Accuracy and reliability of PBV-ASPECTS, CBV-ASPECTS and NCCT-ASPECTS in acute ischemic stroke: a matched-pair analysis

Potreck A¹, Falbesaner A¹, Seker F¹, Weyland CS¹, Mundiyapurath S², Heiland S¹, Bendszus M¹, Pfaff JAR¹

¹Department of Neuroradiology, University Hospital Heidelberg, Heidelberg, Germany
²Department of Neurology, University Hospital Heidelberg, Heidelberg, Germany

Corresponding author:

Pfaff, Johannes Alex Rolf

Department of Neuroradiology, Heidelberg University Hospital

Im Neuenheimer Feld 400

69120 Heidelberg, Germany

Johannes.Pfaff@med.uni-heidelberg.de

phone: +49 6621 567566

fax: +49 6621 564673

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Background and Purpose: To investigate the reliability and accuracy of Alberta Stroke Program Early CT Scores (ASPECTS) derived from Flatpanel-detector CT pooled-blood-volume-(PBV)-maps compared to non-contrast CT (NCCT) and Multidetector-CT-Perfusion cerebral blood volume (CBV)-maps.

Methods: ASPECTS from PBV-maps were evaluated retrospectively by two experienced readers for 37 consecutive patients with acute MCA M1-occlusion who underwent Flatpanel-detector CT-perfusion imaging before mechanical thrombectomy (MT) between 11/2016 and 02/2019. For comparison with ASPECTS from NCCT and CBV-maps, a matched-pair analysis according to pre-stroke mRS, age, stroke severity, site of occlusion, time from stroke onset to imaging and final mTICI was performed in a separate group of patients who underwent multimodal CT prior to MT between 6/2015 and 2/2019. Follow-up ASPECTS was derived from either NCCT or from MRI (in n=7 patients) one day after mechanical thrombectomy.

Results: Interrater-agreement was best for NCCT-ASPECTS (w-Kappa=0.74, vs. w-Kappa=0.63 for CBV-ASPECTS and w-Kappa=0.53 for PBV-ASPECTS). Also, accuracy, defined as correlation between acute and follow-up ASPECTS, was best for NCCT-ASPECTS (spearman-ρ=0.86 (0.65–0.97), p<0.001), while it was lower and comparable for PBV-ASPECTS (p=0.58 (0.32–0.79), p<0.001) and CBV-ASPECTS (p=0.52 (0.17–0.80), p=0.001). Noteworthy, cases of relevant infarct overestimation by ≥ 2 ASPECTS regions (compared to follow-up imaging) were observed for both acute PBV- and CBV-ASPECTS but occurred more often for acute PBV-ASPECTS (25% vs. 5%, p=0.02).

Conclusion: NCCT-ASPECTS outperformed both PBV-ASPECTS and CBV-ASPECTS in accuracy and reliability. Importantly, relevant infarct overestimation was observed more often in PBV-ASPECTS than CBV-ASPECTS, limiting its present clinical applicability for acute stroke imaging.
**Abbreviations:**

FD-CT = Flatpanel-Detector-CT

LVO = Large Vessel Occlusion

MD-CT = Multidetector-CT

MT = Mechanical Thrombectomy

PBV = Pooled blood volume
Introduction:

Mechanical thrombectomy (MT) is the treatment of choice in patients with acute ischemic stroke due to large vessel occlusion (LVO) [1]. As high recanalization rates of 80 % and higher are achieved with the use of modern aspiration catheters and stent retrievers [2], time from stroke onset to recanalization remains one of the most important factors determining patient outcome in acute stroke therapy [3]. C-arm-mounted Flatpanel-detector (FD)-CT imaging offers the possibility to rule out intracranial hemorrhage and proof LVO [4,5] immediately in the angiographic suite. Thereby, depending on the clinical setting, the time from hospital admission to the start of the interventional procedure can be shortened [6, 7].

