MMD 6513 – Anesthésie et système nerveux
Maladies neurovasculaires

Antoine Halwagi, MD FRCPC
Anesthésiologiste intensiviste
Centre hospitalier de l'Université de Montréal

Hiver 2026

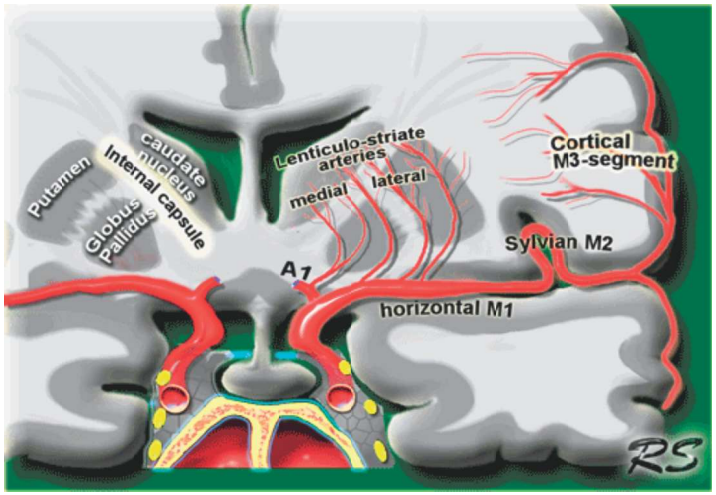
Université de Montréal

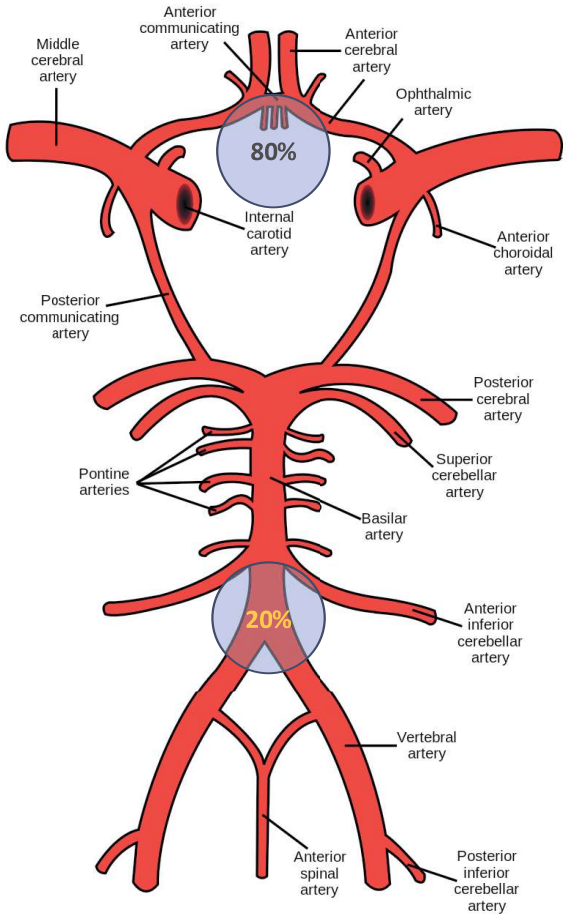
CHUM

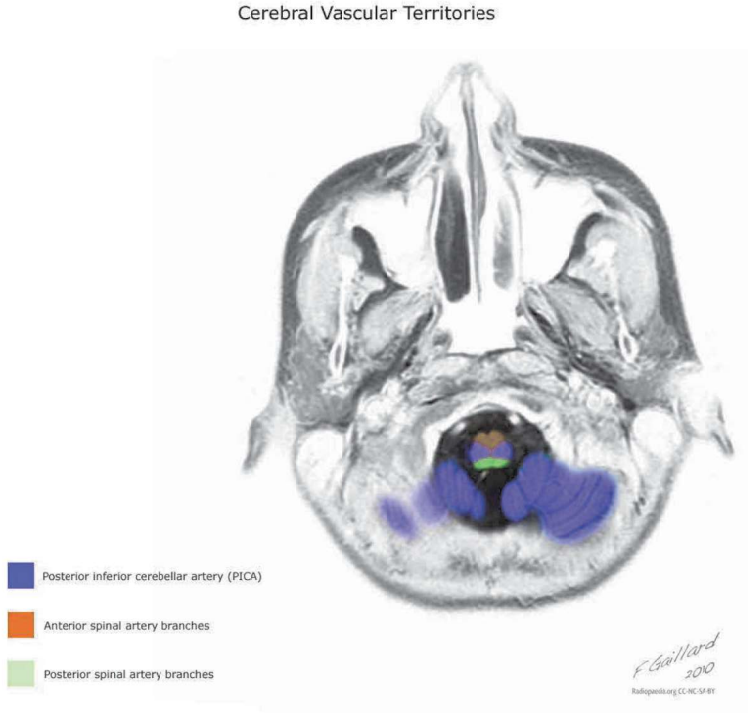
Objectif / plan

- Accident vasculaire cérébral (ischémique)
- Hémorragie intracérébrale
- Hémorragie sous-arachnoïdienne

Rappel de neuroanatomie vasculaire







radiologyassistant.nl, radiopaedia.org

NIH Stroke Scale (NIHSS)

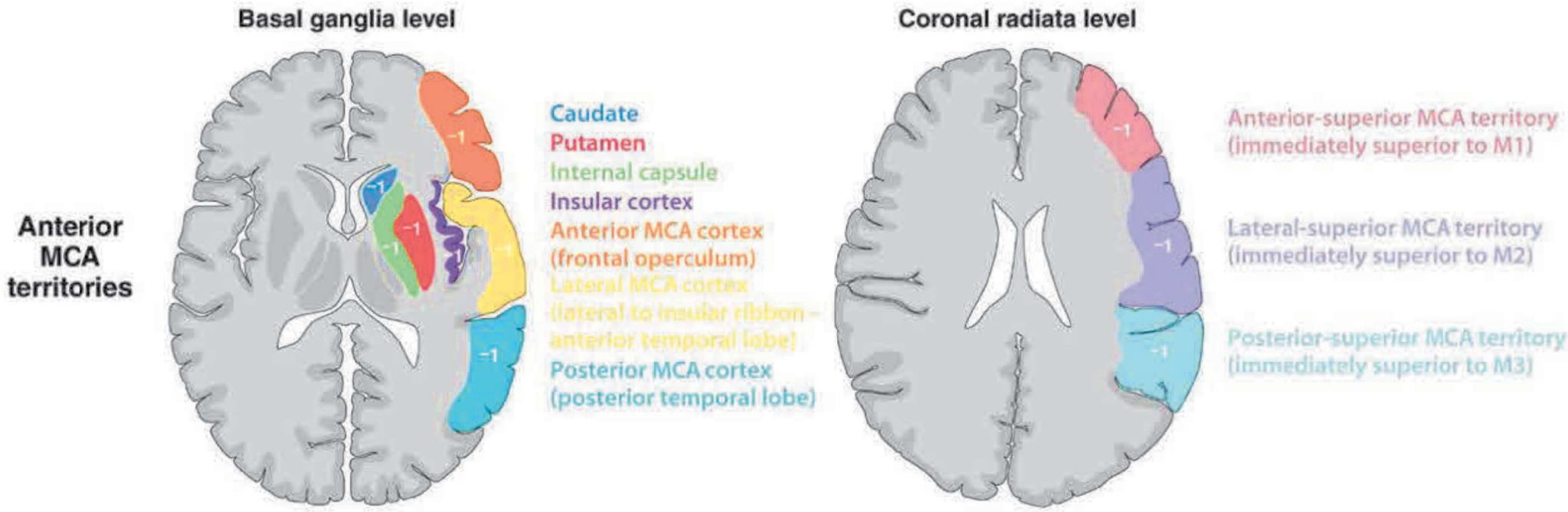
- Examen neurologique standardisé
- 15 items, total 0-42 points
  - État de conscience 0-3
  - Fonction visuelles
  - Langage
  - Fonction motrices
  - Fonction sensitives et négligence
  - Fonction cérébelleuse

