Diffuse axonal injury: a study of patients in neurological intensive care unit, with emphasis on follow up and value of diffusion weighted imaging.

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Authors: L. Amaral\textsuperscript{1}, A. A. S. M. Santos\textsuperscript{2}, V. E. C. Oliveira\textsuperscript{3}, C. A. P. Fontes\textsuperscript{2}, T. C. R. S. SANTOS\textsuperscript{2}, M. H. Santos\textsuperscript{4}, M. L. O. Santos\textsuperscript{2}; \textsuperscript{1}Vila Velha - Espirito Santo, E.S./BR, \textsuperscript{2}Niterói - Rio de Janeiro, RJ/BR, \textsuperscript{3}Niteroi-Rio de Janeiro, RJ/BR, \textsuperscript{4}Niterói-Rio de Janeiro, RJ/BR

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Purpose

• Description of characteristics of lesions in CT and MRI of patients after traumatic brain injury with Diffuse Axonal Injury (DAI) clinically proven and admitted to the Intensive Care Unit neurological.
• To detect diffuse axonal injury (DAI) lesions by diffusion-weighted imaging (DWI), as compared with fluid-attenuated inversion recovery (FLAIR) imaging and to evaluate hemorrhagic DAI lesions with gradient-echo (GRE) imaging.
• Review the sensitivity and specificity of the sequences of Diffusion and T2*GRE/SWI in Diffuse Axonal Injury, when compared to other sequences of MRI.

Methods and Materials

• Cross-sectional study, observational and retrospective, on Diffuse Axonal Injury, in Hospital de Clinicas de Niterói (HCN), State of Rio de Janeiro, Brazil, from January 2007 to June 2010.
• CT scans were performed on Spiral CT and Multidetector CT with 64 channels and MRI at 1.5 T scanner, with specific protocols of the service without intravenous contrast.
• We initially used sequences in DWI, axial FLAIR, axial GRE T2, assessment of urgency, and later added T1 sagital and T2 coronal sequences.
• There was no standardization of time between the initial request of computed tomography and magnetic resonance imaging, with a variance of 5 hours to 30 days between these examinations. This temporal difference depended on the patient's clinical condition and request for further examination by a neurologist of the Neurological Intensive Care Unit.
• We reviewed MR images of 18 patients with a diagnosis of DAI. MR imaging was performed 5 h to 30 days, after traumatic brain injury. We evaluated: lesions on DWI and FLAIR and GRE imaging.
• We also made a comparative analysis of the quality of images in different sequences, correlating with the literature data.
• All examinations were evaluated by two radiologists and discordant results were resolved by consensus and was made follow up of patients who were hospitalized and underwent CT/ MRI control.

Results
We selected 18 patients with clinical and radiological diagnosis of Diffuse Axonal Injury (DAI) and were followed in the Neuro-intensive care unit of Hospital de Clínicas de Niterói, state of Rio de Janeiro, Brazil.

There was male predominance (16 men and 2 women).

All patients suffered an automobile accident and were treated in the emergency department and subsequently admitted to the Neurological Intensive Care Unit of our hospital.

The CT scan was performed as initial examination in all 18 patients.

Only 11 of 18 CT scans were suggestive of diffuse axonal injury. Of the 7 CT scans as normal on admission of patients in all were identified signs suggestive of DAI on MRI performed later. The findings in CT scans were diffuse cerebral edema with only 38% patients with petechial hemorrhagic foci (FIG 1).

In relation to topography, a predominance of lesions suggestive of LAD on CT without contrast (in descending order) were: fronto-parietal lobe> temporal lobe> occipital lobe> corona radiata> basal ganglia and midbrain.

In all exams with DAI on CT and MRI, 18% occurred in the frontal lobe, parietal Lobe in 14% and 14% in the corpus callosum, 10% in temporal lobe> radiated crown 7%> 5% Lobo Occipital / 5% cingulate / midbrain 5%> 22% others (FIG 2).