Still, to select patients who potentially benefit from MT, a reliable estimation of the infarct core by acute stroke imaging is crucial for further treatment decision. To address this question within the setting of C-arm FD-CT imaging in the angiographic suite, modern angiographic systems allow for generating whole-brain pooled blood volume (PBV)-maps. Previous studies found good correlation of such FD-CT derived PBV-maps with multidetector (MD)-CT derived CBV-maps [4-5,8-9] and PBV-reductions were found to correlate well with final infarct volume before [6].

While FD-CT perfusion represents a promising tool for acute stroke imaging, validity of infarct core assessment by FD-CT PBV-maps remains a topic of debate and critical overestimations of ischemic cores were reported previously [10]. In this retrospective study we therefore investigate a) the reliability and b) the accuracy of Alberta Stroke Program Early CT Scores (ASPECTS) derived from FD-CT-perfusion parenchymal-blood-volume-(PBV)-maps compared to non-contrast CT (NCCT) and CT-Perfusion CBV-maps in predicting final infarct size and clinical outcome 3 months after stroke within the setting of a matched-pair analysis.

Material and Methods:

Patient data:
This retrospective study was approved by the institutional review board. We included data from \( n = 54 \) consecutive patients with acute occlusion of the MCA M1-segment who underwent FD-CT Perfusion imaging prior to MT in between 11/2016 and 02/2019 at our institution. Data from \( n = 17/54 \) patients (31 \%) had to be excluded from further analysis due to severe artifacts from motion and beam hardening (\( n = 12 \)), missing contrast agent filling (\( n = 4 \)) and/or incomplete acquisition of FD-CT Perfusion (\( n = 1 \)). To compare PBV-ASPECTS with NCCT- and CBV-ASPECTS, a matched-pair analysis was conducted with patients who underwent multimodal MD-CT imaging prior to MT in between 6/2015 and 2/2019 at our institution (\( n = 186 \)). Patients were matched according to pre-stroke mRS, age, stroke severity (measured by NIHSS), site of occlusion, time from stroke onset (or time from last-seen well) to imaging and final mTICI. Favourable clinical outcome 3 months after stroke was defined as modified Rankin Scale (mRS) of \( \leq 3 \); mRS was evaluated by an independent neurologist blinded to this study and was available in 34/37 patients in the FD-CT cohort and in 37/37 patients in the MD-CT study cohort. In two patients (one per cohort) premorbid mRS was higher than 3 and these patients were not considered in the final outcome analysis.

**Imaging:**

**Multidetector-CT imaging:** Multimodal MD-CT imaging was carried out on a 64-slice CT scanner (Somatom Definition AS, Siemens Healthineers, Erlangen, Germany) and consisted of NCCT, CT-Angiography (CTA) and CT-Perfusion (CTP). NCCTs were acquired at 120 kV with automated adjustment of the tube current in Xcare-technique (Siemens, Erlangen, Germany). Images were reconstructed with a kernel of J40s at 4 mm slice thickness (ST). CT perfusion imaging was obtained at 180 mAs, 80 kV, total acquisition time of 60 s with a z-coverage of 8 cm. In total 480 slices were reconstructed (30 full temporal volumes with each 16 slices at a slice thickness (ST) of 5 mm) using a kernel of H20f. Acquisition was started 10 seconds after i.v. administration of iodine contrast agent (Xenetix 350, Guerbet, Sulzbach, Germany) at 6 ml/s followed by a 20 ml saline flush. CBV-maps were derived from the 4D-dynamic data set using syngo VolumePerfusionCT Neuro on a Syngo CT Workplace, Version VA10A (Siemens Healthineers, Erlangen, Germany).
**Flatpanel-Detector imaging:** FD-CT imaging was performed on a biplane FD angiographic system (Axiom-Artis Q, Siemens Healthineers, Erlangen, Germany). As described previously [5], the limited speed of the gantry movement compared to conventional MD-CT does not allow dynamic measurements of the contrast bolus passage. Instead image-acquisition consisted of two separate 200° rotational runs with a first, native, initial rotation (mask run) followed by a second, contrast-enhanced rotation (fill run). To ensure, that the fill run is acquired during a steady state phase of the contrast medium in the brain parenchyma, the C-arm returns to the (original) start position after acquisition of the mask run and standard 2D-DSA acquisitions are initiated at a rate of 2 images per second. The fill run is then started manually when opacification of the venous sinus is observed by the operator (“bolus watching” approach). Acquisition time of mask and fill run was 6.6 seconds whereby 2D-projections were acquired at a rate of 60 frames per second (leading to a total 397 projections per run, 0.5° rotation per frame) at 70 kV; 616 x 480 matrix size; projection on a 30 x 40 cm flat panel size. Postprocessing of FD-Perfusion was carried out using syngo DynaPBV Neuro on a Syngo X Workplace, Version VD11C (Siemens Healthineers; Erlangen, Germany). First, mask run and fill run were reconstructed at 4 mm slice thickness using both “smooth” and “very smooth” image reconstruction characteristics. As previously described, images are then subtracted from another and air and bone are excluded from further analysis by automated segmentation. By histogram analysis of the vessel tree, a steady state arterial input value was calculated and applied as scaling factor to the image volume. Finally, a filter was applied to reduce pixel noise [5]. Overall, post-processing time for FD-CT Perfusion data was sufficiently fast and comparable to MD-CT.

