The hyperdense basilar artery sign: Is it really helpful, and is there a quantitative cut-off point?

Poster No.: C-2793
Congress: ECR 2010
Type: Scientific Exhibit
Topic: Neuro
Authors: L. Eftimov\textsuperscript{1}, I. Koerte\textsuperscript{1}, D. Morhard\textsuperscript{1}, H. Brueckmann\textsuperscript{1}, R. Bruening\textsuperscript{2}, J. Linn\textsuperscript{1}, R. Laubender\textsuperscript{1}, M. F. Reiser\textsuperscript{1}, B. Ertl-Wagner\textsuperscript{1}; \textsuperscript{1}Munich/DE, \textsuperscript{2}Hamburg/DE
Keywords: CT, hyperdense basilar artery sign, stroke
DOI: 10.1594/ecr2010/C-2793

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

Background
In acute stroke, nonenhanced head CT (NECT) routinely serves as the initial diagnostic tool. In the anterior circulation, the presence of a "hyperdense middle cerebral artery sign" on NECT has been established as a predictor of vessel occlusion [1].

It has recently been shown that in patients with a known high clinical pretest probability of posterior circulation stroke, the "hyperdense basilar artery (HBA) sign" on NECT is a strong predictor of basilar artery (BA) thrombosis, with 71.4% sensitivity, 97.5% specificity and 93.7% accuracy [2].

Purpose

We aimed to investigate

• the diagnostic value of the HBA sign
• the diagnostic value of the quantified BA attenuation

as a predictors of basilar artery occlusion (BAO), when the patient's presentation is unknown to the interpreting radiologist.

Further, we examined

• the influence of acute to subacute (a/sa) ischemic infarctions on the diagnostic decision
• potential influences on BA attenuation, such as atherosclerosis, posterior fossa artifacts (PAF), and hematocrit [3]
Methods and Materials

Institutional Review Board (IRB) approval was obtained prior to study initiation.

Patient Selection

We retrospectively included 47 consecutive patients with BAO (group I) in CT-angiography (CTA) who underwent nonenhanced cranial CT for initial evaluation. The NECTs were matched with NECT studies of 42 patients without BAO (group II), considering patient age and the CT-scanner used.

Inclusion criteria

Group I: Normal anatomy of the BA and the certain diagnosis of BA occlusion in CTA.

Group II: Inconspicuous NECT result (e.g., absence of bleeding, cerebral mass or infarction) and absence of BAO on follow-up.

Exclusion criteria

Group I & II: An unavailable or incomplete scan and the presence of significant artifacts.

In total, 5 patients had to be excluded because of the above criteria (4 in group I, 1 in group II).

Thus, 82 patients were included, with 41 patients in each group.

Scanning Procedures
• multi- and single slice CT scanners
• standard protocols
  • NECT: 120 kVp, 180 to 410 mAs, 0.6 to 4 mm collimation thickness, 4.0 to 5.0 slice width, 0.55 to 1 pitch, and 2.0 to 5.0 mm reconstruction increment
  • CTA: 120 kVp, 135 to 240 mAs, 0.6 to 8 mm collimation thickness, and reconstruction increment of 2 to 5 mm (weight adapted, bolus tracking; MPR & MIP)

Readers

Three readers assessed cases independently on a 5-point scale.

Reader 1 was a board-certified, attending radiologist with a certificate of added qualification (CAQ) in neuroradiology.

Reader 2 was a neuroradiology fellow with a board certification in radiology and 3 years experience in neuroradiology.

Reader 3 was a resident with 1.5 years of experience in general radiology.

Readers were masked regarding any patient information, the type of CT system and the acquisition parameters. Images were reviewed on a PACS workstation. For BA attenuation measurements, a ROI was set in an arbitrary slice.

Image Review

All cases were assessed with a standardized questionnaire, including

• visual BA hyperdensity (1 = no; 2 = little; 3 = equivocal; 4 = distinct; and 5 = very distinct), scores of 4 and 5 were defined as HBA sign
• BA attenuation [HU]
• presence and localization of acute / subacute (a/sa) ischemic infarctions (i.e., < 2 weeks old)
• posterior fossa artifacts (PFA) and degree of atherosclerosis in the vertebral, basilar and internal carotid arteries (1 = no; 5 = very pronounced)

In each case, readers first visually scored BA hyperdensity and evaluated for the presence of BA occlusion (0 = not present; 1 = do not know if present; 2 = present).