The right and left hemispheres were affected with the same frequency without predominance.

Regarding the topography of the lesions were seen in our MRI studies, a total of 109 lesions. There was a clear predominance in the corticomedullary junction and only 5% in upper brainstem (FIG 3).

In all cases MRI showed hemorrhagic foci well demonstrated in the GRE-T2*/ SWI and hyperintense foci of restricted diffusion, especially in gray/white matter junction (FIG. 4).

At the Gray/white matter junction, more lesions were found in the GRE sequence (FIG. 5-7).

In six patients, lesions were observed in the corpus callosum, which were well demonstrated in the diffusion and FLAIR sequences (FIG.8,9).

The GRE showed no focal lesions identified in other MRI sequences (FIG. 10,11).

In the brainstem, the number of injuries was the same in FLAIR and GRE sequences (FIG. 12,13).

Nine patients in the study had some type of intracranial bleeding (hematomas, subarachnoid hemorrhage, acute subdural hematoma) or extra-cranial (subgaleal hematoma).

Of these, 5 patients with LAD showed signs suggestive of acute subdural hematoma (SAH) confirmed by CT and MRI.

There was only one case with lesions in the right thalamus (FIG. 14).

In many cases had multiple DAI lesions in multiple locations, exacerbating the patient's neurological status (FIG 15).
• Assessing the lesion conspicuity between DWI and FLAIR and comparing our results with the referenced article, we had more lesions identified on DWI at the Gray/white matter junction (FIG.16).
• In the FLAIR sequence we had the highest percentage of injuries at the Gray/white matter junction and lower in other locations, comparatively (FIG.17).
• The DWI sequence is very useful in the evaluation of DAI lesions, especially in the acute phase, being better than FLAIR in many cases and can serve to follow up the patient (FIG. 18). Should be assessed in conjunction with the GRE, especially for patients in neurological intensive care units, whereas in subacute and chronic stages the GRE sequence becomes more important than others in the evaluation of DAI lesions.

Images for this section:

Fig. 1: CT scan showing foci of bleeding in the right frontal lobe, left parietal lobe, basal ganglia and thalamus in the right hemisphere.
**Fig. 2:** Graph 1: Prevalence of the main regions affected by Diffuse Axonal Injury in CT and MRI.

**Fig. 3:** Table 1: Regarding the topography of the lesions were seen in our MRI studies, a total of 109 lesions. We had a clear predominance of lesions in gray/white matter junction (n=98)
Fig. 4: Male 23 years old. Car accident with head trauma. Multiple diffuse small foci at gray/white matter junction in GRE sequence
**Fig. 5:** Graph 2: At the Gray/white matter junction, more lesions were found in the GRE sequence.
Fig. 6: Same patient figure 4. FLAIR sequence showing multiple foci of hyperintensity.
Fig. 7: Same patient in the previous figure. DWI showing small foci of restricted diffusion (arrows.)
Fig. 8: Graph 3: DAI lesions in corpus callosum. The number of injuries was the same in DWI and FLAIR.
**Fig. 9:** DAI Lesion in the corpus callosum: hypointense on sagittal T1, hyperintense on FLAIR axial and coronal T2, with no signal on GRE and restricted diffusion on DWI.

**Fig. 10:** Same patient in figure 9: It was also observed foci of with no signal on GRE in the frontal lobes and right parietal (arrows), all at gray/white matter junction, not shown on DWI and FLAIR sequences.
**Fig. 11:** DAI lesions: small focus most clearly shown (or only shown) in the GRE sequence than on FLAIR

**Fig. 12:** DAI lesions: brainstem
**Fig. 13:** DAI lesion in the right cerebral peduncle, as evidenced in DWI and GRE sequences. It was also observed left parietal subgaleal hematoma.
**Fig. 14:** Male 30 years old. Head injury by high-impact car accident. Comatose patient. DAI lesion: in the right thalamus.

