15 Three-Dimensional Evaluation of the Venous System in Varicose Limbs by Multidetector Spiral CT

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15.1 Introduction

The anatomy of the venous system of the lower extremities is extremely complex and variable, especially in varicose and/or postthrombotic limbs [2]. There is a need for research into even more global and morphologically accurate techniques for examination of the vascular tree.

Traditional venography lost its title of gold standard for the morphofunctional examination of the venous tree of the lower limbs because, in the majority of cases, Duplex ultrasonography (US) furnishes a more accurate imaging and more complete hemodynamic evaluation with a less traumatic, expensive and time-consuming technique.

Recent advances in computer techniques have brought an innovative technique for investigation of venous disease based upon the use of spiral CT (veno-CT or VCT). Veno-CT furnishes an accurate three-dimensional (3D) representation of the whole venous system of the lower limb, demonstrating, in some cases, hemodynamic patterns which are not available from Duplex US.

15.2 Principles of Spiral CT

The spiral or helical CT scan is the result of two different moves combined: Firstly, the rotation of an X-ray tube attached with detectors rotating around the patient’s bed; Secondly, a continuous linear translation of the same bed. This enables the acquisition of volume data, with different results: 3D reconstructed images and slices.

15.2.1 Methods

The three steps of the VCT investigation are data acquisition, reconstruction, and postprocessing.

After treatment, reconstructed images are transmitted by intranet and can be seen on a PC by the angiologist (Fig. 15.1).

15.2.1.1 Data Acquisition

A multislice and multidetector CT scan (Siemens Somatom sensation 16) is used, producing 400–600 slices by series during 25–40 s. The protocol details are shown in Table 15.1, for 8- and 16-detector spiral CT.

The patient lies on his/her back (feet-first into the scanner), with no contact points with the table...
except for the buttocks and heels: It is important to avoid any compression of the calf and posterior thigh during acquisition time. The patient has to keep perfectly still during this short time and is often asked to make a Valsalva maneuver.

15.2.1.2
Data Reconstruction

Raw data are processed to perform a slice reconstruction. We use a slice width of 2 mm with a slice increment of 1.5 mm, a filter B30, and a zoom factor of 1.7 (Table 15.1)

15.2.1.3
Postprocessing of Data

To obtain 3D reconstruction of the venous system, the data are sent by intranet on a dedicated workstation for postprocessing using dedicated 3D reconstruction software.

Surface-rendering technique. (Also called “surface-shading rendering” – SSR). Huge progress has been made since 1994 in 3D image reconstruction. At the beginning, a manual segmentation of the image was necessary to obtain reconstructed 3D images by a SSR 3D model. A pixel extraction had to be done by the observer using appropriate windowing: the maximal minimal-density threshold was chosen manually in order to select the voxels corresponding to an anatomical structure. Although performed on Sun or Silicon graphics workstations, this technique was time-consuming and used only some of the data. In turn, it is possible to achieve manual reconstruction of some other structure of interest as nerves (Fig. 15.2).

Volume-rendering techniques (VRT). Today, beautiful 3D images of the venous system (Fig. 15.3) are quickly produced by reconstruction with VRT, with easy-to-

Table 15.1 Multislice and multidetector spiral CT protocols

<table>
<thead>
<tr>
<th>Protocols</th>
<th>Acquisition</th>
<th>Reconstruction</th>
<th>Postprocessing</th>
<th>Contrast injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Detector CT: 400 slices in 30 s</td>
<td>120 kV</td>
<td>Slice width 3 mm</td>
<td>1994–1997</td>
<td>Medrad MCT injector system</td>
</tr>
<tr>
<td></td>
<td>130 mAs</td>
<td>Slice increment 2 mm</td>
<td>Surface-shading rendered</td>
<td>Uniphasic injection 20 ml of iodine contrast medium in 180 ml of serum</td>
</tr>
<tr>
<td></td>
<td>slice collimation: 8×2.5 mm</td>
<td>filter B20</td>
<td>(with manual segmentation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>field 512</td>
<td>Matrix 512×512</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rotation time 0.5-s feed/rotation 15 mm FOV 380 mm</td>
<td>Zoom factor 1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Detector CT: 600 slices in 25 s</td>
<td>120 kV</td>
<td>Slice width 2 mm</td>
<td>1998–2002</td>
<td>Puncture of a vein of the dorsal foot or rarely the varices of the thigh</td>
</tr>
<tr>
<td></td>
<td>150 mAs</td>
<td>slice increment 1.5 mm</td>
<td>Volume rendering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>slice collimation: 16×1.5 mm</td>
<td>filter B30</td>
<td>Fast &amp; automatic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>field 512</td>
<td>matrix 512×512</td>
<td>with tissue transparency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FOV 380 mm</td>
<td>zoom factor 1.7</td>
<td></td>
<td></td>
</tr>
</tbody>
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