Readers then measured BA attenuation [HU] and thereafter reevaluated for the presence of BAO.
**Hematocrit (Hct)**

For each patient, the Hct value which had been assessed within the shortest period of time with regard to NECT was included into the statistical analysis. In 7 patients, Hct values could not be utilized because they had only been assessed more than 24 hours after NECT (3 patients), had not been determined (2 patients), or were not available (2 patients). Hct values of 0.380 to 0.520 were taken as representative of the normal.

**Statistical Analysis**

- multivariate mixed effects linear regression model with simple crossed random effects
  - influence of the independent variables of atherosclerosis, a/sa pons infarctions and PFA on the dependent variable of BA attenuation
  - association between CT number measurements and subjective BA density
- multivariate mixed effects logistic regression model with crossed random effects
  - decision behavior of readers
  - readers' decisions before measurements coding I ("No" and "Don't know" versus "Yes") and coding II ("No" versus "Don't know" and "Yes")
  - readers' arbitrations after measurements, except additionally including BA attenuation as independent variable
- calculation of predicted probabilities (PP) for a positive response of having BAO or not (= estimate)
- evaluation of PP with respect to the true status using receiver operating characteristics (ROC) and calculating the area under the curve (AUC)
- Diagnostic predictiveness: 0.70 to 0.79 = “fair”, 0.80 to 0.89 = “good”
- evaluation of impact of BA density and measured BA attenuation on the true status for each reader using logistic regression and ROC techniques

For all regression models, we performed likelihood ratio tests to assess statistical significance p-value <0.05 (two-sided).
Results

Correlation between visual and measured BA density, HBA sign and presence of BAO

- visual / measured BA densities
  - close, positive linear correlation: \( p<0.001 \) (figure 1)
  - visual and measured BA attenuations / true state (BAO present / not present): \( p<0.001 \)

- statistically expected attenuation values
  - BAO not present: 36.07 HU
  - BAO present: 45.79 HU (\( = 36.07 + 9.72 \))
  - HBA sign: 43.97 HU (\( = 36.09 + 7.88 \)) and 46.63 HU (\( = 36.09 + 10.54 \))

Evaluation of basilar artery occlusion BEFORE and AFTER attenuation measurements

- a/sa infarction: influence on the diagnostic decision = \( p<0.001 \)
- BA attenuation: influence on the diagnostic decision = \( p<0.001 \)
- Codings I & II: similar results regarding the AUC (figure 2)
- All readers: some improvement after attenuation measurements
- only least experienced reader 3: "fair" to "good" diagnostic predictiveness (figure 2, figure 3)
- Figure 4 shows the diagnostic decisions compared to the true state.

Correlation between the predictiveness of the true state (BAO present / not present) and BA attenuation
optimal cut-off points (determined by the highest value of accuracy):
- 40, 42 and 41 HU for readers 1, 2 and 3, respectively (figure 5, figure 6).
- The HBA sign was mostly of lesser diagnostic value (figure 6).

Effect of hematocrit, atherosclerosis and PFA on BA attenuation

- Hematocrit: significant positive effect BA attenuation (p<0.001; estimate 0.66)
- All other factors: no significant effect (p>0.05; figure 2)
Fig. 1: Close positive linear correlation between subjective BA density and objectively measured BA attenuation [HU] in the region of interest (ROI) for readers 1-3.
Fig. 2

Fig. 3: Receivers operating characteristic curves (ROC) for basilar artery occlusion based on visual BA hyperdensity and after additional quantitatively measured density, shown for the first coding. The least experienced reader 3 shows a pronounced amelioration.
Fig. 4: Diagnostic decision concerning BAO before and after ROI-measurement of BA density [HU] compared to the true status for readers 1 - 3. Note the improvement of reader 3. 0 = BAO not present; 1 = do not know if present; 2 = BAO present. A = Pre ROI, B = Post ROI, C = True State.
Fig. 5: ROI-measured BA attenuation in correspondence to the true status for the three readers. The dashed line shows the respective optimal cutoff points where most correct diagnoses occurred.
<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: The table details are not legible in the image.
Conclusion

• Hematocrit has a significant influence on BA attenuation, which is in accordance to previous work. Atherosclerosis and posterior fossa artifacts do not significantly effect BA attenuation.

• When comparing NECTs of patients with and without BAO, attenuation measurements of the basilar artery can improve the diagnostic accuracy compared to the HBA sign alone.

• Attenuation measurements seem to be especially helpful to radiologists who are less experienced in head CT interpretation.

• However, even with optimal cut-off values, a considerable percentage of false negative and positive results remain, making complementary imaging studies necessary to establish the diagnosis.

References

Personal Information

Lara Eftimov, MD,
Dept. of Clinical Radiology,
University of Munich - Campus Grosshadern,
Munich, Germany

E-mail: lara.eftimov@med.uni-muenchen.de