The Value of Non-Contrast Head CT in Acute Ischemic Stroke

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PUERTO RICO

DISCLOSURES
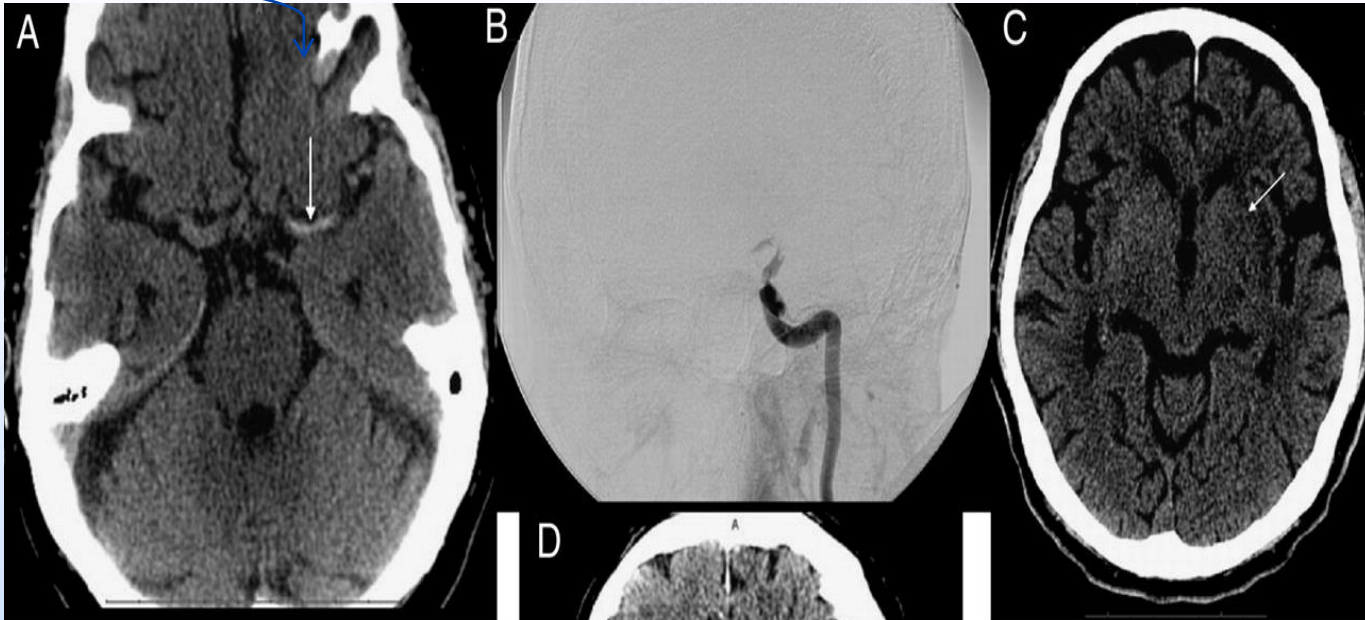
I have no disclosures

NCCT

- Fast

- Widely and easily available

- Does not require iv contrast

- Rules out ICH

- Early ischemic signs

NCCT
Early Ischemic Signs

Hyperdense MCA

Lentiform obscuration

Loss of insular ribbon

Kumar G. JNS. 2010; 288:13-24

1/3 MCA rule

- Hypodensity in >1/3 MCA territory predicted higher risk of development of ICH.

- Criterion for exclusion of patients from treatment in the acute stroke treatment trials.

- Poor interrater agreement.

Hacke W. JAMA 1995;274(13):1017–25.
Schriger DL. JAMA 1998;279(16):1293–7.
Dippel DW. Neuroradiology 2000;42(9):629–33.

ASPECTS

- Alberta Stroke Program Early CT Score was developed to objectively quantify early CT changes in acute ischemic stroke for the purpose of TPA decisionmaking.

- ASPECTS was developed to overcome the insecurity physicians felt applying the 1/3 MCA rule before treating patients with TPA.

Barber PA. Lancet 2000 May 13;355(9216):1670-4.
Pexman JH. AJNR. 2001 Sep;22(8):1534-42.

ASPECTS

- Cut-off of >7 as it predicted functional independence in those who underwent thrombolysis within 3h (n=203).

Barber PA. Lancet 2000 May 13;355(9216):1670-4
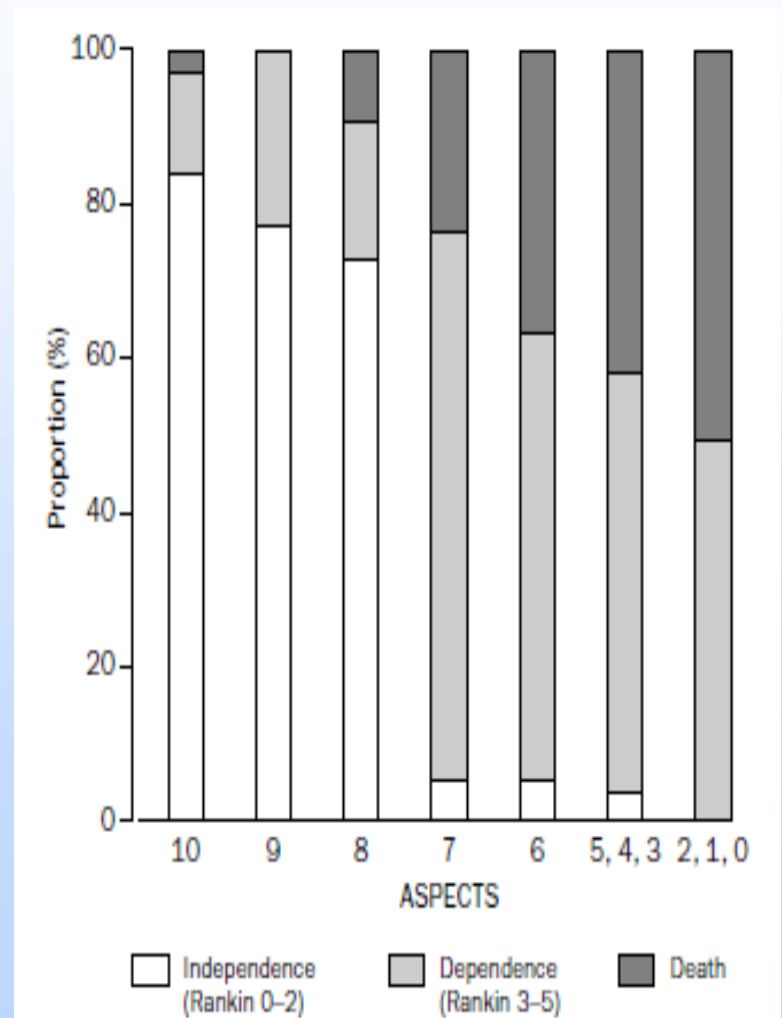
ASPECTS

- Interobserver reliability among physicians was better with ASPECTS as compared to 1/3MCA rule.

- Allows accurate assessment of severity of CT findings.

- Allows consistent and confident communication between colleagues.

- ASPECTS has good agreement between neuroradiologists and neurologists.