**Follow-up imaging:** Follow-up imaging was acquired 21 (15 – 25) hours after MT by NCCT (n=30) and MRI (n = 7) at a 3T Scanner (Magnetom Verio/TIM Trio/Prisma Fit/Skyra; Siemens Healthineers, Erlangen, Germany), respectively, including T2/FLAIR-, diffusion-weighted and susceptibility-weighted imaging.

**ASPECT scoring:** As previously described [10], quantitative analysis of PBV maps was not feasible due to the inhomogeneity of PBV maps and large SD on a voxel level, respectively. The extent of ischemic
cores was therefore assessed qualitatively by ASPECTS and was evaluated separately on FD-CT PBV-maps, on MD-CT NCCT and CBV-maps, and on the follow-up imaging by two experienced readers (AP, JP, both more than 5 years of experience in acute stroke imaging) blinded to clinical and other imaging data. For PBV- and CBV-maps, areas of decreased PBV or CBV (indicated dark blue to purple) were thereby regarded as ischemic core. In case of disagreement, consensus rating was reached. Besides, source images were further checked, whether FD-CT Perfusion was acquired correctly during the venous phase by noting opacification of the intracranial venous sinus before the start of the acquisition of the fill run.

**Statistical analysis:** Statistical analysis was performed with R* (The R Project for Statistical Computing, V3.1.2). Group differences were assessed with Fischer’s exact t-test and Pearson’s Chi-squared test (for count data) and Welch’s t-test (for normally distributed variables) or Mann-Whitney U test (for not normally distributed variables). Interrater-reliability was assessed with weighted Kappa-coefficients. Correlation of acute and follow-up ASPECTS was assessed with spearman-correlation and linear regression analysis. Univariate logistic regressions were carried out for neurological outcome at three months. For all p-values the significance level was set to $\alpha = 0.05$. Means are given with their standard deviation, medians with their interquartile range (IQR), all confidence intervals are quoted as 95%-CI.

**Results:**

**Baseline patient characteristics:**

Baseline patient characteristics for both, the FD- and the MD-CT-cohorts are listed in Table 1. There were no differences in age, prestroke mRS, baseline NIHSS, time from symptom onset or, in cases of unknown onset time ($n = 16$ for both cohorts), time from last-seen well to admission and rates of successful recanalization (86 % in the FD-CT cohort vs. 94 % in the MD-CT cohort, $p = 0.43$). There were further no significant differences for the side of MCA M1-occlusion ($p = 1.0$) or the administration of i.v.-thrombolysis ($p = 0.82$).
Noteworthy, while time from initial hospital admission at our site to imaging was comparable for both cohorts \((p = 0.75)\), time from admission to groin puncture was shorter in patients who directly underwent FD-CT imaging \((41 (31 - 47) \text{ min})\) compared to conventional MD-CT-imaging \((67 (54 - 90) \text{ min}, p < 0.001)\). Further on, this significant correlation holds true \((p = 0.002)\), when considering only the subgroup of patients who did not undergo prior imaging at other hospitals and secondary transfer to our institution \((18 (49 \%) \text{ in the MD-CT cohort vs. 8 (22 \%) in the FD-CT cohort, } p = 0.02)\), a scenario which could have affected processing time at our institute.