- NIHSS > 10 ➔ 80% occlusion proximale

0-4 AVC mineur
5-15 AVC modéré
16-20 AVC mod-sévère
21-42 AVC sévère

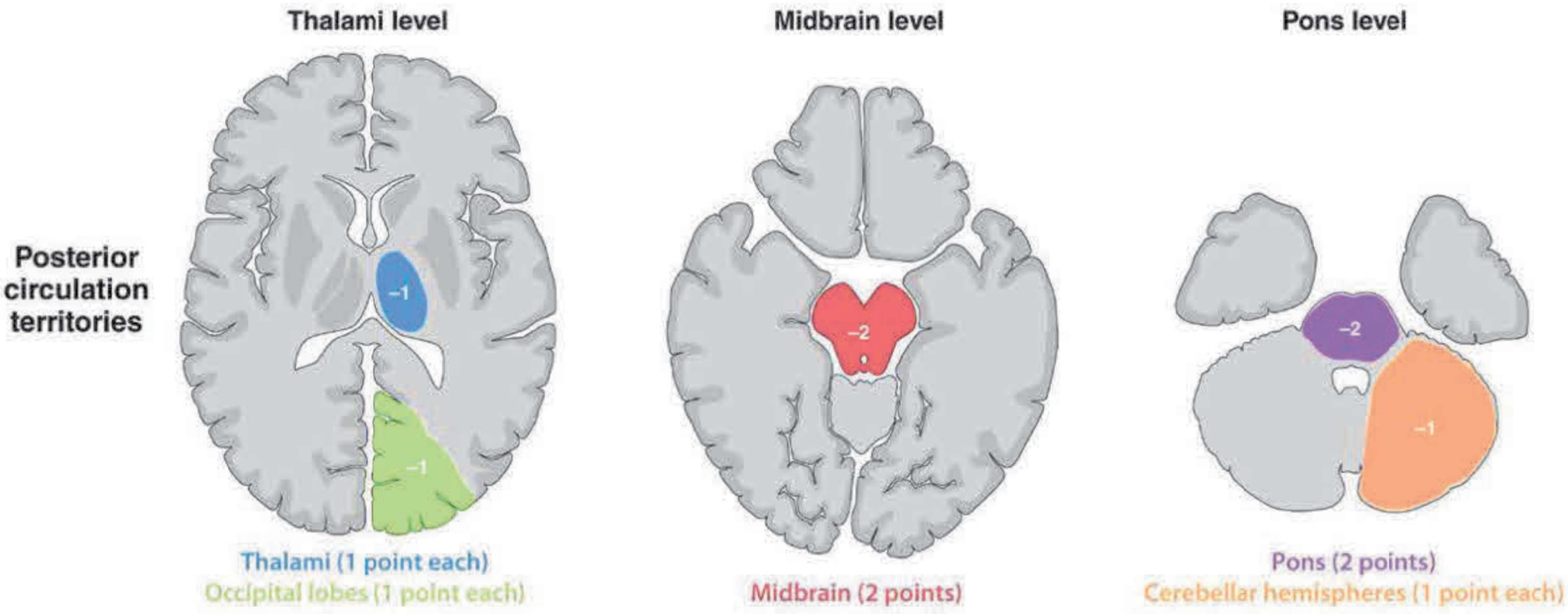
aspectsinstroke.com

Alberta Stroke Program Early CT Score (ASPECTS)



Prabhakaran et al. Stroke 2026

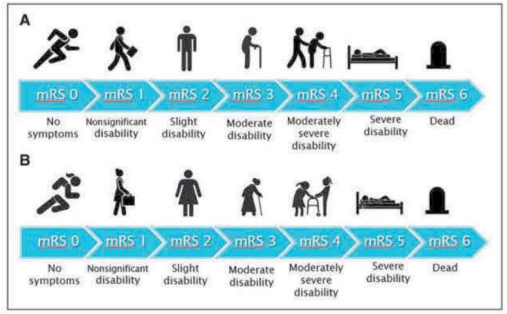
PC-ASPECTS



Prabhakaran et al. Stroke 2026

Modified Rankin Scale (mRS)

0. No symptoms
1. No clinically significant disability – able to carry out all usual activities despite some symptoms
2. Slight disability – able to look after own affairs without assistance but unable to carry out all previous activities
3. Moderate disability – requires some help but able to **walk unassisted**
4. Moderately severe disability – unable to attend to **bodily needs** without assistance and unable to walk unassisted
5. Severe disability – requires constant nursing care, bedridden, incontinent
6. Dead



Saver et al. Stroke 2021

Accident vasculaire cérébral ischémique

AHA/ASA GUIDELINE

2026 Guideline for the Early Management of Patients With Acute Ischemic Stroke: A Guideline From the American Heart Association/American Stroke Association

Endorsed by the American Association of Neurological Surgeons/Congress of Neurological Surgeons, Neurocritical Care Society, the Society for Academic Emergency Medicine, the Society of NeuroInterventional Surgery, and the Society of Vascular and Interventional Neurology.

The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists.

The Canadian Journal of Neurological Sciences (2024), **51**, 1–31
doi:10.1017/cjn.2022.344

Canadian Journal of Neurological Sciences
Journal Canadien des Sciences Neurologiques

Review Article

Canadian Stroke Best Practice Recommendations: Acute Stroke Management, 7th Edition Practice Guidelines Update, 2022

Manraj Heran[1], Patrice Lindsay[2], Gord Gubitz[3,4], Amy Yu[5,6], Aravind Ganesh[7], Rebecca Lund[2], Sacha Arsenault[8], Doug Bickford[9], Donnita Derbyshire[10], Shannon Doucette[11], Esseddeeg Ghrooda[12], Devin Harris[13,14], Nick Kanya-Forstner[15,16], Eric Kaplovitch[6,17], Zachary Liederman[6,17], Shauna Martiniuk[6,18], Marie McClelland[19], Genevieve Milot[20], Jeffrey Minuk[21], Erica Otto[22], Jeffrey Perry[23], Rob Schlamp[24], Donatella Tampieri[25], Brian van Adel[26], David Volders[27], Ruth Whelan[28], Samuel Yip[29], Norine Foley[30], Eric E. Smith[7], Dar Dowlatshahi[31], Anita Mountain[32], Michael D. Hill[7], Chelsy Martin[2] and Michel Shamy[31]

Society for Neuroscience in Anesthesiology and Critical Care Expert Consensus Statement: Anesthetic Management of Endovascular Treatment for Acute Ischemic Stroke*

Endorsed by the Society of NeuroInterventional Surgery and the Neurocritical Care Society

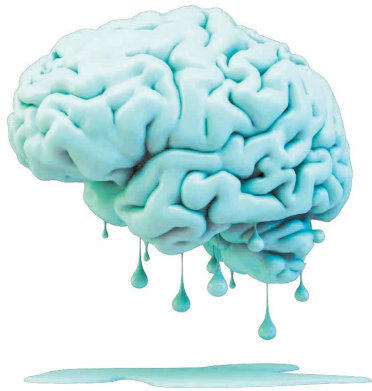
Pekka O. Talke, MD, Deepak Sharma, MD, DM,† Eric J. Heyer, MD, PhD,‡ Sergio D. Bergese, MD,§ Kristine A. Blackham, MD,‖ and Robert D. Stevens, MD¶*

(*J Neurosurg Anesthesiol* 2014;26:95–108)

Évolution spectaculaire de la littérature

- 1980 découverte t-PA
- 1995 NINDS
- 2008 ECASS III
- 2015 Thrombectomie
- 2018 Thrombolyse hors-délai (wake-up)
- 2018 Thrombectomie hors-délai
- 2020 Thrombectomie circulation postérieure
- 2022 Thrombectomie infarctus importants
- 2025 Occlusion distale?
- 2025 Thrombolyse IA post reperfusion par thrombectomie

⚠ TIME IS BRAIN ⚠



- Chaque minute d'occlusion ➔ 1 900 000 neurones perdus

- THROMBOLYSE

  Délai de 30 minutes ➔ ↓ 10% probabilité de mRS 0-1 à 3 mois

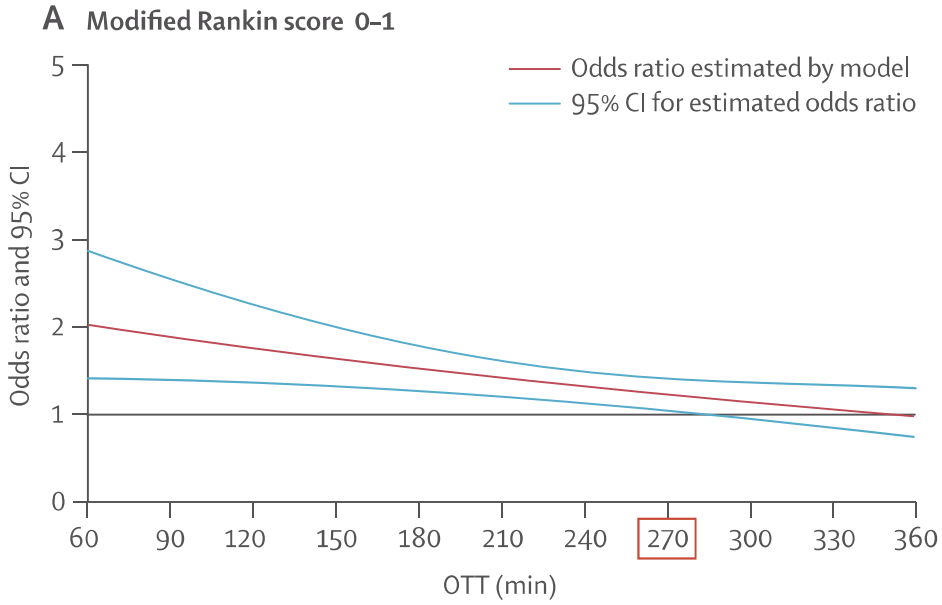
- THROMBECTOMIE

  Délai de 9 minutes ➔ ↑ 1% probabilité d'empirer mRS à 3 mois

Saver JL. Stroke 2006
Lees et al. Lancet 2010
Saver et al. JAMA 2016

Thrombolyse

- **NINDS NEJM 1995** 624 pts US r-tPA vs placébo < 3h
  - **Meilleur évolution** (NIHSS, Barthel, mRS, GOS) à 3 mois (mRS 0-1 39 vs 26%, NNT ~ 8)
- **ECASS III NEJM 2008** 821 pts EU, r-tPA entre 3-4.5h
  - **↑ mRS 0-1 à 90 jrs (52 vs 45%)**, plus sICH 2.4 vs 0.2%, mortalité idem (NNT ~ 14)



