT attenuation was uncertain on their study. Arakawa et al. anticipated a decrease in enhancement of 8 HU if the patient's body weight was increased by 10 kg. In present study, when we used 120 ml of contrast material (300mg I/ml) with the same scanning protocol for patients with mean body weight 50.3 kg, an average CT attenuation of the popliteal veins was 115 HU. The CT attenuation of veins using 120 ml of contrast material (300mg I/ml) was large enough for detection of DVT in lower body weight patients in Asia.

Body weight alone may not be the determining factor in calculating dosage. Other factors such as total blood volume and cardiac output should be considered. When large mass is present in pelvic cavity, enhancement of iliac veins and IVC are poor because of compression of iliac vein due to a large mass. Venous visualization may be unclear because of acute thrombophlebitis. Further study is required to identify the factors associated with venous enhancement for the diagnosis of DVT.

The degree of venous enhancement is important in evaluating DVT, however the dose of contrast material on CTV and the detection rate of DVT may not be directly proportional. Experience of reader is important factor for diagnosis of DVT. Less-experienced readers need marked venous enhancement with high dose of contrast material. Further study with comparison of reader's experience on various cases is required to determine of optimal scanning protocol for detection of DVT on CTV.

In conclusion, we compared the vascular attenuation achieved with 120ml of contrast material for lower body weight patients with that achieved with 150 ml contrast material for middle body weight patients. There was no significant difference on the common femoral and popliteal venous enhancement on both groups. We recommend that 120ml of contrast material should be used on CTV for patients with less than 55 kg of body weight.

References


**Personal Information**

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