**Interrater-reliability:**

Interrater-reliability was best for NCCT-ASPECTS with \(\kappa = 0.74 \ (0.59 - 0.85)\), while it was substantial for CBV-ASPECTS with \(\kappa = 0.63 \ (0.47 - 0.74)\). For PBV-ASPECTS, interrater-reliability was dependent on the image reconstruction characteristics with \(\kappa = 0.53 \ (0.38 - 0.65)\) for “smooth” image reconstruction characteristics and \(\kappa = 0.61 \ (0.49 - 0.71)\) for “very smooth” image reconstruction characteristics (see table 2). Interrater-reliability did not improve when considering only the FD-Perfusions, which were acquired within the venous phase \((n = 32/37 \ (86 \%))\) with \(\kappa = 0.56 \ (0.41 - 0.67)\) for “smooth” image characteristics and \(\kappa = 0.60 \ (0.48 - 0.70)\) for “very smooth” image characteristics.

**Correlation with follow-up ASPECTS:**

To assess the accuracy of ASPECTS derived from NCCT and from CBV- and PBV-maps to predict final infarct size, consensus scores were compared to follow-up ASPECTS 24 hours after MT. First, on a group level, a tendency towards lower ASPECTS on follow-up imaging was noted in the FD-cohort compared to the MD-cohort \((\text{median (IQR) of 6 (3 – 8) vs. 8 (5 – 8), } p = 0.05)\).

With \(p = 0.80 \ (0.61 - 0.94), p < 0.001\) in the spearman analysis and \(R^2 = 0.63\) in the linear regression (see Table 2), NCCT-ASPECTS was found to correlate best with follow-up ASPECTS. Still, a tendency to underestimate final infarct extent by ASPECTS derived from acute NCCT \((p = 0.05, \text{ intercept of the linear regression: } -2.9 \pm 1.3, \text{ see Figure 1})\) was noted.
In the spearman-correlation analysis, ASPECTS derived from CBV-maps and from PBV-maps were found to perform comparably with \( \rho = 0.52 \) (0.17 – 0.80), \( p = 0.001 \) for CBV-maps derived ASPECTS and \( \rho = 0.58 \) (0.32 – 0.79), \( p < 0.001 \) for PBV-maps derived ASPECTS (for “smooth image characteristics”). Accuracy of PBV-ASPECTS improved further when derived from PBV-maps with “very smooth” image characteristics (\( \rho = 0.63 \) (0.40 – 0.83), \( p < 0.001 \)). However, linear regression revealed a systematic error of PBV-derived ASPECTS with significant overestimation of the final infarct extend (intercept of the linear regression: 2.1 ± 0.9 (“smooth” image characteristics) and 1.7 ± 0.8 (“very smooth” image characteristics) vs. 0.9 ± 1.6 for CBV-derived ASPECTS, see Figure 1). Especially, we observed relevant infarct overestimation by at least 2 ASPECTS regions in 10 of 37 patients (27 %) for PBV-maps derived ASPECTS (see exemplarily Figure 2). Importantly, such potentially misleading, and hence relevant, overestimation of final infarct extent was observed significantly less often in CBV-maps derived ASPECTS (n = 2/37 (5 %), \( p = 0.02 \)). Noteworthy, such relevant overestimations were not observed for NCCT derived ASPECTS. For FD-CT PBV derived ASPECTS, correlation did not improve, when considering only PBV-maps derived from perfusion data or respectively fill runs which were acquired in the venous (steady state) phase: “smooth” image characteristics: \( \rho = 0.54 \) (0.25 – 0.80), \( p = 0.001 \); “very smooth” image characteristics: 0.62 (0.35 – 0.87), \( p < 0.001 \) and, especially, relevant infarct overestimation was still observed in 25 % of these cases (8 of 32).