Lees et al. Lancet 2010

Impact du délai de traitement: thrombolyse

	Modified Rankin score 0–1 at 90 days,* n/N (%)		Odds ratio (95% CI)	p value	Estimated number needed to treat† for modified Rankin score 0–1
	Alteplase	Placebo			
0–90 min	67/161 (41·6%)	44/151 (29·1%)	2·55 (1·44–4·52)	0·0013	4·5
91–180 min	127/303 (41·9%)	91/315 (28·9%)	1·64 (1·12–2·40)	0·0116	9·0
181–270 min	361/809 (44·6%)	306/811 (37·7%)	1·34 (1·06–1·68)	0·0135	14·1
181–270 min (excluding EPITHET[7] data)	358/795 (45·0%)	303/794 (38·2%)	1·32 (1·04–1·66)	0·0202	14·9
271–360 min	215/575 (37·4%)	193/542 (35·6%)	1·22 (0·92–1·61)	0·1628	21·4
271–360 min (excluding EPITHET[7] data)	200/539 (37·1%)	184/512 (35·9%)	1·16 (0·87–1·54)	0·3063	28·7

Autonomie

- Réduction des bénéfices avec le temps…
- Augmentation de mortalité après > 4.5h de délai…

- **Délai de 30-minutes = réduction de probabilité d'évolution favorable vers autonomie complète (mRS 0-1) à 3 mois de 10%**

Lees et al. Lancet 2010

Thrombolyse: hors délai

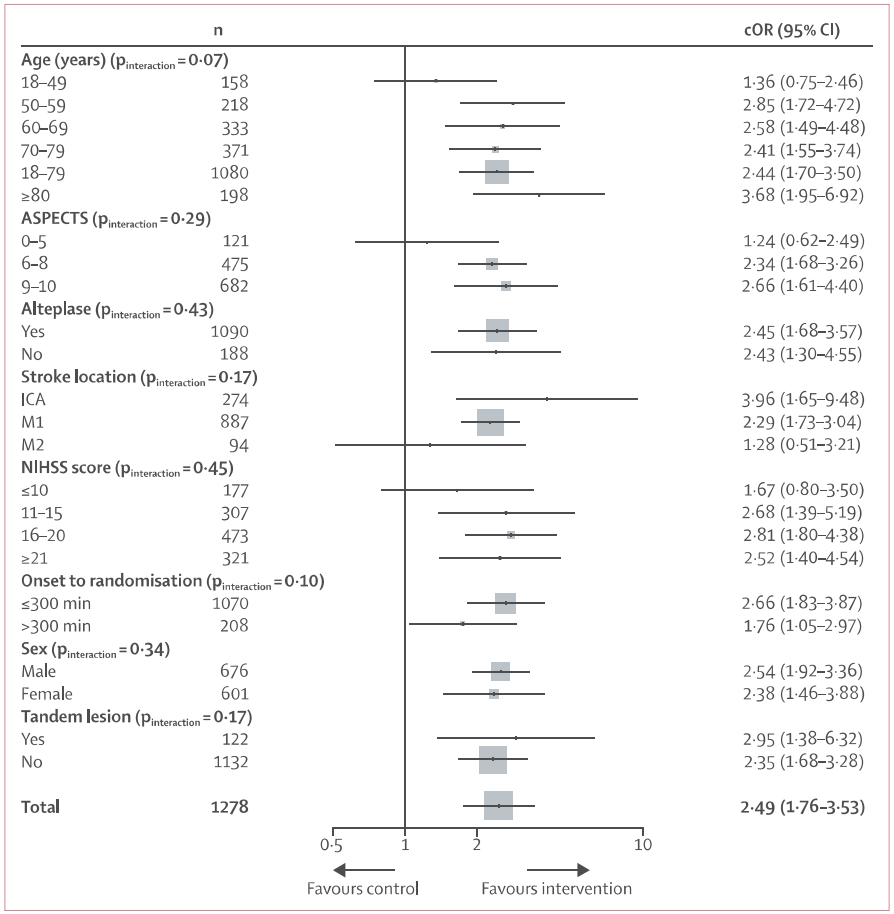
- **WAKE-UP NEJM 2018** 503/800 pts EU r-tPA vs placebo, wake-up stroke ou délai incertain avec imagerie favorable (missmatch DWI/FLAIR suggérant délai probable < 4.5h)
  - **↑ mRS 0-1 à 90 jrs 53 vs 42%**, augmentation mortalité (4 vs 1%), tendance plus sICH
  - (arrêt de financement)
- **EXTEND NEJM 2019** 225/310 pts  r-tPA vs placebo, LKW 4.5-9h avec imagerie favorable (CTP ou IRM) délai LKW-r-tPA ~ 7h12
  - ↑ mRS 0-1 à 90 jrs 35 vs 30% **(OR ajusté âge+NIHSS 1.44)**, tendance plus de sICH (6 vs 1%)
  - (perte equipoise)
- **ECASS-4: ExTEND Int J Stroke 2019** 119/264 pts EU r-tPA vs placebo, LKW 4.5-9h avec imagerie favorable (IRM) délai ~ 7h42
  - Distribution mRS idem, mortalité 12 vs 7% (NS)
  - (recrutement lent)
- **THAWS Stroke 2020** 131/300 pts JP r-TPA 0.6 mg/kg vs placebo, LKW > 4.5h avec imagerie favorable (idem à WAKE-UP)
  - Évolution favorable, mortalité, sICH idem
  - (perte equipoise)

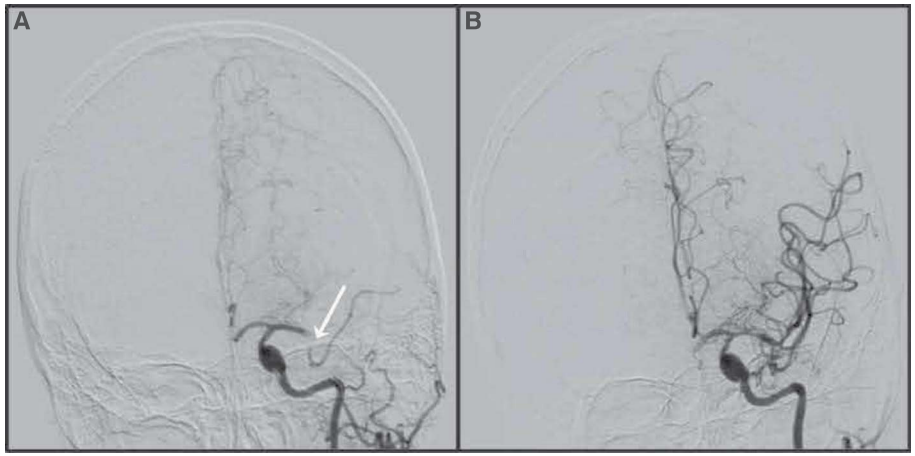
Thrombectomie: résultats SPECTACULAIRES!

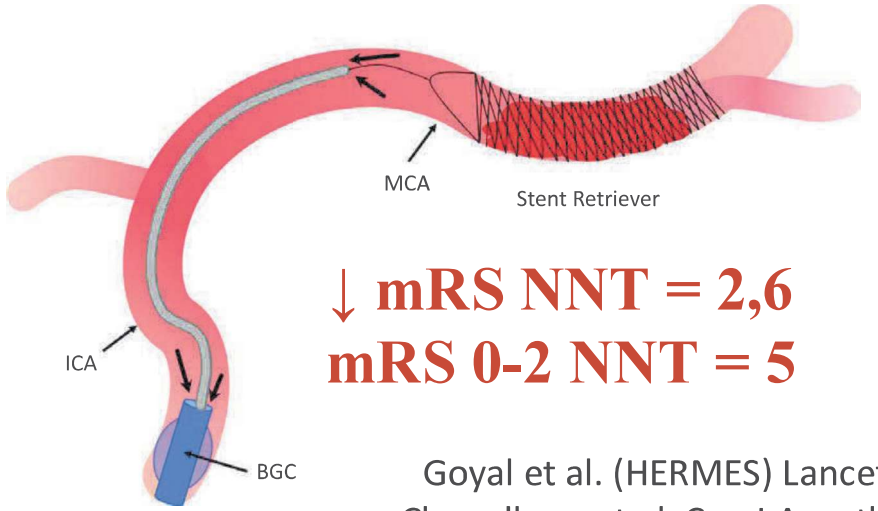
- **MR CLEAN NEJM 2015** 500 pts NL, LVO (CI,M1M2,A1A2), EVT < 6h (thrombectomie +/- thrombolyse IA (~10%)
  - Thrombolyse IV préalable permise (89%), NIHSS 18
  - **↑↑ mRS 0-2 à 90 jrs (33 vs 19%)**, OR 1.67 (1.21-2.30) d'améliorer mRS de 1 point avec tx
- **ESCAPE NEJM 2015** 316/500 pts CA, LVO (CI,M1M2), ASPECT 6-10, bonne collatérales, MT < 12h
  - Thrombolyse IV préalable permise (73-79%) NIHSS 16-17, délai LKW-rando ~ 3h
  - ↑↑ mRS 0-2 à 90 jrs (53 vs 29%), **OR 2.6 (1.7-3.8)**, réduction mortalité 10 vs 19%, sICH idem (**interrompue pour efficacité**)
- **EXTEND-IA NEJM 2015** 70/100 pts AUNZ, LVO (CI,M1M2), r-TPA IV reçu, mismatch favorable (RAPID), MT < 6h
  - NIHSS 17 vs 13 (en défaveur du groupe thrombectomie)
  - **↑↑ reperfusion à 24h et amélioration NIHSS à 3 jrs**, ↑↑ mRS 0-2 à 90 jrs (71 vs 40%), sICH 0 vs 6 (**perte equipose**)
- **SWIFT PRIME NEJM 2015** 196/833 pts USEU, LVO (CI,M1), r-tPA IV, mismatch favorable (RAPID), MT < 6h
  - NIHSS 17, ASPECTS 9
  - **mRS shift favorable**, ↑↑ mRS 0-2 à 90 jrs (60 vs 35%), mortalité idem (**interrompue pour efficacité**)
- **REVASCAT NEJM 2015** 206/500 pts ES, LVO (CI,M1M2), r-tPA IV sans recanalisation ou CI, ASPECTS > 6, MT < 8h
  - NIHSS 17, ASPECTS 7-8
  - **mRS shift favorable**,↑↑ mRS 0-2 à 90 jrs (44 vs 28%), sICH idem (4,9 vs 1,9%) (**perte equipose**)