Barber PA. Lancet 2000 May 13;355(9216):1670-4.
Pexman JH. AJNR. 2001 Sep;22(8):1534-42.
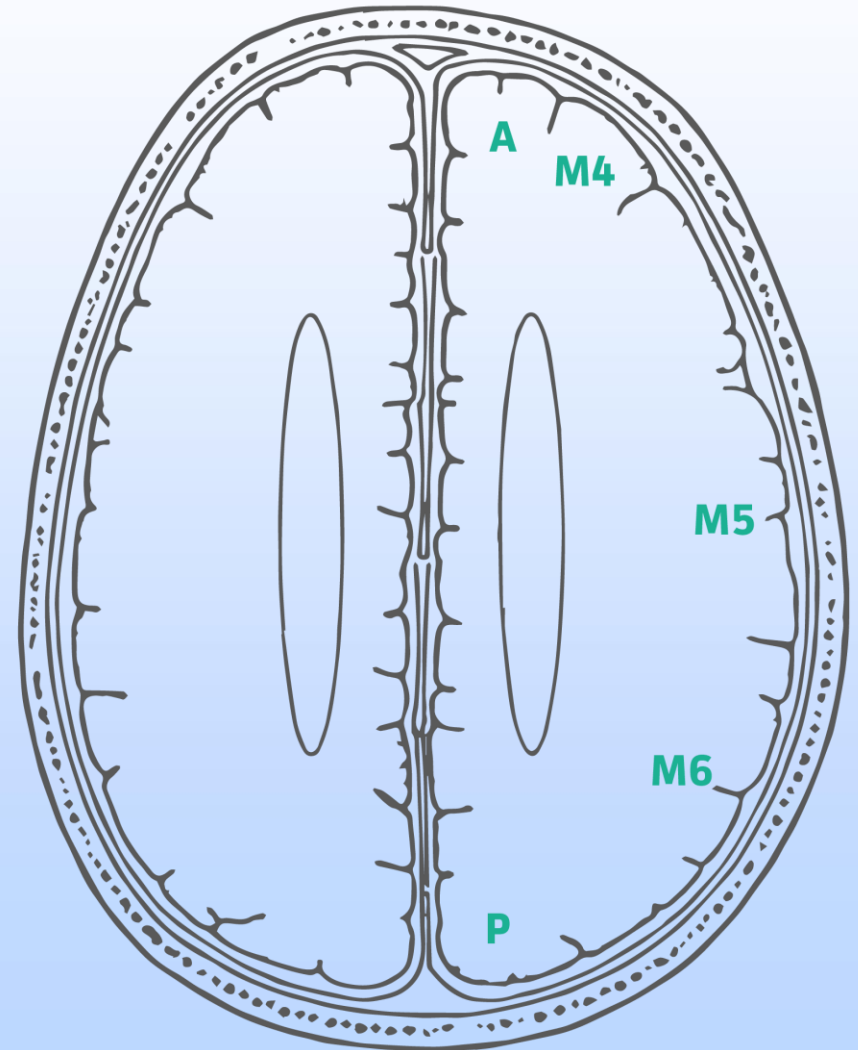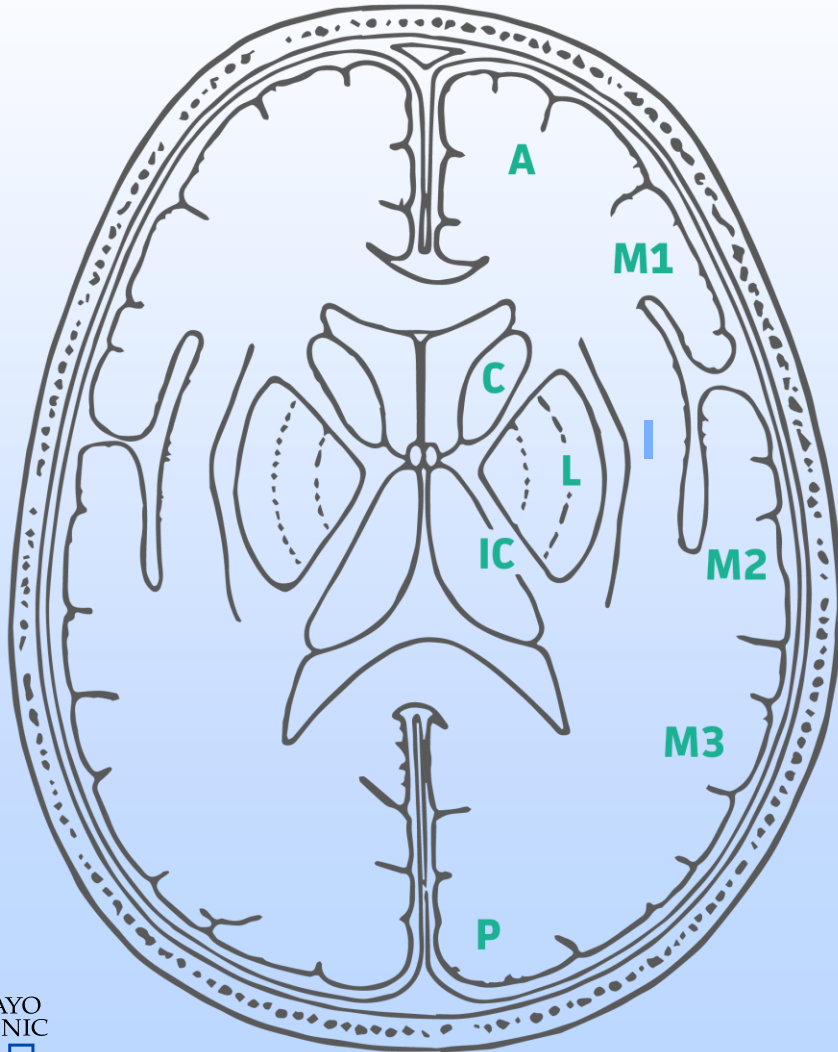
ASPECTS

ASPECTS
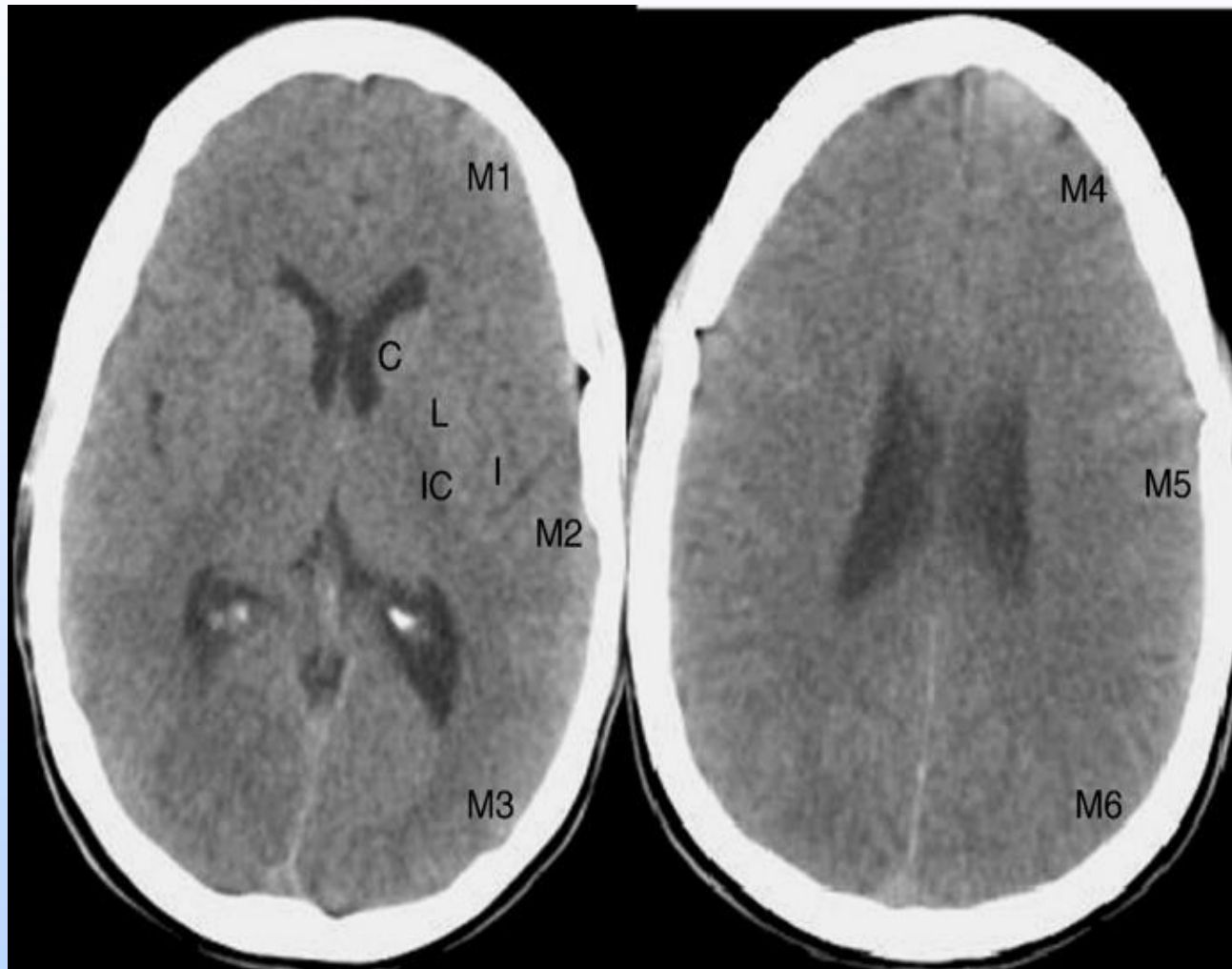
Vignette

- 56 RHW developed Left hemispheric stroke syndrome, NIHSS 23 on Telestroke assessment.

- TPA contraindicated due to Apixaban.

- CTA showed a LMCA M1 occlusion.

- Transferred to Mayo Clinic.