Correlation between acute and follow-up ASPECTS was not found to depend on prior contrast-agent administration. So, spearman-correlation between acute and follow-up imaging was \( \rho = 0.61 \) (0.29 – 0.84), \( p < 0.001 \) for PBV-ASPECTS (for “smooth image characteristics”), \( \rho = 0.50 \) (0.0 – 0.9), \( p = 0.03 \) for CBV-ASPECTS and \( \rho = 0.77 \) (0.34 – 1.0), \( p < 0.001 \) for NCCT-ASPECTS for the subgroups of patients who underwent prior external imaging and secondary transfer to our hospital.

**Clinical outcome analysis:**

A favorable clinical outcome was observed in 48 % (16/33) of patients who underwent FD-CT imaging and in 58 % (21/36) of patients who underwent conventional NCCT and CT-perfusion prior to MT (\( p = 0.42 \)). In the logistic regression, NCCT-derived ASPECTS (OR 2.30 (1.40 – 4.72), \( p = 0.007 \)) and PBV-
derived ASPECTS (“smooth” image characteristics: OR 1.48 (1.31 – 2.08), p = 0.010; “very smooth” image characteristics: OR 1.55 (1.17 – 2.23), p = 0.006) were predictors of a favorable clinical outcome, while CBV-derived ASPECTS missed significance in our cohort (OR 1.29 (0.90 – 1.95), p = 0.19). Besides, NIHSS on admission was a predictor of favorable clinical outcome (OR 0.89 (0.81 – 0.96), p = 0.008).

While time from admission to groin puncture was shorter for patients who underwent FD-imaging compared to MD-CT (see above), neither time from symptom onset to admission, nor time from symptom onset to groin puncture (both p = 0.59) were predictors for clinical outcome. There was a tendency for successful MT as a predictor for favourable clinical outcome in the univariate analysis (OR 8.31 (1.31 – 161), p = 0.06) in our study.

Discussion:

While FD-CT imaging has been proven to allow for the exclusion of intracranial hemorrhage and diagnosis of LVO in acute ischemic stroke before [4, 5], we could demonstrate in this study, that ASPECTS derived from FD-CT PBV-maps predicts clinical outcome 3 months after MT and thereby even outperformed MD-CT CBV-derived ASPECTS on a group level.

Nevertheless, NCCT-derived ASPECTS still outperformed both PBV- and CBV-derived ASPECTS in the prediction of clinical outcome and revealed superior reliability and accuracy. Especially the occurrence of relevant infarct overestimation on an individual patient level could prevent FD-CT PBV-maps from wide clinical application in acute stroke care. Here, relevant overestimation of final infarct extent (by at least 2 ASPECTS regions) was present in 27 % for PBV-derived ASPECTS, which is in line with a previous study by Ava et al. reporting relevant infarct overestimation on FD-CT derived PBV-maps in 25 % [10].

Likewise, even though to a lesser extent, infarct overestimation occurred on MD-CT derived CBV-maps as well, while it was not observed for NCCT-derived ASPECTS. This finding is corroborated by previous studies [11-14], where the occurrence of infarct overestimation was already noted for the, nevertheless, widely established MD-CT-perfusion mismatch assessment [15]. As the factors
contributing to MD-CT CBF- and CBV-reduction in cerebral ischemia are complex [11], a variety of reasons for the misclassification of infarct core by CT-perfusion have been discussed. Time dependency of infarct growth leading to different infarct volumes in cases of early reperfusion can be decisive [13], as well as states of so-called misery perfusion, where an elevated oxygen-extraction fraction may compensate for reductions in CBF and CBV [10]. Variations in vascular anatomy and auto-dysregulation of perfusion pressure; upstream flow restriction and finally, technical reasons including misplacement and motion of the patient during the CT-perfusion scan can play a role as well [12].