- **THRACE Lancet Neurol 2016** 414 pts FR, LVO (CI,M1), r-tPA IV reçu < 4h, TX < 5h
  - Pas de critères d'imagerie (ASPECT 0-4 ~14%), NIHSS 18-17, délai r-TPA-rando < 20 min (tous thrombolysés pré-rando)
  - Pas d'évaluation de réponse à r-tPA ➔ 29% des patients n'ont pas eu (besoin) de thrombectomie ➔ ↑ taux de mRS 0-2 chez contrôles
  - **↑ mRS 0-2 à 90 jrs (53 vs 42%)**, mortalité et sICH idem

Thrombectomie







↓ mRS NNT = 2,6
mRS 0-2 NNT = 5

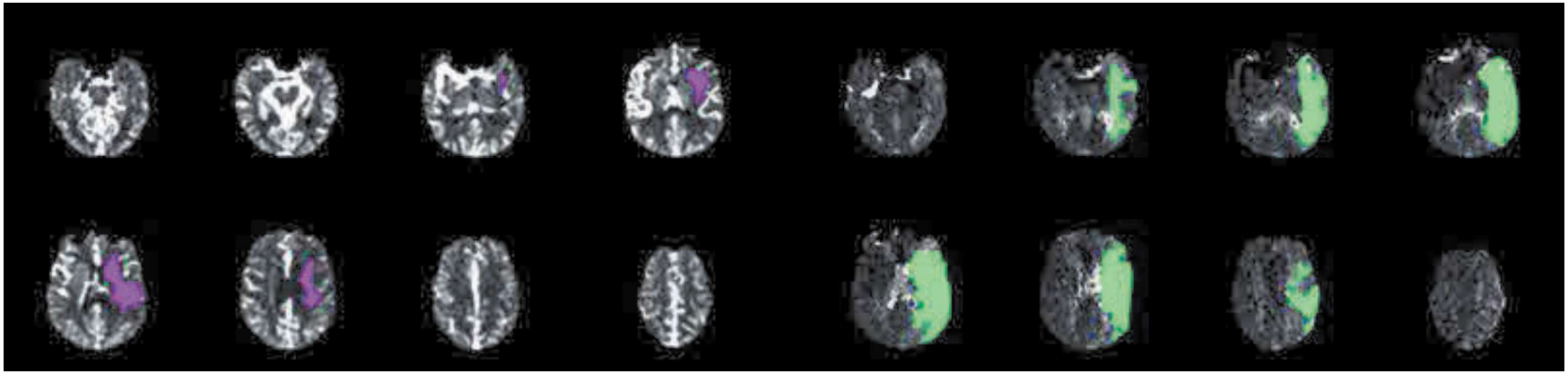
Goyal et al. (HERMES) Lancet 2016
Chowdhury et al. Can J Anesth 2022

Thrombectomie: hors délai

- **DAWN NEJM 2018** 206/500 pts LVO (CI, M1), NIHSS ≥ 10, LKW 6-24h pré-rando, Mismatch clinico-radiologique (NIHSS vs core CTP ou DWI RAPID, sous groupes âge/core)
  - NIHSS 17, délai LKW-rando 12-13h, core 7.6 vs 8.9 mL, r-tPA 5 vs 13%
  - Réduction du volume d'infarctus cérébral, plus de recanalisation
  - **↑↑ UW-mRS et mRS 0-2 à 90 jrs (49 vs 13%)**, sICH 6 vs 3% NS, mortalité 19 v 18% NS
  - (interruption à 1ère analyse intérimaire pour d'efficacité préspécifié)
- **DEFUSE 3 NEJM 2018** US 182/476 LVO (CI, M1), NIHSS ≥ 6, LKW 6-18h, core < 70mL Mismatch radiologique (CTP ou DWI/perfusion) ratio ≥ 1.8 ou pénombre ≥ 15mL)
  - NIHSS 16, ASPECT 8, délai LKW-rando 9.5h (pour les non-wake-up stroke), core 9 vs 10 mL
  - **mRS shift favorable (OR 2.77)**, ↑↑ mRS 0-2 à 90 jrs (45 vs 17%), sICH 7 vs 4% NS, ~↓ mortalité (14 vs 26%)
  - (**interruption pour efficacité suivant publication de DAWN**)

- **MR CLEAN-LATE Lancet 2023** NL 502 pts LVO (CI, M1, M2), NIHSS ≥ 2, LKW 6-24h, flot collatéral ACM CTA **pts remplissant critères DAWN/DEFUSE 3 exclus**
  - NIHSS 10, ASPECT 9 vs 8, délai LKW-rando ~ 11.5h, ~30% M2
  - **mRS médian 3 vs 4 (OR 1.67 1.20-2.32)**, mRS 0-2 à 90 jrs idem (39 vs 34%), sICH 7 vs 2%, mortalité idem
  - Résultats moins spectaculaires que DAWN et DEFUSE 3 mais significatifs néanmoins
- **RESILIENT-Extend (ISC 2024, non publié)** BR 245 pts LVO, LSW 8-12h, CT/CTA seulement
  - NIHSS 16, ASPECTS 7-8
  - **↑ mRS 0-2 à 90 jrs (25 vs 14%)**, sICH idem

Exemple de quantification RAPID



Volume of Ischemic Core, 23 ml **Volume of Perfusion Lesion, 128 ml**

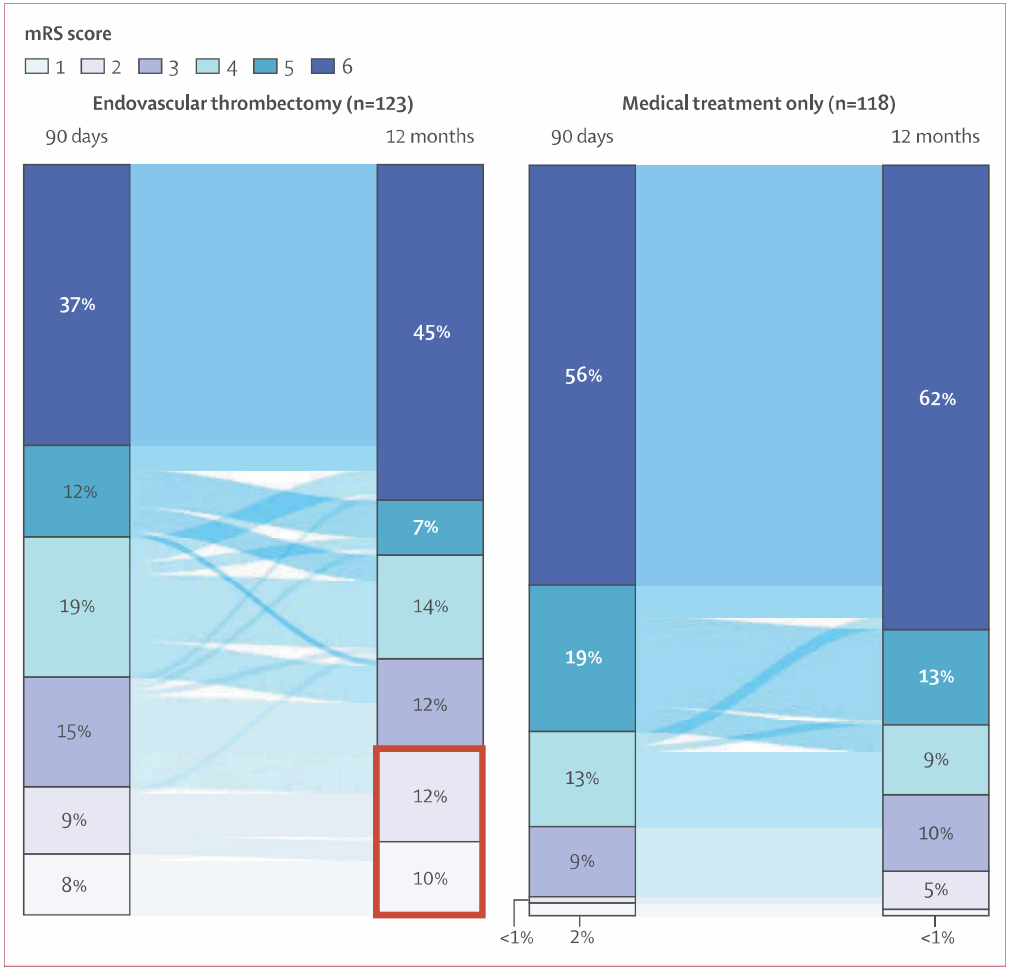
Mismatch volume, 105 ml
Mismatch ratio, 5.6