Initial ASPECTS

ASPECTS on arrival
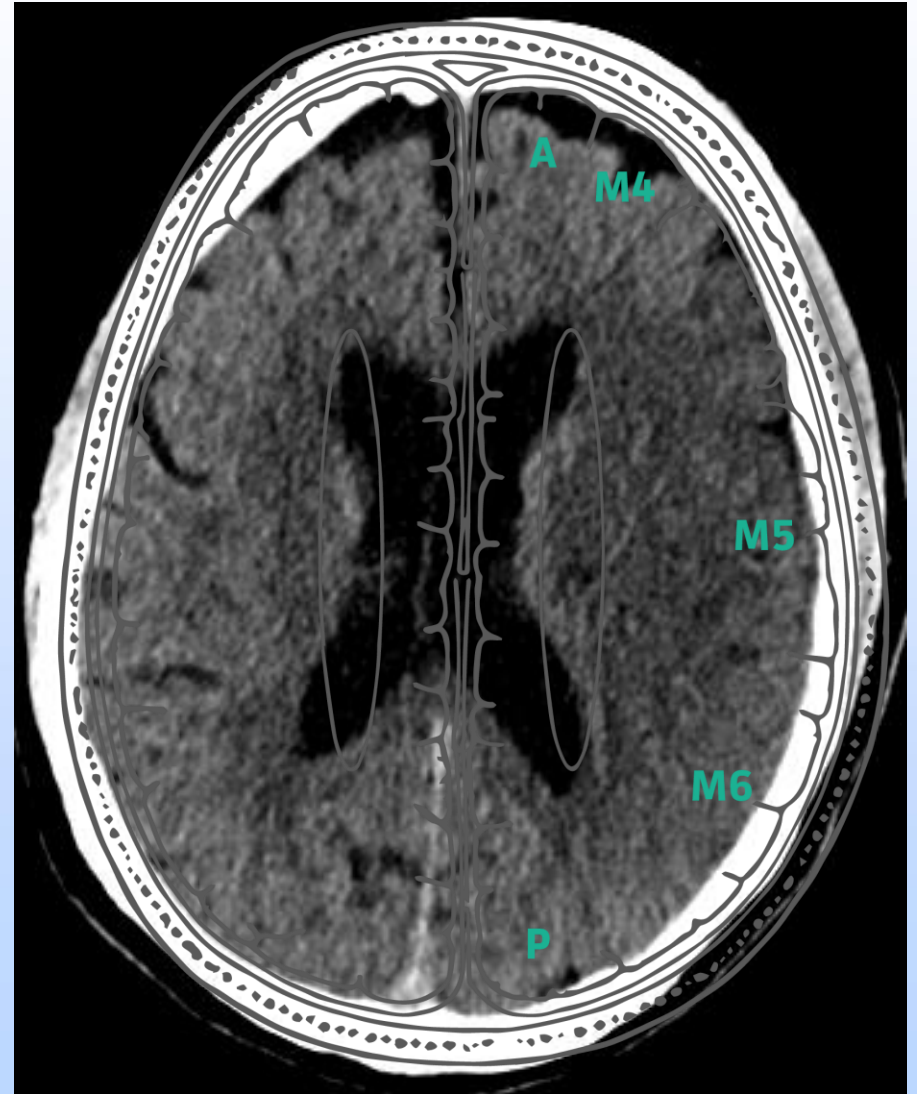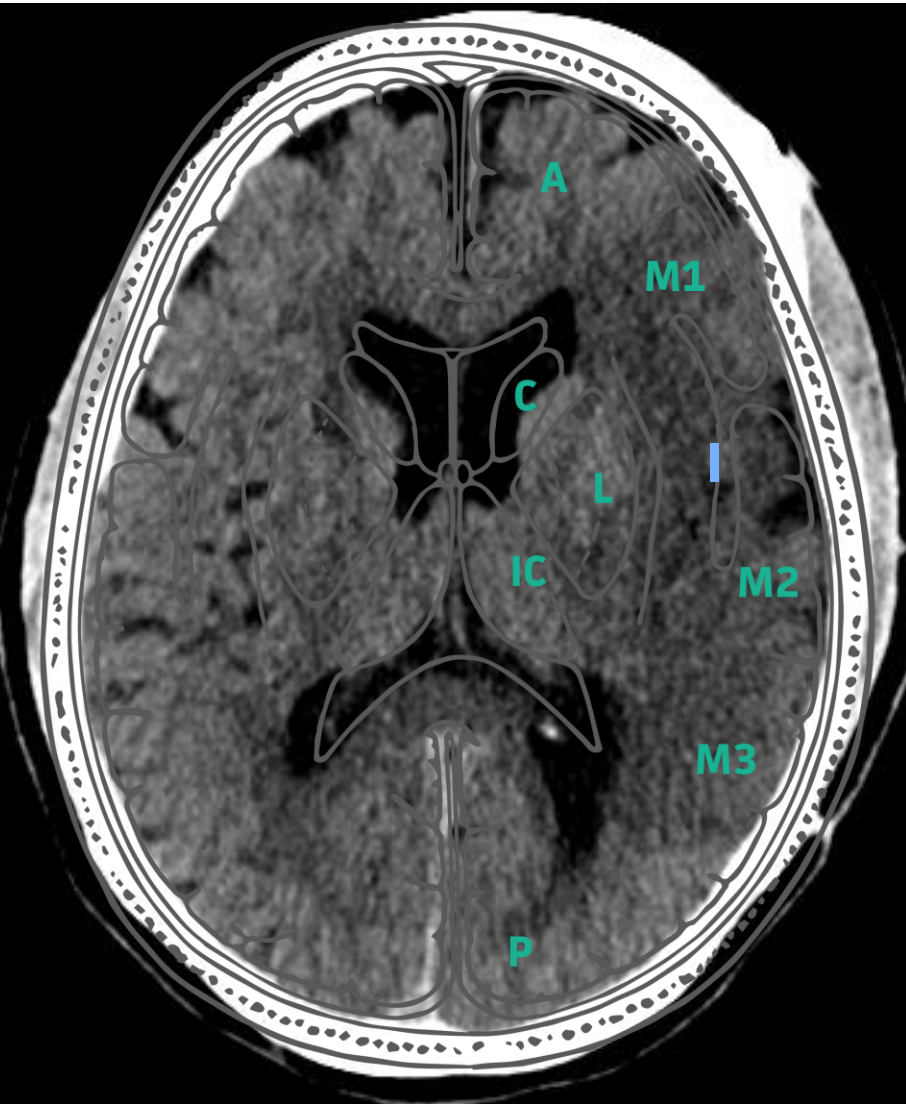
MRI
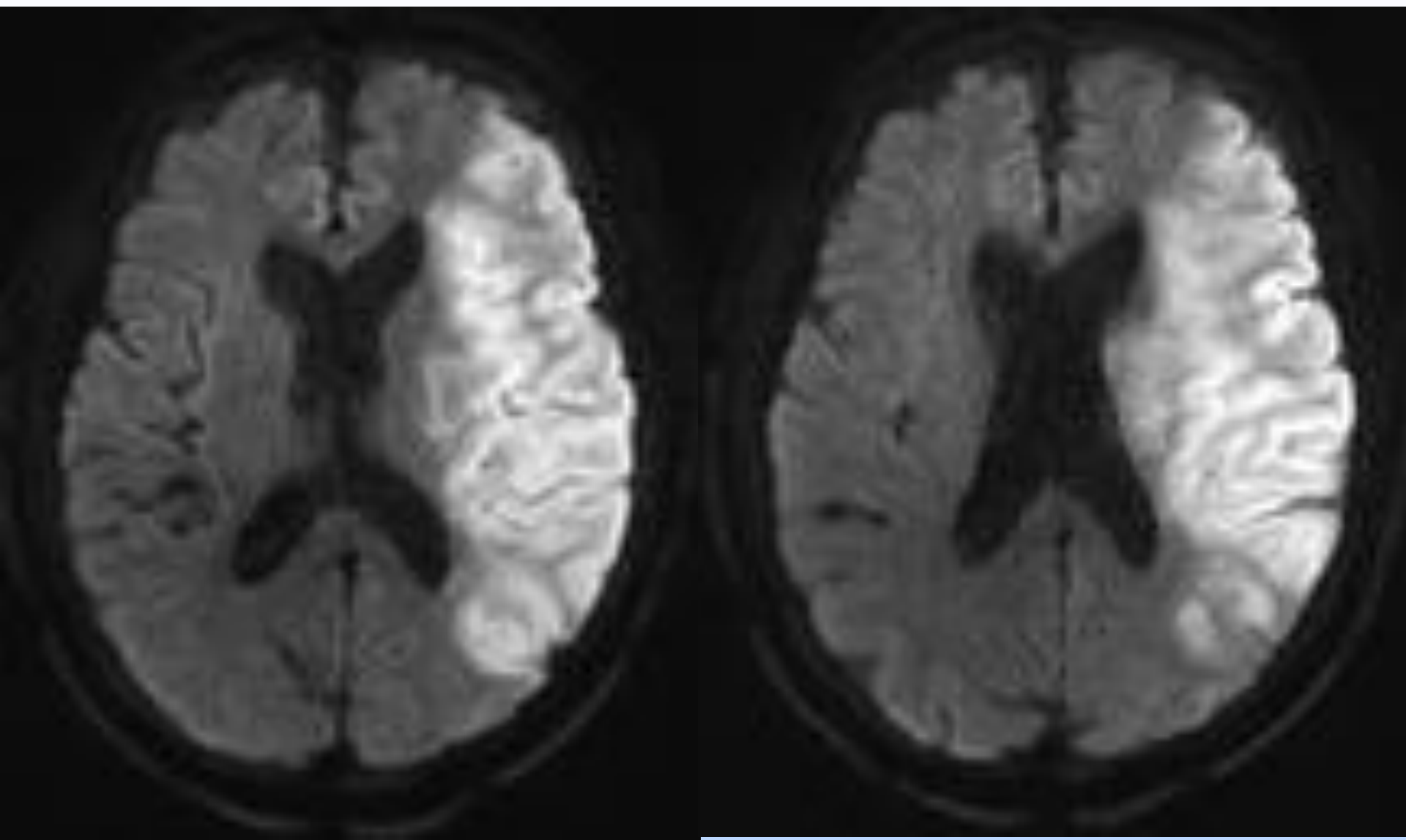
DHC

