Improving the diagnostic quality of CT venography - a question of timing gone wrong?

Poster No.: C-0432
Congress: ECR 2011
Type: Scientific Exhibit
Authors: H. Al-Chalabi, K. Mankad, H. S. CHANDRASHEKAR, I. Davagnanam; London/UK
Keywords: CT, Neuroradiology brain
DOI: 10.1594/ecr2011/C-0432

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

Computed Tomographic Venography (CTV) was first described as a diagnostic tool by Casey et al. [1] as a rapid method to obtain images with contrast enhanced visualisation of the cerebral venous system [2]. Its uses include the diagnosis of cerebral venous thrombosis and pre-operative mapping of venous structures in patients with neoplasms [3,4]. It is performed via injection of a bolus of iodinated contrast material followed by time-optimised image acquisition.

The diagnostic quality of CTV has the potential to be compromised by technical and clinical factors including the sub-optimal distribution of contrast material throughout the cerebral venous system. The purpose of this study is to evaluate the diagnostic quality of CTVs and to analyse the factors that can influence this.

Methods and Materials

Materials:

Over a 12 month period from June 2009 until May 2010, 75 consecutive intracranial CTVs were evaluated at a single specialist centre. Investigations repeated as follow-up studies were included as separate cases. Patient demographics are displayed in Table 1. All scans were acquired with a slice thickness of 0.6mm on a 128 Multi Detector CT scanner with a 30 second delay following intravenous administration of 90ml of iodinated contrast material at 4ml per second, in accordance with current standardised protocol.

Methods

Images were displayed and analysed using a PACS system. Two neuro-radiologists of consultant grade assessed the diagnostic quality of the scans using a qualitative scale; both radiologists were blinded to the indication for radiological investigation in each case. Images were classified as diagnostically adequate or inadequate and any identifiable reasons for inadequate images were recorded. The proportion of inadequate scans was calculated and Kappa statistics performed to assess for any inter-observer variability.

As a measure of contrast opacification throughout the venous system, the CT-Hounsfield values were recorded at 9 consistent points within the venous sinuses and one point in the internal carotid artery by a third, independent, observer who was also blinded to
the indication for scanning. Each reading for the Hounsfield value was obtained using the PACS system to calculate the average CT-Hounsfield value within a 0.5cm$^2$ area within the particular sinus. Any sinuses for which a value could not be obtained due to anatomical variation were omitted from the data and taken into account during statistical analysis.

The following points of the venous system were chosen to obtain a range of data allowing an interpretation of contrast distribution throughout the venous sinuses; 1. Vertex of the superior sagittal sinus, 2. Mid-point of the superior sagittal sinus, 3. Vein of Galen, 4. Torcular Herophili, 5. Right transverse sinus, 6. Left transverse sinus, 7. Right sigmoid sinus, 8. Left sigmoid sinus, 9. Dominant internal jugular vein.

Mean values and standard deviations for the opacification of each sinus were calculated and histograms were produced to show the distribution of opacification within each sinus between cases, for comparison with a physiological flow model.

In addition regression analysis was performed to evaluate the effect of the variables of age, sex and ethnicity as factors predictive of opacification.

**Physiological flow model**

The classical distribution and drainage of the dural venous sinuses (DVS) was assumed when considering the results for opacification during this study.

The dural venous sinuses collect blood from the brain, meninges and skull, eventually transporting it to the internal jugular veins at the skull base [5]. The superior group of the DVS, which is the focus of this study, consists of the superior and inferior sagittal sinuses and the straight, occipital and transverse sinuses. The superior sagittal sinus (SSS) drains blood from the majority of the hemispheres via the superior convexity veins and the inferior sagittal sinus (ISS) drains blood from the medial cerebral hemispheres, falx cerebri and corpus callosum. The ISS confluences with the Vein of Galen to form the straight sinus which carries blood inferiorly towards the internal occipital protuberance.