DEFUSE 3 Albres et al. NEJM 2018

Thrombectomie: infarctus étendu

- **RESCUE-Japan LIMIT NEJM 2022** JP 202 pts, NIHSS ≥ 6, LVO (CI,M1), ASPECTS 3-5, LKW < 6h ou 6-24h si FLAIR-, délai tx < 60 min (exclu si effet de masse)
  - NIHSS 22, ASPECTS 3 vs 4 (IRM surtout), core 94 vs 110 mL, délai ~ 3.7h, r-tPA 27%
  - **↑↑ mRS 0-3 à 90 jrs (31 vs 13%), NNT ~6**, ↑ ICH 58 vs 31%, sICH (9 vs 5%), DC (10 vs 14%) et mortalité idem
- **ANGEL-ASPECT NEJM 2023** CN 456/502 pts, LVO (CI,M1), ASPECT 3-5 ou core 70-100mL (CTP/ADC), LKW < 24h, NIHSS 6-30
  - NIHSS 16, ASPECT 3, core 62 mL, délai ~ 7.6h, r-tPA 28%
  - **mRS shift favorable (OR 1.37)**, ↑↑ mRS 0-2 à 90 jrs (30 vs 12%), ↑↑ mRS 0-3 à 90 jrs (47 vs 33%), ICH 49 vs 17%, sICH (6 vs 3%) idem, DC (7 vs 4%) idem et mortalité idem
  - **(interrompue pour efficacité après analyse intérimaire)**
- **SELECT2 NEJM 2023** 352/560 pts, LVO (CI,M1), ASPECTS 3-5 ou core > 50mL (CTP/ADC), LKW < 24h
  - NIHSS 19, ASPECTS 4, core 80 mL, délai LKW-rando ~ 9.8h, r-TPA ~ 19%, AG 59%
  - **mRS shift favorable (OR 1.51)**, ↑ mRS 0-2 à 90 jrs (20 vs 7%), ↑↑ mRS 0-3 à 90 jrs (38 vs 19%), sICH (1%) et mortalité (~40%) idem
  - Détérioration neuro précoce 24 vs 16% = œdème cérébral?
  - **(interrompue pour efficacité après analyse intérimaire précoce – re: publication RESCUE-Japan LIMIT)**
- **TENSION Lancet 2023** EUCA 253/665 pts, LVO (CI,M1), ASPECTS 3-5, LKW < 11h, NIHSS < 26 (pas d'IRM,CTP,RAPID)
  - NIHSS 19, CT/CTA ~80%, r-tPA ~ 36%, délai LKW-rando ~ 2h, délai LKW-revasc ~ 4.4h, AG 44%
  - **mRS shift favorable (OR 1.51)**, ↑ mRS 0-2 à 90 jrs (17 vs 2%), ↑↑ mRS 0-3 à 90 jrs (31 vs 13%), sICH (1%), ↓ mortalité (40 vs 51%), sICH (5%) et CD (8%) idem
  - **(interrompue pour efficacité après 1ère analyse intérimaire)**
- **LASTE NEJM 2024** FRES 333/450 pts, LVO (CI,M1), ASPECTS < 5, NIHSS > 6, LKW < 6.5h
  - NIHSS 21, ASPECT 2, core ~ 134 mL, délai LKW-rando ~ 4.5h, délai LKW-MT ~ 5h, r-tPA ~ 35%
  - **mRS shift favorable (OR 1.63)**, ↑ mRS 0-2 à 90 jrs (13 vs 5%), ↑↑ mRS 0-3 à 90 jrs (34 vs 12%), ↓↓ mortalité (36 vs 56%), sICH (10 vs 6%) idem, CD (9 vs 12%) et détérioration précoce idem
  - **(interrompue suivant publication 1-3 et pour efficacité suivant analyse intérimaire précoce)**
- **TESLA JAMA 2024** US 300 pts, LVO (CI,M1), ASPECTS 2-5, LKW < 24h, NIHSS > 6 (pas d'IRM,CTP,RAPID)
  - NIHSS 19, délai rando ~ 11-12h, r-tPA ~ 20%
  - **UW-mRS et mRS 0-2 à 90 jrs (15 vs 9%) idem**, ↑ mRS 0-3 à 90 jrs (30 vs 20%), mortalité, sICH et CD idem, plus d'ICH

Évolution à 1 an



- mRS médian 5 vs 6
- mRS 0-2 22-24% vs 6%
- mRS 0-3 34-37 vs 17-18%
- Meilleure qualité de vie
  - Cognitif
  - Santé mentale
  - Mobilité
- Diminution mRS 5-6
- ↑ HIC, mais pas sICH
- Pas plus de CD…
- Enjeux organisationnels locaux?
  - MT sous AG?
  - Admissions aux SI? CD?

TENSION Thomalla et al. Lancet Neurol 2024
SELECT2 Sarraj et al. Lancet 2024
Chen et al. JAMA Neurol 2024

AVC circulation postérieure: thrombectomie

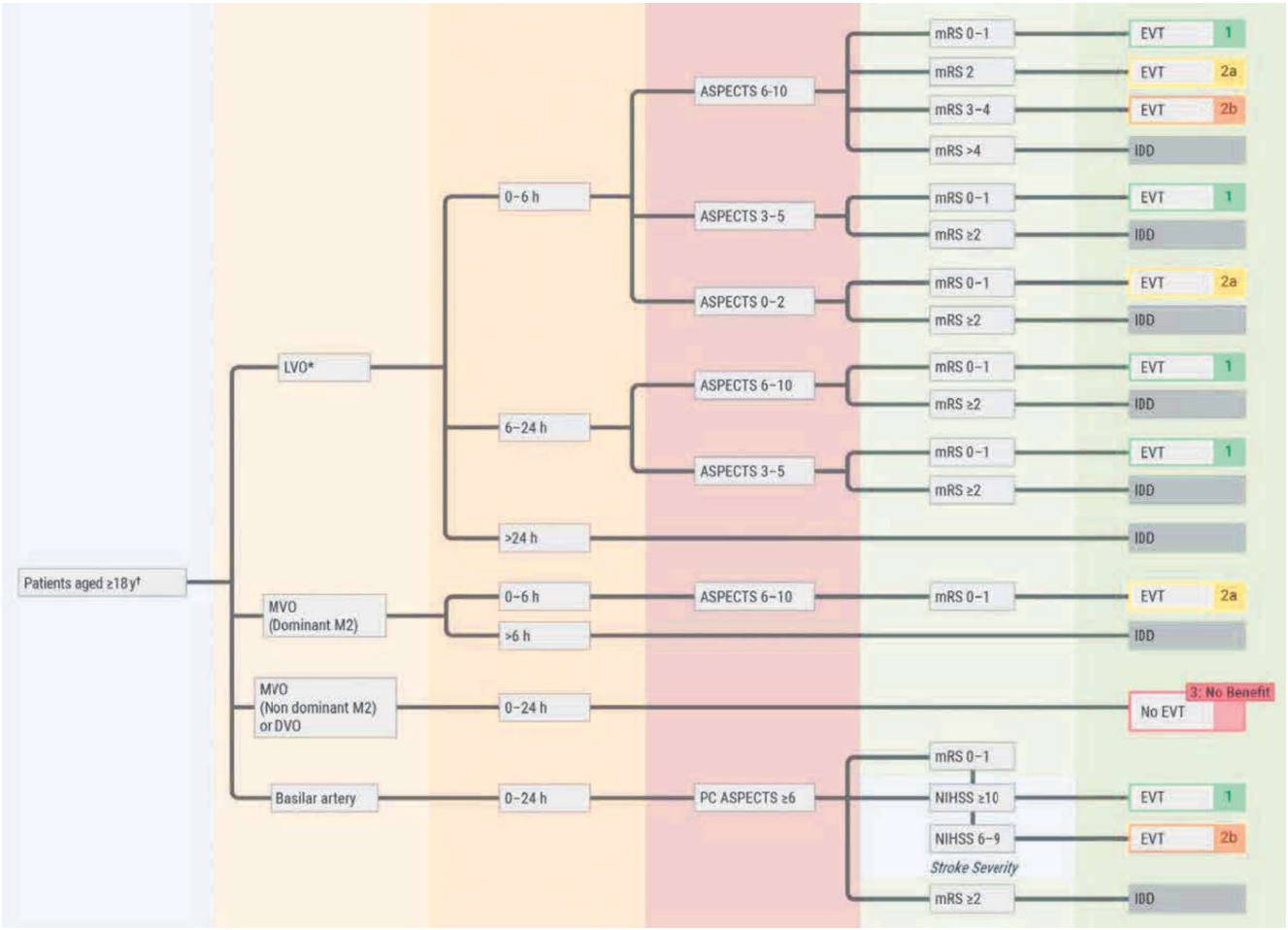
- **BEST Lancet Neurol 2020** CN 288/344 pts, occlusion VB, LKW < 8h
  - Occlusion basilaire ~ 90%, NIHSS ~ 30, r-tPA ~ 30%, délai revasc ~ 6.7h, TICI 2b-3 71%, **cross-over 22%**
  - mRS 0-3 à 90 jrs idem (42 vs 32%, **PP 44 vs 25%**)
  - (interrompue cross-over et pauvre recrutement)
- **BASICS NEJM 2021** EUBR 300/750 pts, occlusion basilaire, <85 ans, NIHSS > 10, délai < 6h; élargi après 91 pts: CI r-tPA, pas de limite âge/NIHSS
  - NIHSS 22, r-tPA ~ 80%, délai tx ~ 4.4h, TICI 2b-3 72%
  - mRS 0-3 à 90 jrs idem (44 vs 38%), plus de sICH 4.5 vs 0,7%, mortalité (59 vs 63%) idem
  - (modification de taille d'échantillon – publications LVO 2015 et pauvre recrutement)
- **BAOCHE NEJM 2022** CN 217/318pts, occlusion basilaire, délai tx 6-24h, NIHSS > 6, PC-ASPECTS > 5
  - Tous occlusion basilaire, NIHSS 20, PC-ASPECTS 8, r-tPA ~ 15%, délai revasc ~ 13h, TICI 2b-3 88%
  - **↑↑ mRS 0-3 à 90 jrs (46 vs 24%)**, sICH (6 vs 1%) et mortalité idem
  - (**interrompue pour efficacité à 1ère analyse intérimaire**, modification outcome primaire)
- **ATTENTION NEJM 2022** CN 340 pts, occlusion VB, délai tx < 12h, NIHSS ≥ 10, PC-ASPECTS > 5
  - Occlusion basilaire ~90%, NIHSS 24,PC-ASPECT 9-10, r-tPA ~ 30%, délai revasc ~ 6.9h, TICI 2b-3 93%
  - **↑↑ mRS 0-3 à 90 jrs (46 vs 23%)**, **↓ mortalité (37 vs 55%)**, sICH 5 vs 0%
  - **↑↑ mRS 0-3 à 1 an 46 vs 19%, ↑↑ mRS 0-1 à 1 an (28% vs 8%), ↓ mortalité (46 vs 64%)** (JAMA Neurol 2024)