2nd generation EVT trials

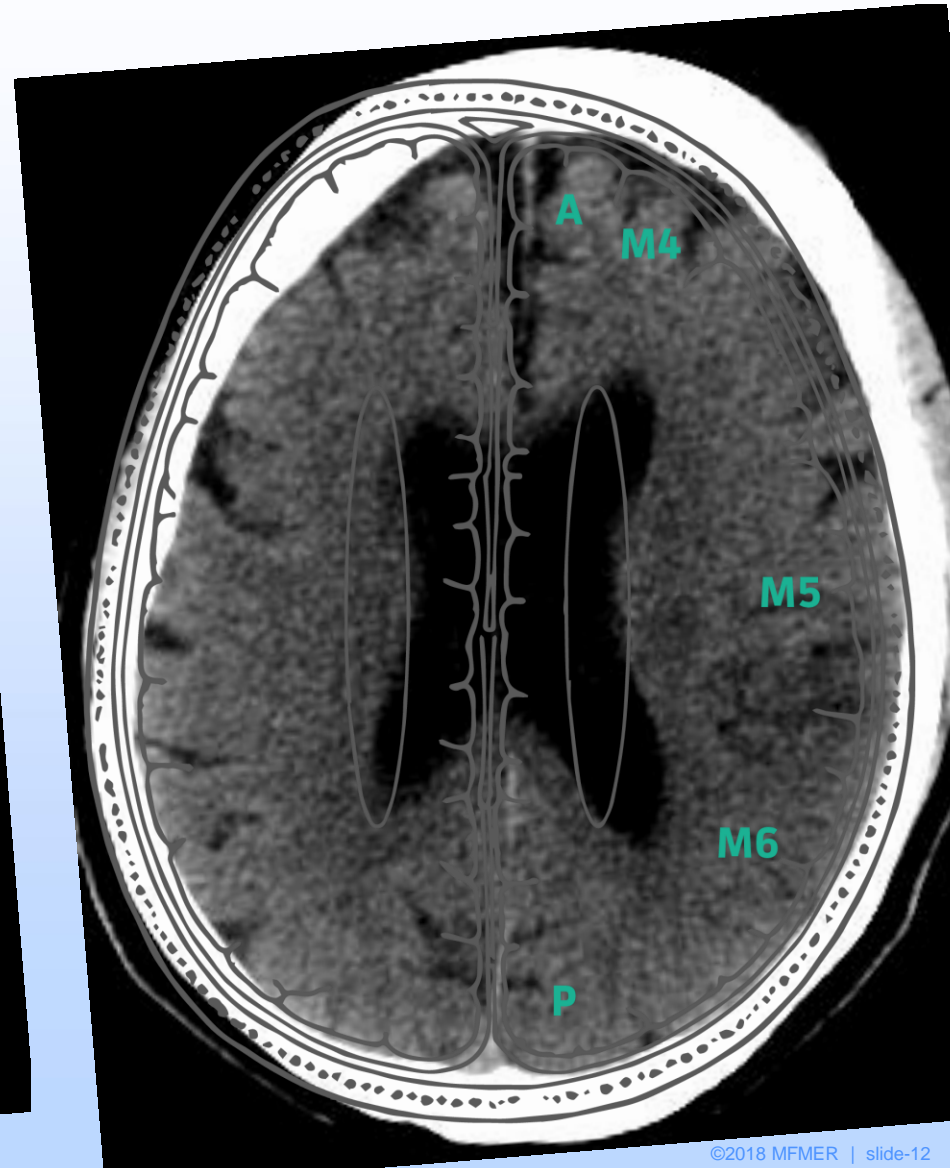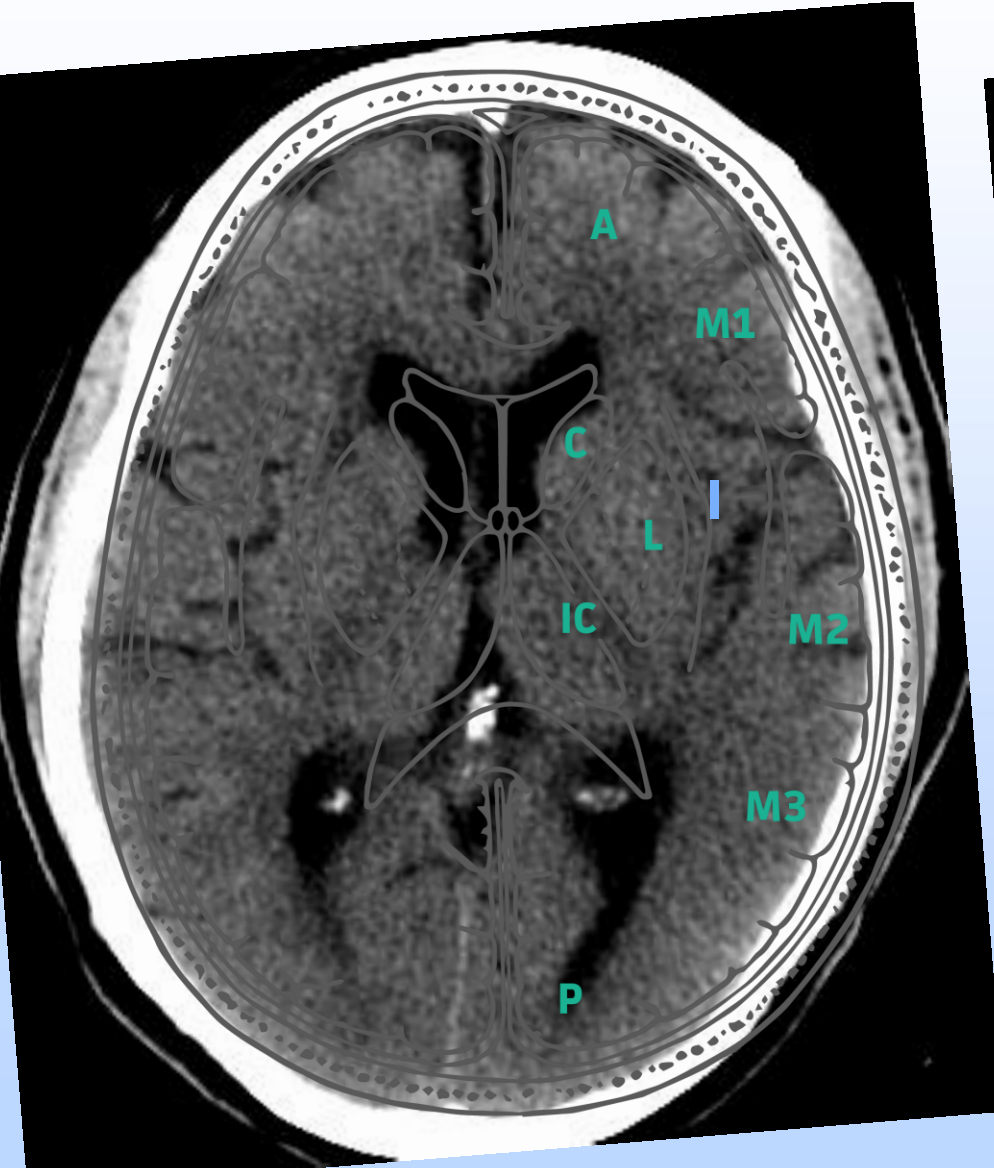| Study	Wind-hours	N	IVTPA %	Imaging	NIHSS	CT to Groin Punct, min	TICI 2b/3, %	mRS 0-2 @3mo EVT/cont,%	Mort EVT/cont, %	sICH EVT/cont, %
MR CLEAN	6	500	87	CT (ASPECTS); CTA/MRA/DSA	17-18	NA	59	33/19	19/18	6/5
ESCAPE	12	315	75	CT + Multiphase CTA	16-17	51	72	53/29	10/19	3.6/2.7
EXTEND – IA	6	70	100	CT + CTA + CTP	13-17	93	86	72/39	9/20	0/6
SWIFT PRIME	6	196	100	CT (ASPECTS/MRI; CTA/MRA/CTP or MRP	17	57	88	60/35	9/12	0/3
REVASCAT	8	206	68	CT (ASPECTS)	17	NA	66	44/28	18/15	2/2
THRACE	5	414	100	CT or MRI with CTA or MRA	17-18	82	69	53/42	12/13	2/2