Previous studies have reported good correlation of FD-CT PBV-maps with MD-CT derived CBV-maps in animal studies and in humans [5,8] and correlation with final infarct volume has been demonstrated before [16]. Remarkably, relevant infarct overestimation was more frequent for PBV-derived ASPECTS than for CBV-derived ASPECTS in our study. Image quality of FD-CT Perfusion may be an important factor that contributes to the disadvantage of FD-CT, limiting accuracy of perfusion-derived infarct assessment due to the low signal to noise ratio and high standard-deviation [11,17]. Moreover, patient motion may have affected PBV-map quality in our study. We thereby emphasize on the finding that in our study 12 of 54 patients (22 %) who underwent FD-CT Perfusion imaging, had to be excluded from the analysis due to strong beam hardening and motion artifacts on PBV-maps. Besides infarct overestimation, this presents a second major drawback of the method which could potentially limit the applicability of FD-CT perfusion imaging at the current state of technology. Stroke patients are often agitated and, in contrast to above mentioned studies [5,8,16], imaging was not carried out under general anesthesia in our study. Nevertheless, we point out that motion artifacts alone do not explain above discussed occurrence of infarct overestimation. We remind, that interrater-reliability could substantially be improved by changing the image postprocessing algorithm from “smooth” to “very smooth” for the evaluable PBV-maps and hence observer-dependent visual delineation of PBV-reduction alone does not account for the observed differences. Rather, interactions between CBV and CBF may contribute to the overestimation of PBV-derived ASPECTS. Kamran et al. found that a reduction in PBV does not directly translate to a reduction in CBV, but instead both CBV-weighting
~40%) and CBF-weighting (~60%) contribute to the pooled blood volume parameter [18]. While oligemic tissue is now described to exhibit increased CBV at mild reductions in CBF (resulting ideally in constant PBV-values), penumbral tissue may already exhibit stronger CBF-reductions (still above the typical thresholds for ischemic core) combined with beginning decreases in CBV [19-20]. Depending on the contribution of these two parameters to PBV, their interaction may already lead to visually severe reductions within penumbral tissue on PBV-maps. The interplay of these two parameters may hence impede visual differentiation between infarct core and penumbral tissue, possibly explaining the observed tendency to overestimate the infarct core on PBV-maps even compared to CBV-maps. As an additional complicating factor, the contribution of CBV and CBF to PBV depend on the acquisition parameters, as namely contrast wash-in or wash-out during the acquisition of the fill run result in variable CBF weighting [18]. Even the “bolus-watching” approach to ensure acquisition during a steady state phase may overlook the differences in individual patient hemodynamics [18] and we observed relevant infarct overestimation also in the subgroup of patients fulfilling the steady state condition (opacification of the venous sinus). These findings imply, that, though noise-levels on PBV-maps may be reduced in the future, the interplay of CBV and CBF could nevertheless limit the applicability of PBV-maps to identify mismatch reliably. We point out, that this limitation only applies to the visual delineation of infarcted tissue on PBV-maps and not to threshold-based approaches, which may be realized when substantial improvements in image quality and signal-to-noise ratio are achieved. So far, the additional information gained from FD-CT perfusion imaging may not allow for precise treatment decision making in acute ischemic stroke. Noteworthy and as a side effect of our matched-pair analysis, we found a reduction in time from initial admission to groin puncture in patients who underwent FD-CT imaging prior to MT compared to patients who underwent primarily conventional MD-CT imaging. Although the study design does not allow for the generalization of this finding, it is corroborated by previous studies [7] and still motivates for further research on the technique to identify ischemic tissue in acute ischemic stroke by FD-CT imaging.
Finally, we point out, that there is a potential bias towards better correlation between NCCT-ASPECTS (compared to PBV- or CBV-ASPECTS) and final infarct extend in our study, as post-treatment ASPECTS was evaluated also on NCCT and not gold-standard MRI-DWI. Further limitations of our study result from the monocenter, retrospective study design and the potential for a selection bias in the groups for the matched-pair analysis. More patients underwent prior external imaging in the MD-group compared to the FD-group. Thereby, contrast agent extravasation due to blood brain barrier disruption could mask early ischemic changes on NCCT. Still, we point out, that such an effect would not influence the study results, as already NCCT-ASPECTS was found to outperform PBV- and CBV-ASPECTS. Moreover, compared to infarct overestimation, our study is not designed to investigate the reasons for infarct underestimation. In cases where infarcts were underestimated compared to follow-up imaging, our data does not allow to deduce whether final infarct extend was already evident in the acute setting (“true underestimation”) or developed within the time from imaging to recanalization and follow-up imaging. Furthermore, the lack of mRS prediction by CBV-ASPECTS in our study may be due to the small sample size and the relatively homogenous patient cohort. The cohort size of, in total, n = 74 patients asks for further validation of our results.