En résumé…

- Considération de thrombolyse
  - AVC invalidant (NIHSS 0-5)
  - Délai début des symptômes < 4.5h
  - Délai début des symptômes 4.5-24h si imagerie neurovasc avancée favorable

- Considération de thrombectomie
  - AVC invalidant (NIHSS ≥ 6)
  - Occlusion intracrânienne proximale pertinente prouvée et traitable
  - ASPECTS ≥ 6
  - ASPECTS < 6 considérés au cas par cas…
  - Délai début des symptômes < 6h
  - Délai début des symptômes 6-24h avec imagerie neurovasc avancée favorable

Algorithme décisionnel pour thrombectomie



Prabhakaran et al. Stroke 2026

Thrombectomie sous AG

Effect of general anaesthesia on functional outcome in patients with anterior circulation ischaemic stroke having endovascular thrombectomy versus standard care: a meta-analysis of individual patient data

Bruce C V Campbell, Wim H van Zwam, Mayank Goyal, Bijoy K Menon, Diederik W J Dippel, Andrew M Demchuk, Serge Bracard, Philip White, Antoni Dávalos, Charles B L M Majoie, Aad van der Lugt, Gary A Ford, Natalia Pérez de la Ossa, Michael Kelly, Romain Bourcier, Geoffrey A Donnan, Yvo B W E M Roos, Oh Young Bang, Raul G Nogueira, Thomas G Devlin, Lucie A van den Berg, Frédéric Clarençon, Paul Burns, Jeffrey Carpenter, Olvert A Berkhemer, Dileep R Yavagal, Vitor Mendes Pereira, Xavier Ducrocq, Anand Dixit, Helena Quesada, Jonathan Epstein, Stephen M Davis, Olav Jansen, Marta Rubiera, Xabier Urra, Emilien Micard, Hester F Lingsma, Olivier Naggara, Scott Brown, Francis Guillemin, Keith W Muir*, Robert J van Oostenbrugge*, Jeffrey L Saver*, Tudor G Jovin*, Michael D Hill*, Peter J Mitchell*, for the HERMES collaborators*

nterpretation Worse outcomes after endovascular thrombectomy were associated with GA, after adjustment for baseline prognostic variables. These data support avoidance of GA whenever possible. The procedure did, however remain effective versus standard care in patients treated under GA, indicating that treatment should not be withheld in those who require anaesthesia for medical reasons.

Lancet Neurol 2018; 17: 47–53

Thrombectomie: modalité anesthésique

- Méta-analyse sur données individuelles de 7 RCT
  - 1764 patients, 131 centres
  - **Études évaluant thrombectomie vs traitement standard**
  - **Analyse rétrospective**
  - AG vs pas d'AG (= SC ou AL seule)
  - **Pas de protocole standardisé pour AG**

BIAIS DE SÉLECTION!

- AG 30%
  - AG – plus jeunes, plus de rtPA IV, mois de DLP/Db
  - SC – meilleur ASPECT (8 vs 7)
  - Délai début sx ad reperfusion = idem
  - Délai radomisation ad reperfusion = SC 85 vs AG 105 min
- AG n'élimine pas bénéfices de thrombectomie
- SC shift vers bon outcome (mRS ≤ 2) OR 2,62 (p<0.001)

	No GA *vs* GA*	
	Effect size OR (95%CI)	p value
Primary outcome		
Functional outcome at 90 days (mRS)†	..	..
Covariate adjusted common odds ratio	1·53 (1·14–2·04)	0·0044
Propensity-score stratification common odds ratio	1·44 (1·08–1·92)	0·012
Secondary outcomes		
Independent functional outcome (mRS 0–2)	1·65 (1·14–2·38)	0·0078
Excellent functional outcome (mRS 0–1)	1·68 (1·12–2·52)	0·013
Early neurological improvement (NIHSS reduction ≥8 points or reaching 0–1 at 24 h)‡	1·75 (1·23–2·48)	0·0020
Safety		
Death within 90 days	0·71 (0·44–1·14)	0·15
Symptomatic intracerebral haemorrhage§	0·95 (0·41–2·19)	0·90
Parenchymal haematoma	0·97 (0·60–1·58)	0·90

HERMES Lancet Neurol 2018

Thrombectomie circulation antérieure: SC vs AG

Étude	N	Maintient	SC → AG (%)	Délai (min) HOP-PCT NRI-PCT PCT-reperf	TICI 2b-3 (%)	Δ NIHSS à 24h	mRS (0-2) à 90 jrs (%)	Δ taille AVC (mL)	Note
SIESTA Schönenberger et al. DE (JAMA 2018)	150	SC = PPF/rémi AG = PPF/rémi	14%	**66 vs 76** ---------- 109 vs 90	81 vs 89	-3.8 vs -3.2	**18 vs 37**	N/A	AG plus de complications (HypoTo 33 vs 9%, pneumo 14 vs 4%)
AnStroke Hendén et al. SE (Stroke 2017)	90	SC = rémi TCI AG = sévo/rémi TCI	16%	---------- 25 vs 34 74 vs 55	89 vs 91	-8 vs -9	40 vs 42	N/A	AG désavantagé (NIHSS, T carot, G) AG plus hypoTA > 20% (PAM 95 vs 91)
GOLIATH Simonsen et al. DK (JAMA Neurol 2017)	128	AG = PPF/fenta SC = PPF/rémi	6%	---------- 15 vs 24 29 vs 34	**60 vs 77**	-7 vs -10	**52 vs 67**	19 vs 8	AG plus hypoTA (PAM 102 vs 90)
CANVAS Sun et al. CN (J Neurosurg Anesthesiol 2020)	43	SC = PPF/suf TCI AG = PPF/rémi TCI	20%	---------- **15 vs 27** 78 vs 102	65 vs 95	N/A	50 vs 55	N/A	AG plus hypoTA > 20% (PAM 108 vs 89) LMA

Thrombectomie circulation antérieure: SC vs AG

Étude	N	Maintient	SC → AG (%)	Délai (min) HOP-PCT NRI-PCT PCT-reperf	TICI 2b-3 (%)	Δ NIHSS à 24h	mRS (0-2) à 90 jrs (%)	Δ taille AVC (mL)	Note
Ren et al. CN (Front Neurol 2020)	90	SC = PPF/dex + F/M AG = PPF/rémi/dex	10%	---------- 11 vs 11 39 vs 47	86 vs 88	-5 vs -5	?idem? Pas formellement rapporté!	N/A	Pneumonie **5 vs 21** mRS médian idem
GASS Maurice et al. FR (Anesthesiology 2022)	351 multi	SC = rémi TCI AG = PPF/rémi TCI TAs 140-185 SpO2 > 96	4%	60 vs 69 ---------- 59 vs 51	**75 vs 85**	-5 vs -5	36 vs 40	N/A	AG plus hypoTA et hyperTA
AMETIS Chabanne et al. FR (JAMA Neurol 2023)	273 multi	Pragmatique TAs 140-180 SpO2 > 94 EtCO2 30-35 (AG)	11%	---------- 9 vs 11 41 vs 35	78 vs 85	-7 vs -7	39 vs 33	N/A	mRS 0-2 à 90 jrs et absence de complications 36 vs 28
SEGA Chen et al. US (JAMA Neurol 2025)	260 multi	Pragmatique TAs 140-180 EtCO2 35-40 (AG)	14%	69 vs 78 13 vs 17 43 vs 41	95 vs 97	N/A	39 vs 48 **Prob post de bénéfice 89%**	N/A	Amélioration mRS OR 1.22 (0.79-1.87) **Prob post de bénéfice (81%)**