2nd generation EVT trials

Core

Study	Wind-hours	N	IVTPA %	Imaging	NIHSS	CT to Groin Punct, min	TICI 2b/3, %	mRS 0-2 @3mo EVT/cont,%	Mort EVT/cont, %	sICH EVT/cont, %
MR CLEAN	6	5	None	CT (ASPECTS); CTA/MRA/DSA	17-18	NA	59	33/19	19/18	6/5
ESCAPE	12	315	75 ASPECTS ≥ 6	CT + Multiphase CTA	16-17	51	72	53/29	10/19	3.6/2.7
EXTEND – IA	6		CTP <70cc core with RAPID					89	9/20	0/6
SWIFT PRIME	6	196	100 ASPECTS ≥ 7	CT (ASPECTS/MRI CTA/MRA/CTP or MRP) CTP with RAPID initially						
REVASCAT	8	206	ASPECTS ≥ 7 on CT; ≥ 6 on DWI	CT (ASPECTS)	17	N/A	66	44/28	18/15	2/2
THRACE	5	4	None	CT or MRI with CTA or MRA	17-18	82	69	53/42	12/13	2/2

ASPECTS

ASPECTS	n	cOR	
9 - 10	682	1,81 – 4,40	
6 - 8	475	1,68 – 3,26	
0 - 5	121	0,62 – 2,49	

0,5   1   2   4
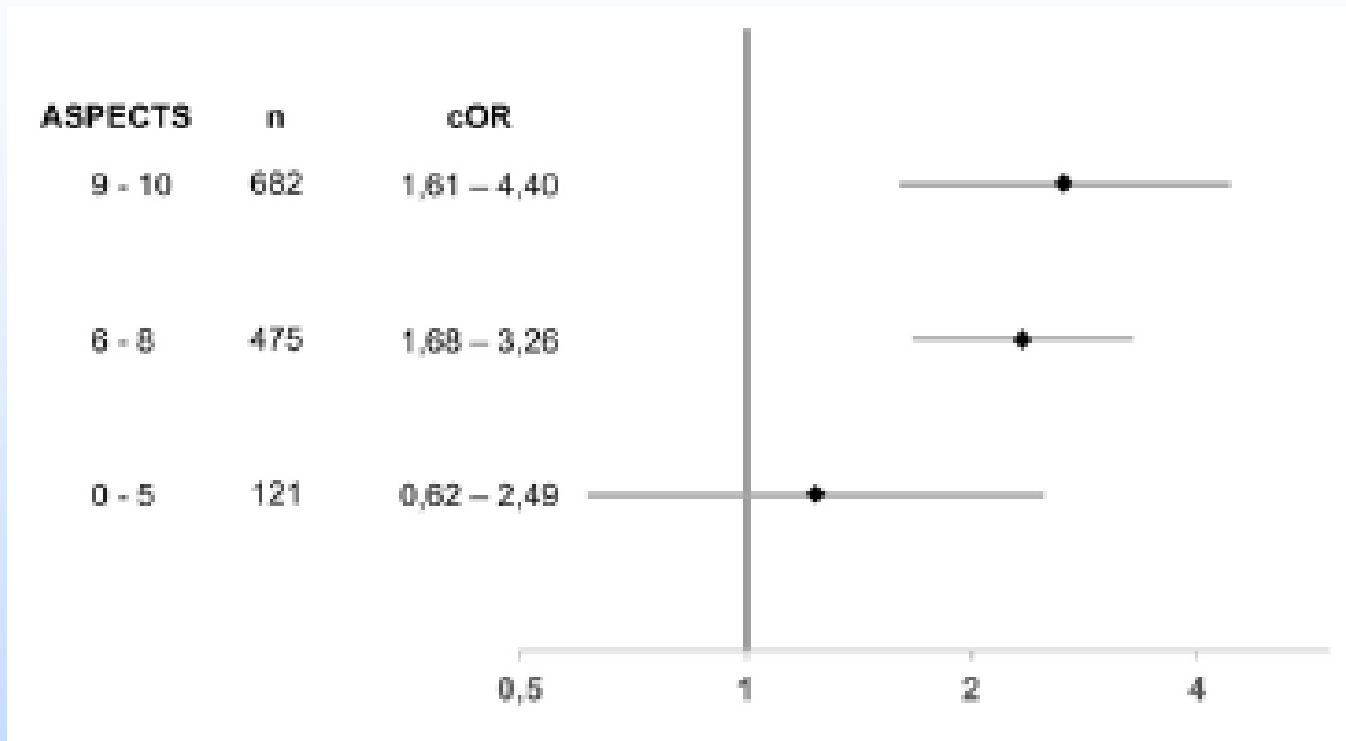
- ORs for adjusted treatment effect for MRS 0–2 at 90 days stratified for different ASPECTS subgroups in the HERMES metaanalysis
- There was no significant heterogeneity of effect ($p = 0.29$)
- *n* indicates the number of patients analyzed; cOR, common odds ratio.

Goyal M. Lancet (2016) 387(10029):1723–31.

AHA/ASA guideline

3.7. Mechanical Thrombectomy (Continued)	COR	LOE
3. Patients should receive mechanical thrombectomy with a stent retriever if they meet all the following criteria: (1) prestroke mRS score of 0 to 1; (2) causative occlusion of the internal carotid artery or MCA segment 1 (M1); (3) age ≥18 years; (4) NIHSS score of ≥6; (5) ASPECTS of ≥6; and (6) treatment can be initiated (groin puncture) within 6 hours of symptom onset.	I	A

Powers WJ. Stroke. 2018 Mar;49(3)

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3RD Generation

Study	Wind-hours	N	IVTPA %	Imaging	NIHSS	LKW to randomization (hr)	Sx discov to rand (hr)	Infarct vol (EVT/cont)	mRS 0-2 @3mo EVT/cont,%	Mort EVT/cont,%	sICH EVT/cont,%
DAWN	6-24	206	9	DWI MRI or CTP with RAPID	17	12/13	5/5.6	7.6/8.9	49/13	19/18	6/3
DEFUSE 3	6-16	182	10	DWI MRI or CTP with RAPID	16	~11/11		9.4/10	45/17	14/26	7/4

DAWN imaging criteria

	A	B	C
Age (y)	≥ 80	< 80	< 80
NIHSS	≥ 10	≥ 10	≥ 20
Core volume (ml)	< 21	< 31	31-51

RAPID

Core *clinical* mismatch

Other inclusions	
mRS	0-1
CT/MRI	No ICH No evidence of infarct > 1/3 MCA

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DEFUSE 3 Imaging Criteria

- Core <70 ml

RAPID

- Total perfusion defect/Core ratio ≥ 1.8
  - Also called "mismatch ratio"

- Absolute penumbral volume ≥ 15 ml
  - Also called "mismatch volume"

Core *Perfusion* mismatch

Other inclusions	
Age	18-90
mrS	0-2
NIHSS	≥ 6
Femoral puncture	6-16h

- How does NCCT ASPECTS compare with CTA and CTP?

ASPECTS vs. CTP/CTA

- 508 patients with anterior ELVO

- Incorporating CTP measures of core and penumbra (instead of ASPECTS) did not improve prognostication of 3 month outcomes.

Raza SA, et al. J NeuroIntervent Surg 2018;0:1–5.
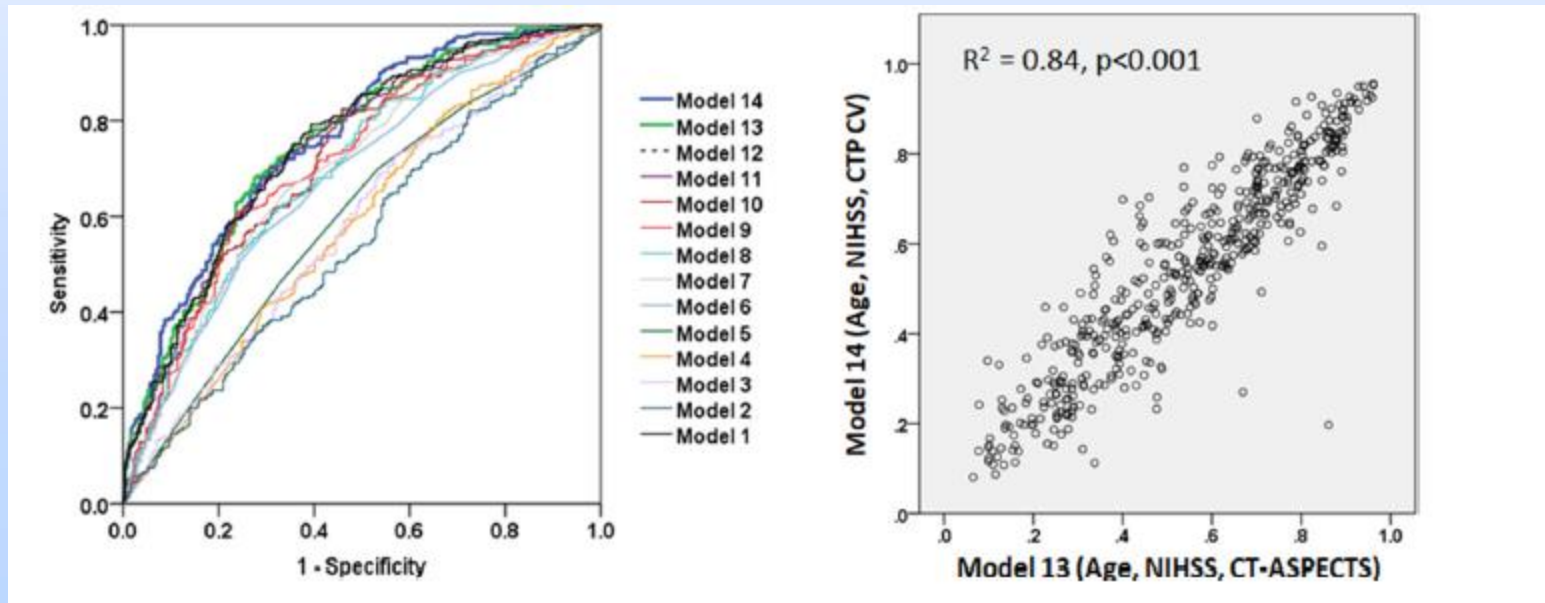
ASPECTS vs. CTP/CTA

- 1374 patients from a prospective Dutch stroke registry.