Both the SSS and straight sinus may drain into the torcular Herophili but in the majority of cases the straight sinus drains into the left transverse sinus and the SSS into the right transverse sinus. The transverse sinuses also receive other cerebral veins before terminating in the sigmoid sinuses at the tentorial margin. The sigmoid sinuses drain into the jugular bulbs [6,7].
Fig. 1: Table 1 - Demographic Profile.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>59</td>
<td>79</td>
</tr>
<tr>
<td>Caucasian</td>
<td>52</td>
<td>69</td>
</tr>
<tr>
<td>Non-Caucasian</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>Age (range 16 to 79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 ≤ Age &lt; 36</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>36 ≤ Age &lt; 60</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>60 ≤ Age &lt; 79</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>
Fig. 2: Fig 1. Normal anatomy of dural venous sinuses. 1, superior sagittal sinus; 2, inferior sagittal sinus; 3, straight sinus; 4, torcular Herophili; 5, transverse sinus; 6, sigmoid sinus; 7, occipital sinus; 8, vein of Galen; 9, basal vein of Rosenthal; 10, internal cerebral veins; 11, septal veins; 12, thalamostriate veins; 13, vein of Labbé; 14, superficial middle cerebral vein; 15, vein of Trolard; 16, cavernous sinus; 17, clival venous plexus; 18, superior petrosal sinus; 19, inferior petrosal sinus; 20, sphenoparietal sinus.
Results

Qualitative assessment of diagnostic quality

When assessing the diagnostic quality of each CT venography study the observers agreed in 54 out of 75 cases that images were diagnostically adequate and agreed to 15 cases being in adequate (Fig1). The number of images considered to be diagnostically inadequate by at least one observer was 28% (Kappa = 0.78).

Distribution of Hounsfield Unit values for each sinus

The histograms displayed show the range and distribution of CT number for each venous sinus (Fig 2,3,4). In the majority of cases these show a poor correlation with the normal distribution.

A plot of the average CT-Hounsfield value for each venous sinus was used to plot figure 5. The values reveal a fairly consistent concentration of contrast throughout the venous sinuses with a much larger concentration present in the internal jugular vein. A paired student’s t-test was used to establish that the increase in contrast opacification between the superior sagittal sinus and the internal jugular vein was statistically significant (p<0.001, mean difference of +65.3).

The influence of other factors on contrast opacification

Linear regression analysis revealed no statistically significant correlation (at the 5% level) between age, gender or ethnicity and contrast opacification in any of the venous sinuses. This seems unusual with regards to patient age which may be assumed to have a significant effect on venous drainage; it is possible that any errors in the current protocol are masking any consequences of age related change that are occurring.

Comparison with physiological flow model

The majority of CTV protocols use a contrast injection of 70-100ml at a rate of 3-4ml/sec followed by a 30-40 second prescanning delay [3,8,9,10] and even scans triggered after 4 seconds following maximum contrast enhancement at the aortic arch show opacification of the dural venous system [8].
The observed opacification of the cerebral venous sinuses in our population of patients seems to be discordant with a physiological flow model which would be indicated by graded opacification of the venous sinuses. The fact that the concentration of contrast in the internal jugular vein, at the termination of the dural venous system, is significantly higher than at earlier points of the DVS suggests that the current delay between contrast injection and image acquisition is missing the ‘first pass phase’ of contrast perfusion. This may be causing a suboptimal concentration of contrast medium with the venous sinuses which could be compromising the diagnostic quality of images.

**Images for this section:**

**Fig. 1:** Table 1 - Observer interpretation of diagnostic quality

<table>
<thead>
<tr>
<th>Observer 1</th>
<th>Observer 2</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate</td>
<td>Adequate</td>
<td>54</td>
</tr>
<tr>
<td>Adequate</td>
<td>Inadequate</td>
<td>5</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Adequate</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Inadequate</td>
<td>15</td>
</tr>
</tbody>
</table>
Fig. 2: Distribution of Hounsfield Values in the locations of; 1. the vertex of the superior sagittal sinus, 2. the mid-point of the superior sagittal sinus, 3. the vein of Galen, 4. the Torcular Herophili
Fig. 3: Distribution of Hounsfield Values in the locations of: 1. the right transverse sinus, 2. the left transverse sinus, 3. the right sigmoid sinus, 4. the left sigmoid sinus.
Fig. 4: Distribution of Hounsfield Values in the locations of; 1. the dominant internal jugular vein, 2. the dominant internal carotid artery.

Fig. 5: Mean Hounsfield Value Distribution
Conclusion

There is no significant effect of patient age, gender or ethnicity on contrast opacification of the venous sinuses when using the current protocol at our centre.

Common protocols for CTV involve prescanning delays of 30 seconds and more; the current protocol for CT venography image acquisition at our centre does not produce optimised graded opacification of the venous sinuses. This may be compromising the diagnostic quality of CTV studies and is most likely due to a timing error in image acquisition.

References


Personal Information