**Fig. 15:** Same patient in the previous figure, showing the thalamic lesion, lesion in the splenium of the corpus callosum (DWI, FLAIR), and multiple foci DAI lesions in GRE sequences at gray/white matter junction.
**Fig. 16:** We had a higher percentage of DAI lesions in the gray/white matter junction visualized in the DWI sequences.

**Fig. 17:** Graph comparing FLAIR sequences
Fig. 18: DAI lesion in the splenium of the corpus callosum: best seen on DWI than on FLAIR
Conclusion

After a review of 18 proven cases of Diffuse Axonal Injury, we conclude that:

- MRI is the best exam for the identification and follow-up of the DAI, with the DWI the most sensitive and specific sequence in the acute phase.
- DWI is as useful as FLAIR in detecting DAI lesions. GRE imaging is still the superior tool for the evaluation of hemorrhagic DAI.
- A limitation of our study was that DWI and FLAIR images were compared in a small number of patients.
- There was agreement to our findings with those described in the literature.

References


**Personal Information**

**Leonardo P. G. Amaral. MD.**

Fellow in the Department of Neuroradiology, Hospital Roger Salengro University of Lille II - France. Master of Radiology, Federal University of Rio de Janeiro. Radiology Specialist in the Course of Specialization in Radiology Institute of Postgraduate Medical Carlos Chagas (IPGMCC).

Email: leopgamaral@gmail.com

**Alair Augusto Sarmet M. D dos Santos. MD, PhD.**

Corresponding Author. Associate Professor, Department of Radiology and Head of the Radiology and Diagnostic Imaging Service of University Hospital Antônio Pedro (HUAP) / UFF (Federal Fluminense University) - Niterói, RJ, Brazil. Coordinator of Image Center-HCN (Hospital Clinicas de Niterói) and Coordinator of the Specialization Course in
Radiology Institute of Postgraduate Medical Carlos Chagas (IPGMCC). Rio de Janeiro, Brazil.

Email: alairsarmet@globo.com

e-curriculum: http://lattes.cnpq.br/1215394507629695

**Vinicius Eduardo Campos Oliveira.**

Student of the Specialization Course in Radiology Institute of Postgraduate Medical Carlos Chagas (IPGMCC). Rio de Janeiro, Brazil.

Email: viduardo@gmail.com

**Cristina Asvolinsque Pantaleão Fontes. MD.**

Assistent Professor. Departament of Radiology, and Diagnostic Imaging Service of University Hospital Antônio Pedro (HUAP) /UFF (Federal Fluminense University) - Niterói, RJ, Brazil.

Medical radiologist in Image Center-HCN (Hospital Clinicas de Niterói).

Email: cristinasvolinsque@gmail.com

**Teresa Cristina de Castro R.S. dos Santos**

Medical radiologist in Radiology Services: University Hospital Antônio Pedro/UFF (Federal Fluminense University), Fernandes Figueiras Institute(FIOCRUZ) and HCN (Niteroi Clinical Hospital). Student of Master of Medical Sciences UFF

teresasarmet@globo.com

**Márcia Heizer Santos**
Medical radiologist in Image Center-HCN (Hospital Clinicas de Niterói). Niteroi, RJ, Brazil.

Email: marciahsantos@bol.com.br

**Maria Lucia Oliveira Santos.** MD, PhD.

Associate Professor, Department of Radiology University Hospital Antônio Pedro (HUAP) /UFF (Federal Fluminense University) - Niterói, RJ, Brazil.

Email: mlucia.santos@gmail.com

**Study site**

Hospital de Clínicas de Niterói, Institute of Postgraduate Medical Carlos Chagas (IPGMCC) and Federal Fluminense University (UFF) - Niterói, Rio de Janeiro, Brazil.

**Potential Conflict of Interest**

No potential conflict of interest relevant.

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