- Multivariate logistic regression models were developed with NCCT ASPECTS, CTA-ASPECTS, and ASPECTS applied to CTP measures.

Van Seeters T. Cerebrovasc Dis (2015) 40(5–6):258–69.
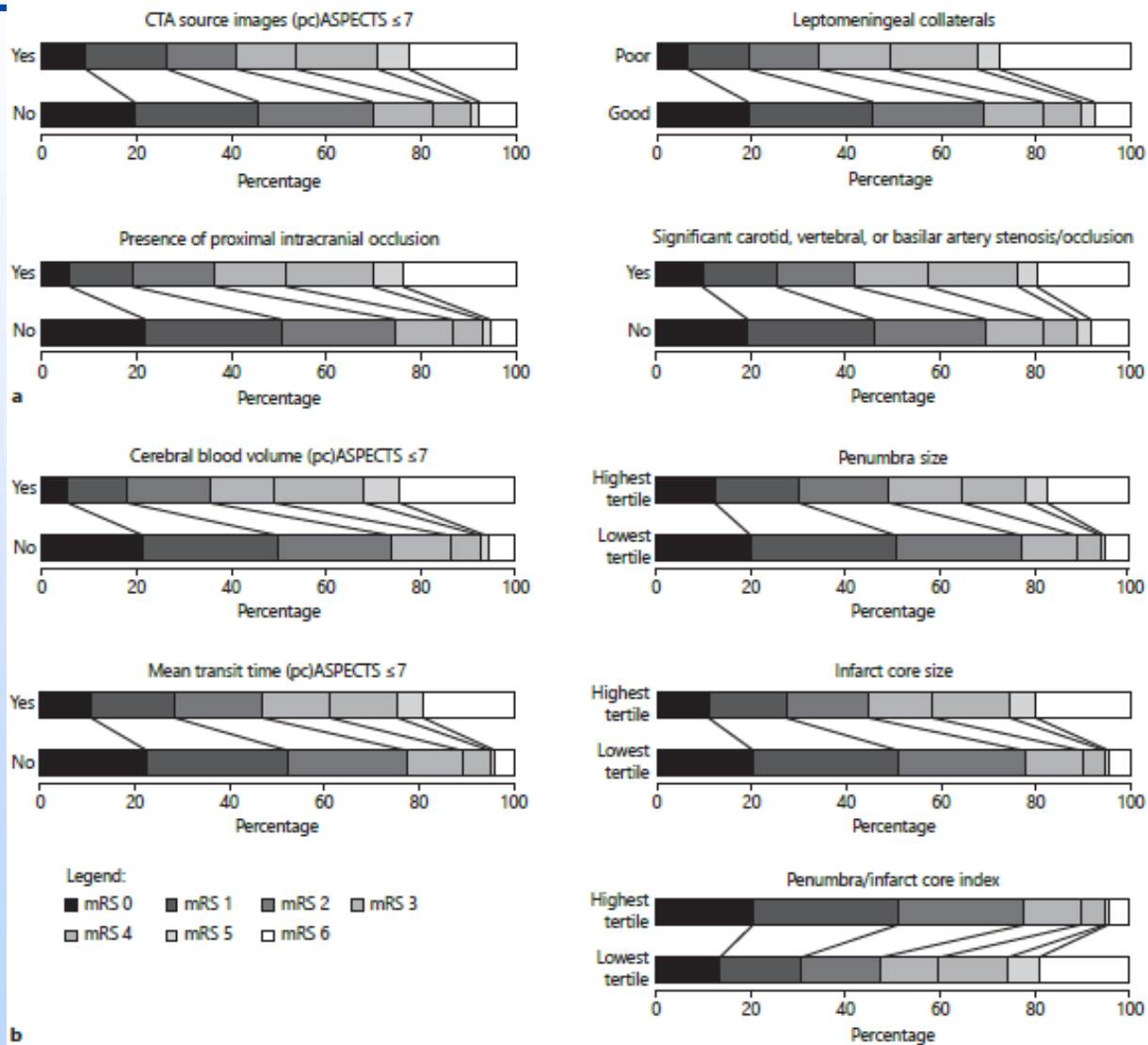
ASPECTS vs. CTP/CTA

Van Seeters T. Cerebrovasc Dis (2015) 40(5–6):258–69.

ASPECTS vs. CTP/CTA

- Addition of CTP and CTA measures did not improve prediction of outcome over patient characteristics and NCCT ASPECTS.

Van Seeters T. Cerebrovasc Dis (2015) 40(5–6):258–69.

ASPECTS vs. CTP/CTA

- Conflicting data.

- As time to initial NCCT increases, inter-rater agreement of ASPECTS improves.

- Compared to pre-thrombolysis score, 24h-ASPECTS and serial ASPECTS are better predictors of 3 month outcome.

- Inter-rater agreement of CTP remains stable over time.

- For hyperacute stroke, CTP may be a better predictor of outcome.

- CTA source image ASPECTS may predict outcome better than NCCT ASPECTS.

- Data do not support a clear advantage of CTP/CTA ASPECTS over NCCT ASPECTS.

Park JS. JNIS. 2018 Nov 24. doi: 10.1136/neurintsurg-2018-014359
Naylor J. Cerebrovasc Dis. 2017;44(3-4):195-202
Kong WY. J Stroke Cerebrovasc Dis. 2017 Oct;26(10):2264-2271

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Kong WY. J Stroke Cerebrovasc Dis. 2017 Oct;26(10):2264-2271.

Limitations of ASPECTS

- Limited to anterior circulation

- Unequal weighing of brain regions
    - Individual regions cover different amount of brain tissue
    - Thus, poor correlation with DWI lesion volume

- No clear "low ASPECTS" cut-off for poor outcome

- Poor sensitivity in the first 24 hours

- Inconsistent/unreliable outcome predictor

Schröder *J*. Front Neurol. 2017 Jan 12;7:245

Phan TG. Neuroimage (2006) 31(2):477–81

Limitations of ASPECTS
Unequal weighing

- Retrospective analysis of 100 patients.

- CTP abnormalities assessed in various ASPECTS regions.

- Some regions are more outcome-relevant

- Infarction in the Insular ribbon, M2, and M5 were associated with poorer outcomes (mRS).

Limitations of ASPECTS
Correlation with DWI-ASPECTS

- Poor correlation with DWI volumes

- PRE-FLAIR study

- Multicenter observational study analyzed clinical and MRI data

- 496 patients

- For any given ASPECTS, lesion volume varied widely

Lesion volume strong predictor outcome.
→Unjustified treatment exclusion could occur.

Schröder *J. Stroke* (2014) 45(12):3583–8.
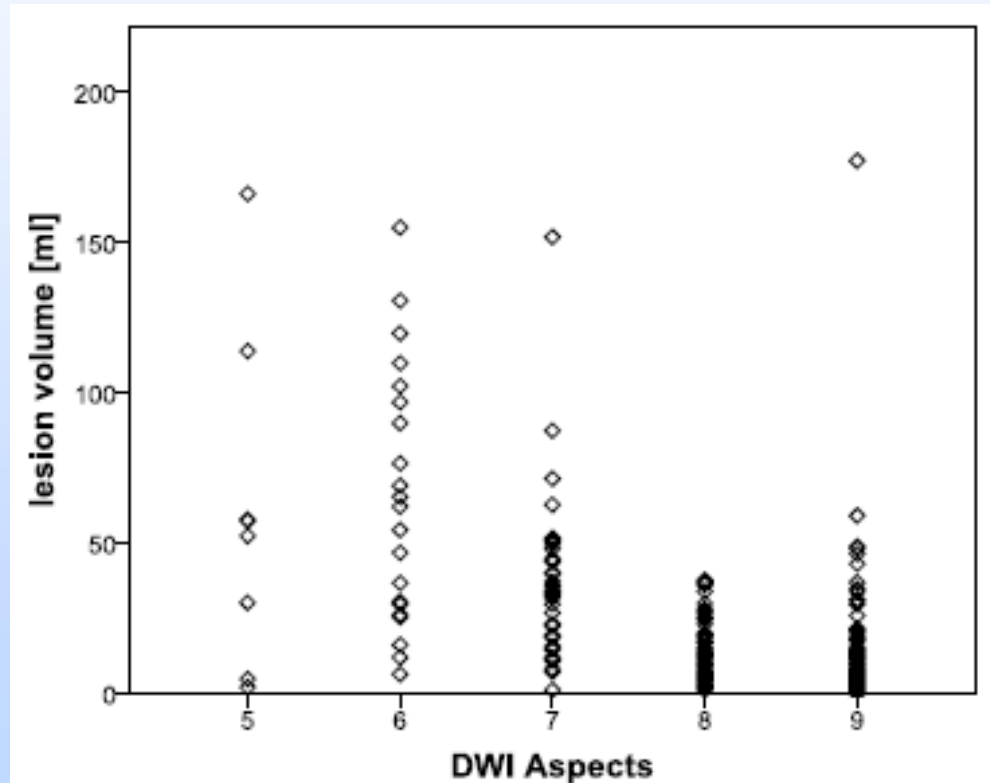
Limitations of ASPECTS
Correlation with DWI-ASPECTS

- DWI-ASPECTS
  - has good agreement with CT-ASPECTS for NIHSS <16 and CT ASPECTS>7 as well as CT ASPECTS of <6.
  - For NIHSS >16 and CT ASPECTS of 6/7, 20% probability of disagreement with DWI-ASPECTS.