**Conclusion**

NCCT-ASPECTS prior to MT outperformed both FD-CT PBV-ASPECTS and MD-CT CBV-ASPECTS in accuracy and reliability. Moreover, we observed relevant overestimations of acute infarct core size for both CBV-ASPECTS and PBV-ASPECTS. Importantly, visual overestimation of the infarct core occurred thereby more often for PBV-ASPECTS than for CBV-ASPECTS, potentially limiting the applicability of FD-CT PBV imaging for clinical routine and standard stroke protocols.

**Competing Interests:** non declared
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Table 1 Baseline patient characteristics (if applicable median and IQR are given). *recanalization was defined to be successful when mTICI was 2b or better.

|                          | FD-CT     | MD-CT     | p-value |
|--------------------------|-----------|-----------|---------|
| Age                      | 79 (70 – 84) | 77 (70 – 84) | 0.75    |
| Gender (female/male)     | 19/18     | 25/12     | 0.24    |
| Prestroke mRS            | 1 (0 – 2) | 1 (0 – 2) | 0.73    |
| baseline NIHSS           | 17 (9 – 21) | 14 (11 – 20) | 0.36    |
| Side of occlusion (left/right) | 17/20 | 16/21     | 1.0     |
| Prior external imaging and secondary patient transfer to the stroke center | 19 (51 %) | 29 (78 %) | 0.02    |
| Time from symptom onset to admission (min) | 270 (161 – 503) | 245 (152 – 581) | 0.81    |
| Time from admission to imaging (min) | 17 (14 – 31) | 20 (15 – 28) | 0.75    |
| Time from admission to groin puncture (min) | 41 (31 – 47) | 67 (54 – 90) | < 0.001 |
| i.v.-Lysis (y)           | 19 (51 %) | 17 (46 %) | 0.82    |
| Successful recanalization* (y) | 32 (86 %) | 35 (94 %) | 0.43    |
Table 2 Interrater-reliability of ASPECTS (weighted κ – coefficients) and correlation of acute to follow-up ASPECTS in dependence of the modality (and for FD-CT PBV-maps derived ASPECTS in dependence of the image reconstruction characteristics “smooth” or “very smooth”).

| Modality     | Interrater-reliability | Correlation to follow-up ASPECTS | Linear regression |
|--------------|------------------------|----------------------------------|-------------------|
|              | κ (CI)                 | ρ (CI)                           | p-value           | r²     |
| NCCT         | 0.74 (0.59 – 0.85)     | 0.80 (0.61 – 0.94)               | < 0.001           | 0.63   |
| CBV          | 0.63 (0.47 – 0.74)     | 0.52 (0.17 – 0.80)               | < 0.001           | 0.28   |
| PBV (“smooth”) | 0.53 (0.39 - 0.64)    | 0.58 (0.32 – 0.79)               | 0.001             | 0.33   |
| PBV (“very smooth”) | 0.61 (0.49 – 0.71)   | 0.63 (0.40 – 0.83)               | < 0.001           | 0.42   |