Thrombectomie sous AG

RESEARCH ARTICLE

General Anesthesia Compared With Non-GA in Endovascular Thrombectomy for Ischemic Stroke

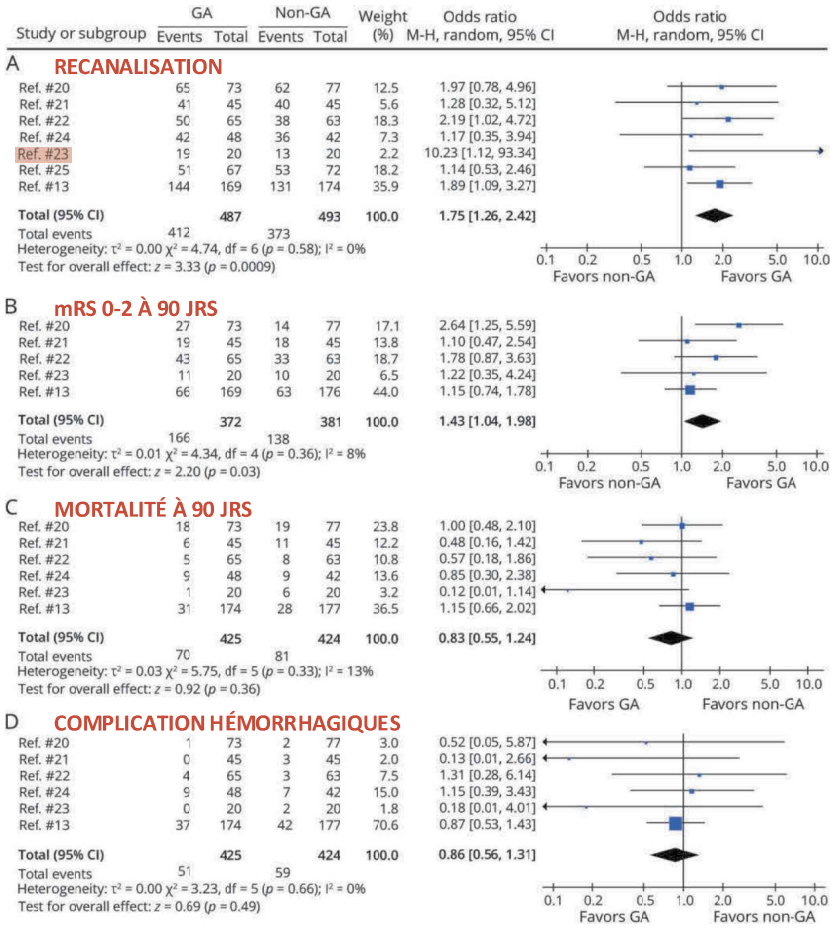
A Systematic Review and Meta-analysis of Randomized Controlled Trial

Douglas Campbell, BM, Elise Butler, MB ChB, Ruby Blythe Campbell, Jess Ho, MB ChB, and P. Alan Barber, MBChB, PhD, FRACP

dcampbell@adhb.govt.nz

Neurology® 2023;100:e1655-e1663. doi:10.1212/WNL.0000000000207066

- ↑recanalisation de 9%
- ↑mRS 0-2 à 90 jrs de 8,4% (NNT 12)
- Limites de RCT non-centrée sur cette comparaison (MA données individuelles, ajustement)
  - Biais de sélection inhérent
  - Délai de traitement
  - Gestion AG/HD péri-thrombectomie
  - Présence d'anesth/intensiviste (SC/AG)



Pooled estimates were performed only if trials reported the endpoint and in the correct format. GA = general anesthesia.

Thrombectomie circulation postérieure: SC vs AG

Étude	N	Maintient	SC ➔ AG (%)	Délai (min) HOP-PCT NRI-PCT PCT-reperf	TICI 2b-3 (%)	Δ NIHSS à 24h	mRS (0-2) à 90 jrs (%)	Δ taille AVC (mL)	Note
Hu et al. CN (Am J Transl Res 2021)	139 mono	SC = PPF/fenta AG = PPF/rémi	3%	143 vs 130 (procédure)	76 vs 73	N/A	N/A	**29 vs 12**	Étude non-infériorité mRS (2 vs 3) idem
CANVAS II Liang et al. CN (JAMA Neurol 2022)	93 mono	SC = PPF/rémi AG = PPF/rémi BIS >70 vs 40-60	30% (!!!) 	**151 vs 185** **15 vs 20** 81 vs 99	**77 vs 95**	NS	55 vs 49 (ITT)	N/A	Peu rTPa (11-16%) Plus d'hypoTA en AG (23 vs 7%) Objectif TAsyst 140-180mmHg non atteint

Thrombectomie: RCT SC vs AG

- Limites des données disponibles
  - Maintenant quelques multicentriques (3)
    - (validité externe, variation performance – délai, succès…)
  - Anesthésistes (ou neurointensiviste) pour toute procédures (SC ou AG)
    - Plan anesthésiques variés (agent, monitoring, intubation vs LMA)
    - **Protocole standardisé avec cibles précises – éviter hypotension**

- AG semble sécuritaire… bénéfique?
  - Effet « neuroprotecteur » direct?
  - Procédure de meilleure qualité?
  - Effet différentiel selon agent utilisé (PPF vs volatiles)? Pas de données convaincantes

- Délais – AG = 10 minutes de plus mais délai sx à reperfusion similaire
  - Équipes rodées avec protocoles et objectifs clairs

Thrombectomie: modalité anesthésique

Modification des lignes directrices AHA/ASA

US

Privilégier sédation consciente plutôt qu'anesthésie générale (Stroke 2015)

↓

Individualiser de technique anesthésique en fonction des facteurs de risques du patient, de considérations techniques de la procédure et d'autres caractéristiques cliniques (Stroke 2019)

↓

Recommendations for Endovascular Techniques (Continued)		
COR	**LOE**	**Recommendations**
1	B-R	3. In patients with AIS undergoing EVT, either general anesthesia or procedural sedation are recommended to facilitate EVT.[7–9]

Prabhakaran et al. Stroke 2026

Thrombectomie: modalité anesthésique

CA

Canadian Stroke Best Practices

Mise à jour 2025

5.4.2 Sedation for Endovascular Interventions

i. For endovascular interventions, procedural sedation is generally preferred over intubation and general anesthesia for most patients undergoing EVT [Strong recommendation; Moderate quality of evidence]

ii. General anesthesia is appropriate if medically indicated (e.g., for airway compromise, respiratory distress, depressed level of consciousness, severe agitation, or other indication potentially impairing the technical ability to perform the procedure, as determined by the treating physician). General anesthesia may also be considered when technical complexity is anticipated during the stroke intervention. In such cases, excessive and prolonged hypotension and time delays should be avoided [Strong recommendation; Moderate quality of evidence].

iii. A process should be in place at EVT enabled centres to activate notification of Anesthesiology without delay when deemed necessary for patients who meet criteria for EVT [Strong recommendation; Moderate quality of evidence].

https://www.strokebestpractices.ca/recommendations/acute-stroke-management/acute-ischemic-stroke-treatment

Anesthésie pour thrombectomie

- Modalité selon le patient: individualisation
- Situation urgente!!
- **Fenêtre de traitement élargie ≠ ralentir cadence du traitement**
- Information disponible limitée…
  - « Baseline ECG, troponin, creatinine, platelet count, coagulation studies (…) should not delay »

Rôle de l'anesthésiste

⚠ TIME IS BRAIN ⚠

NHISS

Imagerie

Thrombolyse

Thrombectomie

Door-to-needle

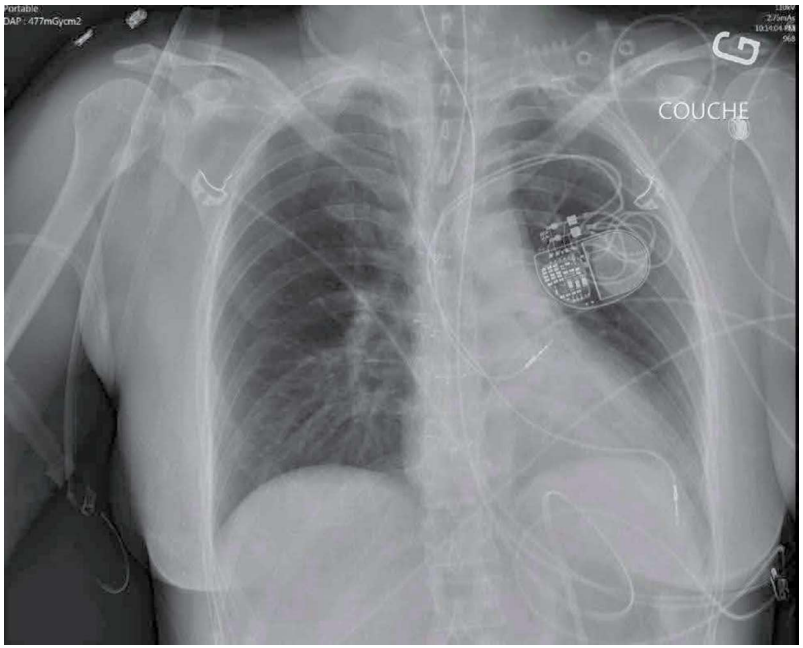
Door-to-puncture

GO! GO! GO!