- DWI-ASPECTS has higher sensitivity and better inter-rater agreement than NCCT ASPECTS.

Limitations of ASPECTS
Prediction of outcome

- Original publication suggested a cut-off of ≤7 as it predicted functional independence in those who underwent thrombolysis within 3h.

- In the NINDS trial patients, no treatment effect modification was seen with various ASPECTS categories.

- In NINDS patients, a trend toward reduced mortality and improved outcome was seen with ASPECTS>7.

- Various cutoffs to identify patients at risk of poor outcome have been suggested.

- Larger studies suggested a linear relationship or even no significant outcome prediction by ASPECTS at all.

Barber PA. Lancet 2000 May 13;355(9216):1670-4.

Figure 1. Relationship between functional outcome at 3 months (modified Rankin scale) and baseline ASPECTS scores dichotomized (>7, ≤7) and trichotomized (>7, 3 to 7, <3) by treatment assignment.

NINDS tpa trials

3 month mRS
☐ 0 to 1 ☐ 2 to 3 ☐ 4 to 5 ■ Death

ASPECTS

		n
8-10 tPA	48 / 21 / 19 / 12	n=201
8-10 Placebo	29 / 28 / 25 / 18	n=205
<=7 tPA	33 / 21 / 20 / 25	n=99
<=7 Placebo	21 / 23 / 30 / 25	n=103
3-7 tPA	36 / 21 / 20 / 23	n=89
3-7 Placebo	23 / 23 / 30 / 24	n=97
0-2 tPA	10 / 10 / 30 / 50	n=10
0-2 Placebo	0 / 33 / 33 / 34	n=6
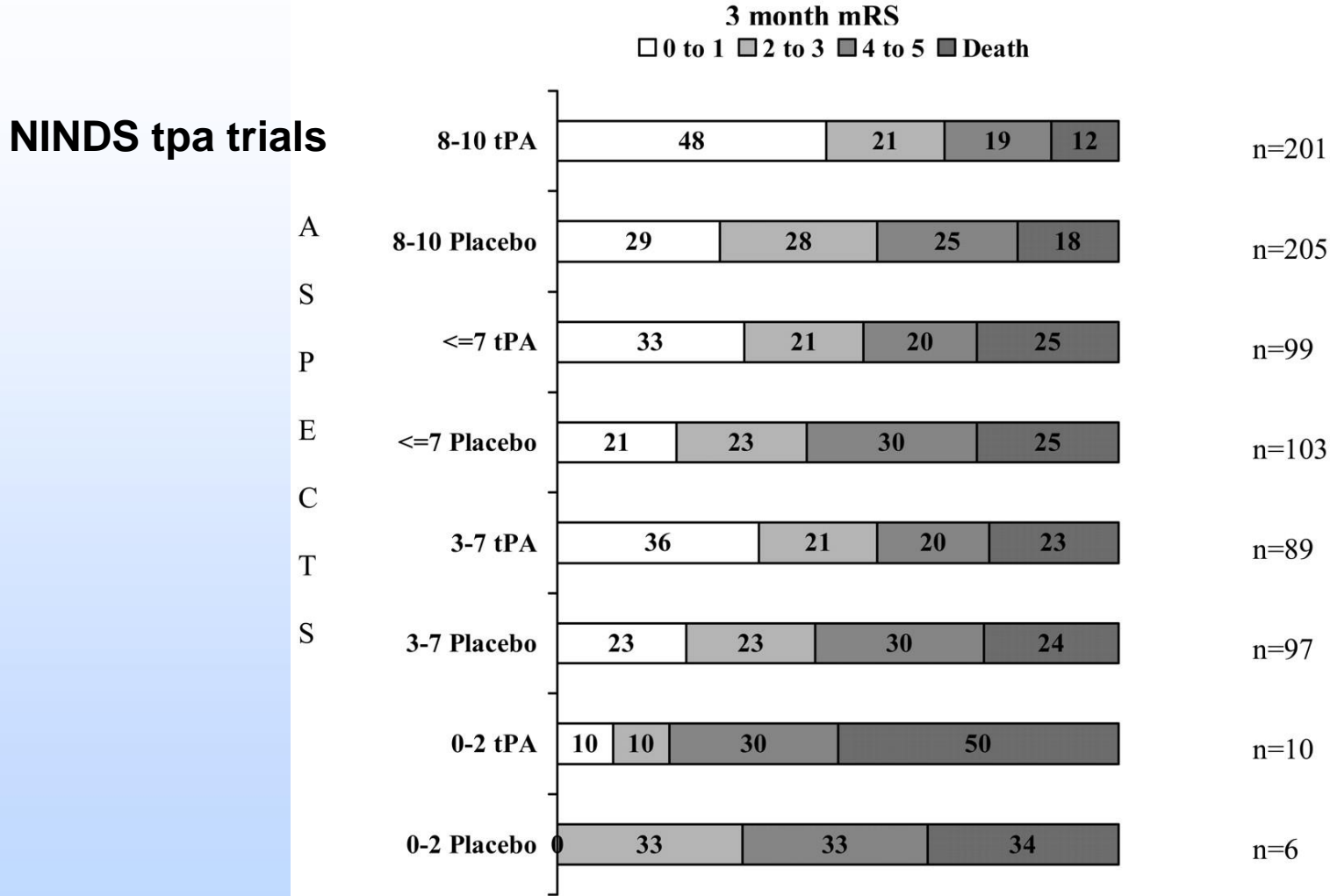
Demchuk A et al. Stroke 2005;36:2110-2115

No modification of treatment effect with ASPECTS

American Heart Association

Learn and Live

Fig. 1: Baseline ASPECTS (Alberta Stroke Program Early CT Score) as predictor of an excellent outcome (functional independence) in patients experiencing an acute ischemic stroke.
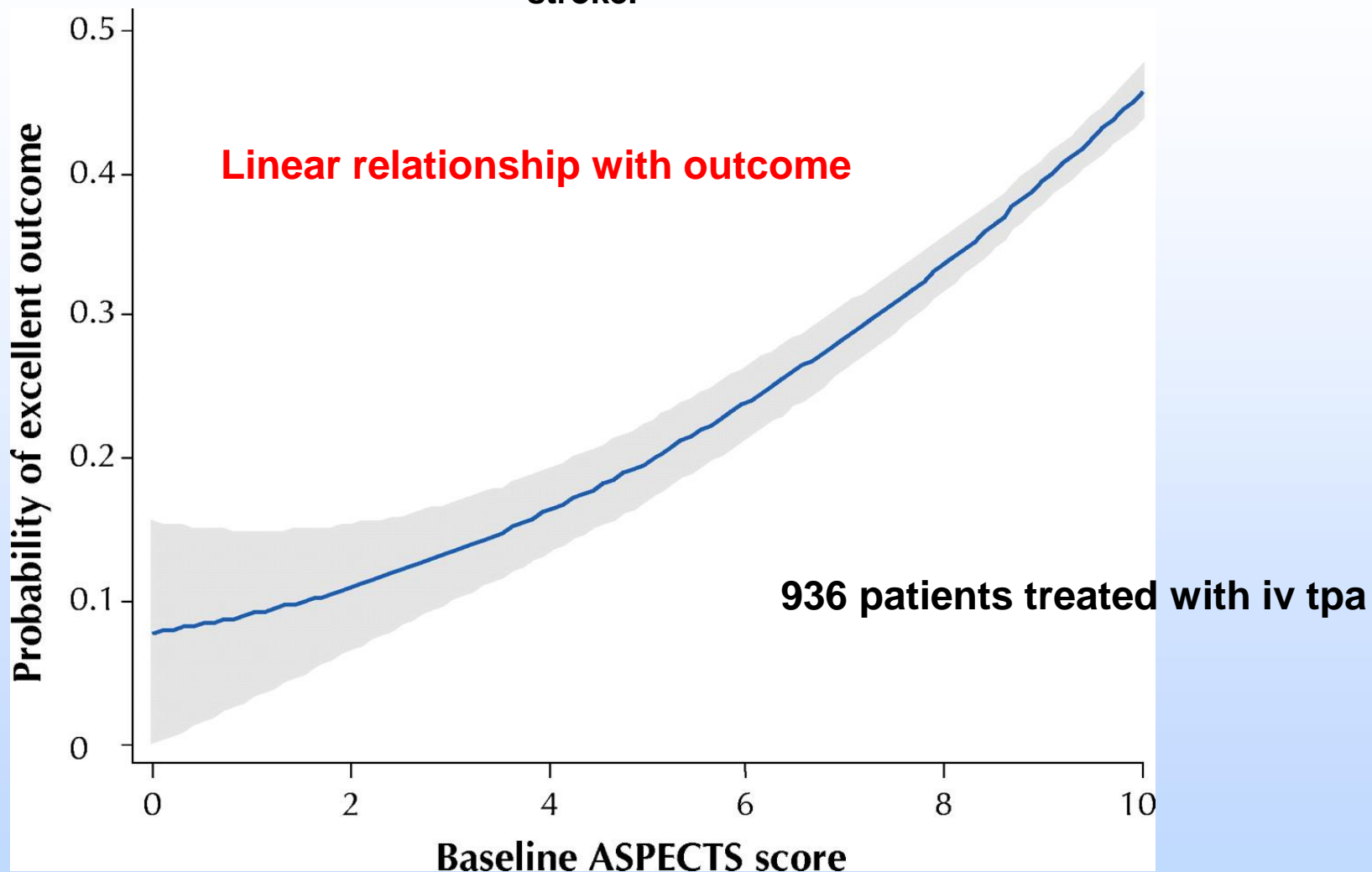
Michael D. Hill, and Alastair M. Buchan CMAJ
2005;172:1307-1312

Table 2. Prediction of poor outcome.

ASPECTS did not predict mRS>2 at 6 months

	NIHSS>10	BASIS	ASPECTS
Sensitivity	54.5	59.7	30.0
Specificity	87.4	75.3	88.6
PPV	73.4	60.6	62.8
NPV	75.1	74.5	66.5
Accuracy	74.6	69.2	65.8

doi:10.1371/journal.pone.0030352.t002

González RG, Lev MH, Goldmacher GV, Smith WS, Payabvash S, et al. (2012) Improved Outcome Prediction Using CT Angiography in Addition to Standard Ischemic Stroke Assessment: Results from the STOPStroke Study. PLOS ONE 7(1): e30352. https://doi.org/10.1371/journal.pone.0030352
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0030352
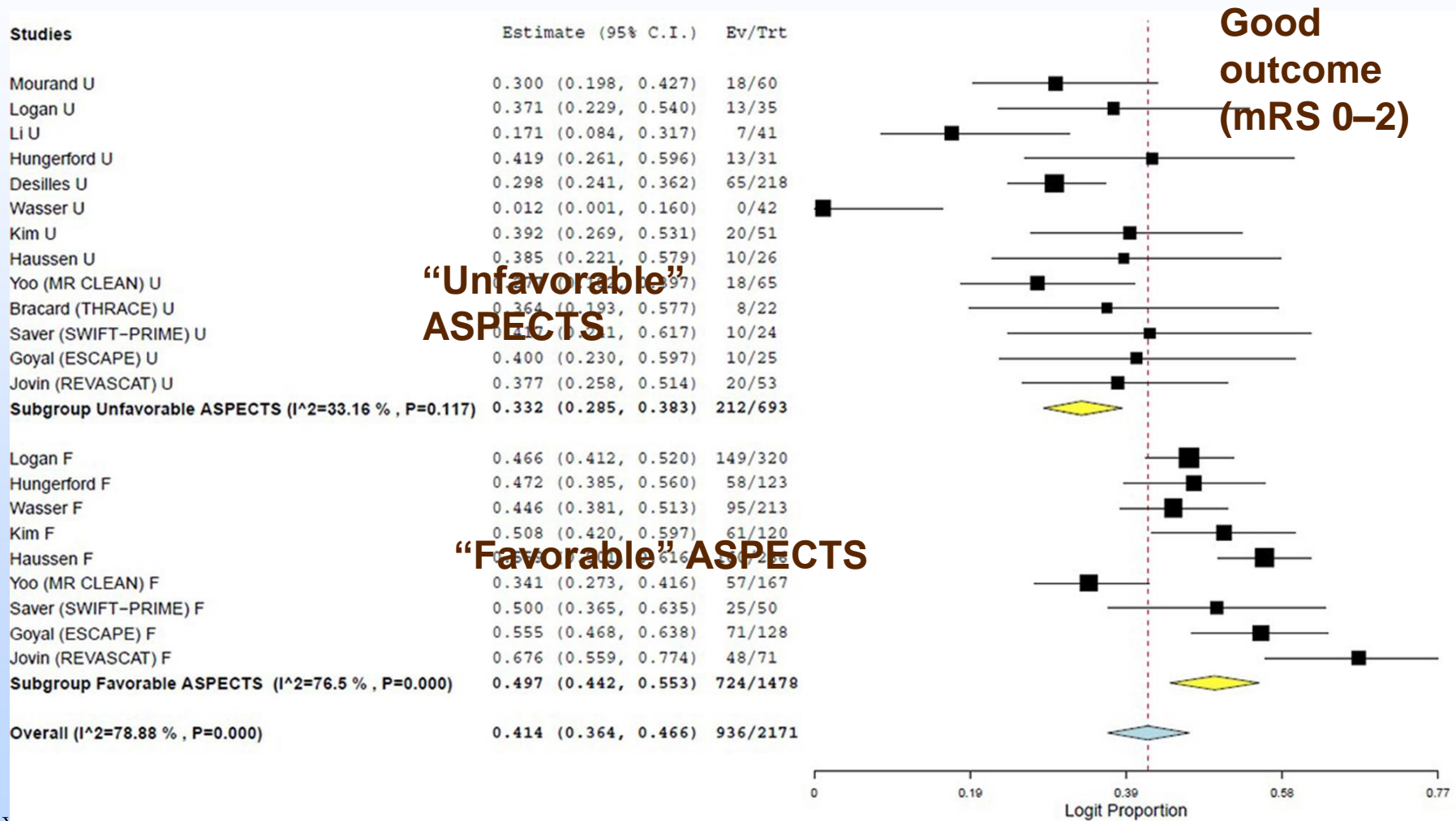
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PLOS ONE

Limitations of ASPECTS
No cut-off value for "low ASPECTS"

Forest plot titled with "Good outcome (mRS 0–2)" label on the right side.

Studies	Estimate (95% C.I.)	Ev/Trt
Mourand U	0.300 (0.198, 0.427)	18/60
Logan U	0.371 (0.229, 0.540)	13/35
Li U	0.171 (0.084, 0.317)	7/41
Hungerford U	0.419 (0.261, 0.596)	13/31
Desilles U	0.298 (0.241, 0.362)	65/218
Wasser U	0.012 (0.001, 0.160)	0/42
Kim U	0.392 (0.269, 0.531)	20/51
Haussen U	0.385 (0.221, 0.579)	10/26
Yoo (MR CLEAN) U	(0.197)	18/65
Bracard (THRACE) U	0.364 (0.193, 0.577)	8/22
Saver (SWIFT–PRIME) U	(0.617)	10/24
Goyal (ESCAPE) U	0.400 (0.230, 0.597)	10/25
Jovin (REVASCAT) U	0.377 (0.258, 0.514)	20/53
Subgroup Unfavorable ASPECTS (I^2=33.16 % , P=0.117)	0.332 (0.285, 0.383)	212/693
Logan F	0.466 (0.412, 0.520)	149/320
Hungerford F	0.472 (0.385, 0.560)	58/123
Wasser F	0.446 (0.381, 0.513)	95/213
Kim F	0.508 (0.420, 0.597)	61/120
Haussen F	0.616	
Yoo (MR CLEAN) F	0.341 (0.273, 0.416)	57/167
Saver (SWIFT–PRIME) F	0.500 (0.365, 0.635)	25/50
Goyal (ESCAPE) F	0.555 (0.468, 0.638)	71/128
Jovin (REVASCAT) F	0.676 (0.559, 0.774)	48/71
Subgroup Favorable ASPECTS (I^2=76.5 % , P=0.000)	0.497 (0.442, 0.553)	724/1478
Overall (I^2=78.88 % , P=0.000)	0.414 (0.364, 0.466)	936/2171

X-axis: Logit Proportion (0, 0.19, 0.39, 0.58, 0.77)

Labels on plot: "Unfavorable" ASPECTS, "Favorable" ASPECTS

Phan K. J NeuroIntervent Surg 2018;**0**:1–7.

ASPECTS
Conclusion

- Remains a reliable and objective means to communicate among colleagues.

- Applied for patient selection for thrombectomy within 6 hours of symptom onset.

- "Favorable" ASPECTS predicts good outcome.

- No clear "cut-off" for favorable ASPECTS.

- DWI-ASPECTS has higher sensitivity and inter-rater agreement than NCCT ASPECTS.

- CTP-ASPECTS does not offer clear advantage over NCCT ASPECTS.

The End