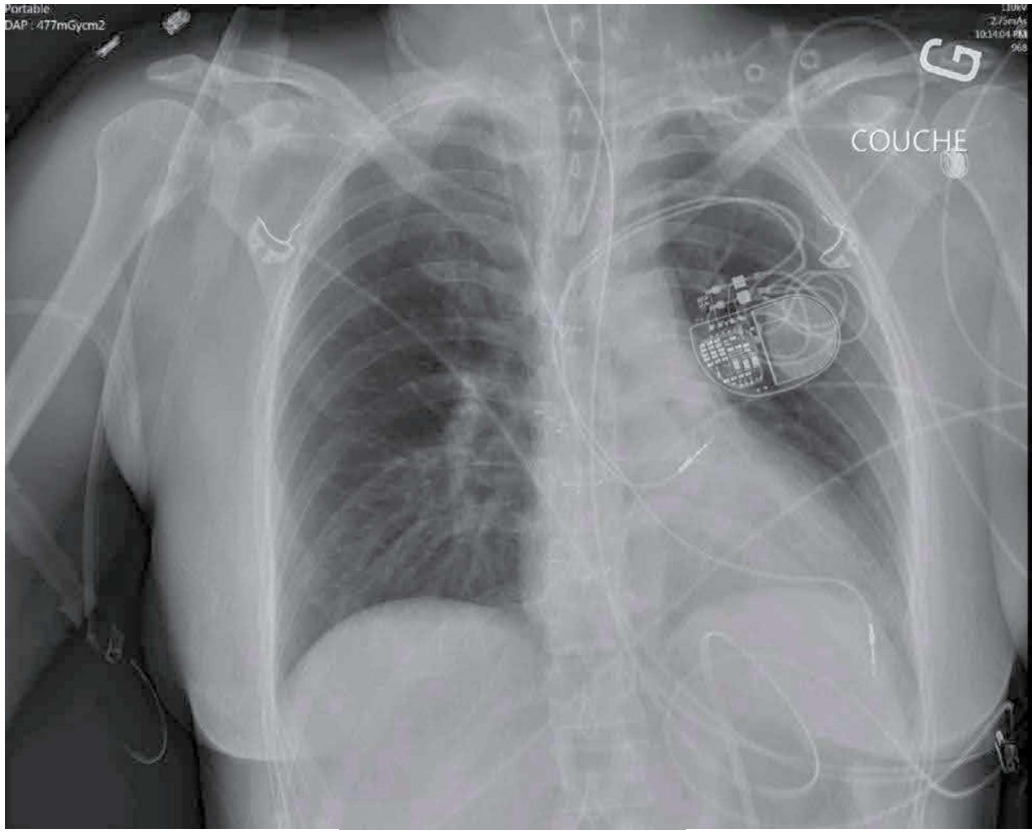
Anesthésie pour thrombectomie

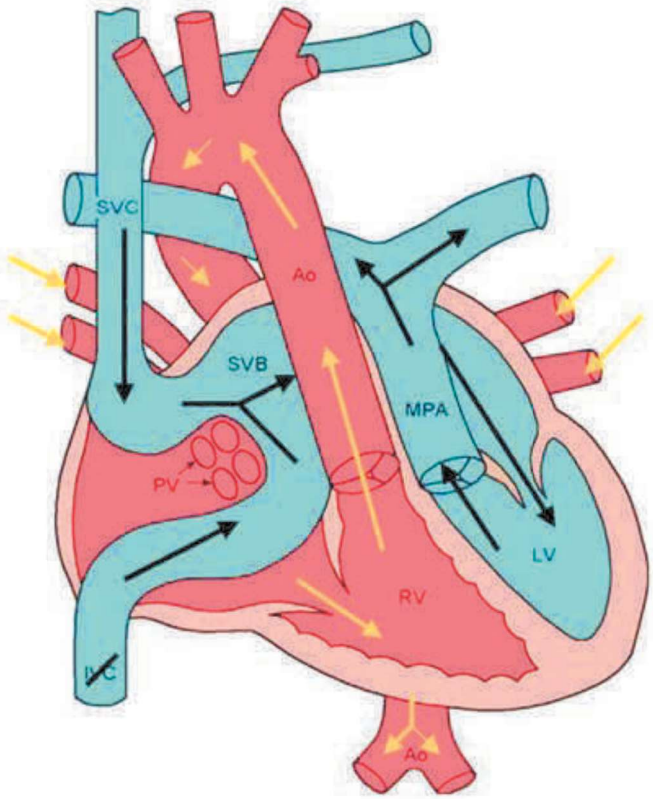
- Placé devant le fait accompli…
  - Procédure déjà en cours
  - Information limitée
  - Altération d'état de conscience
  - Hypoxémie, obstruction VRS, vomissements
  - Agitation
  - Accès au patient limité

- Terrain hostile (hors bloc)



TGV ➔ correction de Mustard





A-B-C en AVC: AIRWAY

- Cause possibles d'intubation / prise en charge airway
  - Cause intracrânienne – AEC (CGS ≤ 8), dysfonction tronc (gestion OP, protection VRS), œdème malin, HTIC/engagement, status epilepticus et agitation extrême
  - Cause extracrânienne – hypoxémie (pneumonie, OAP), apnée/hypopnée (exacerbée par physionomie, sédation), instabilité HD (cardiopathie, choc)
  - Contextuel – pré-procédure (immobilité), agitation ou complication péri-procédurale, évolution clinique anticipée, sécurisation pré-transport…

A-B-C en AVC: AIRWAY

- Sédation procédurale vs **estomac plein** - pistes de réflexion
- Recommandations de jeûne s'appliquent aux procédures électives[1,2,3]
  - En situation urgente, évaluer le risques d'inhalation selon FR
  - Procédure « urgente » en est un!
- Consensus de sédation procédurale en salle d'urgence[4]

  Level B recommendations. Do not delay procedural sedation in adults or pediatrics in the ED based on fasting time. Preprocedural fasting for any duration has not demonstrated a reduction in the risk of emesis or aspiration when administering procedural sedation and analgesia.

ABSENCE DE JEÛNE
≠
CONTRE-INDICATION ABSOLUE À SÉDATION PROCÉDURALE

- Sédation consciente en thrombectomie prévalente x des années

1- Procedural sedation – Dobson et al. Can J Aneth 2018
2- Guide d'exercice de l'anesthésie 2025 – Can J Anesth 2025
3- Lignes directrices de l'ASA 2017 – Anesthesiology 2017
4- Politique de l'ACEP – Ann Emerg Med 2014

A-B-C en AVC: BREATHING

- Éviter hypoxémie
  - Viser SpO2 > 97%, O_2 PRN

  - ~~O2 non-indiqué si non-hypoxémique?~~
  - ~~Effets délétères de l'hyperoxie?~~

  - **NOUVELLES RECOMMANDATIONS EN CONTEXTE DE THROMBECTOMIE**

Recommendations for Airway, Breathing, and Oxygenation
Referenced studies that support the recommendations are summarized in the online data supplement.

COR	LOE	Recommendations
1	C-LD	1. In patients with acute stroke and decreased consciousness or bulbar dysfunction, airway support and ventilatory assistance are recommended as needed to provide airway maintenance, protection and adequate ventilation and oxygenation.[1–3]
1	C-LD	2. In patients with AIS with hypoxia, supplemental oxygen should be provided to maintain oxygen saturation (SpO_2) >94%.[4,5]
2b	B-R	3. In patients with AIS within 6 hours from onset, NIHSS score 10 to 20, CT ASPECTS of ≥6, and anterior circulation LVO (M1 or carotid terminus) with planned EVT (with or without IVT) normobaric hyperoxia (NBO) before EVT may be reasonable to improve functional outcomes at 90 days.[6–9]
2b	B-NR	4. In patients with AIS due to arterial air embolism, hyperbaric oxygen (HBO) may be reasonable to improve clinical outcome.[10]
3: No benefit	B-R	5. In patients with AIS without hypoxia who are ineligible for EVT, supplemental oxygen is not recommended to improve functional outcomes.[11–16]
3: No benefit	B-R	6. In patients with AIS, not associated with air embolism, HBO is not recommended to improve functional outcomes.[17]

Prabhakaran et al. Stroke 2026
Robba et al. Crit Care 2019
Recommandations ESCIM Intensive Care Med 2020

A-B-C en AVC: BREATHING

- RCT multicentrique CN
  - 282 patients, thrombectomie
  - LVO circulation antérieure (CI, M1)
  - LKW < 6h, NIHSS 10-20
  - ASPECTS ≥ 6

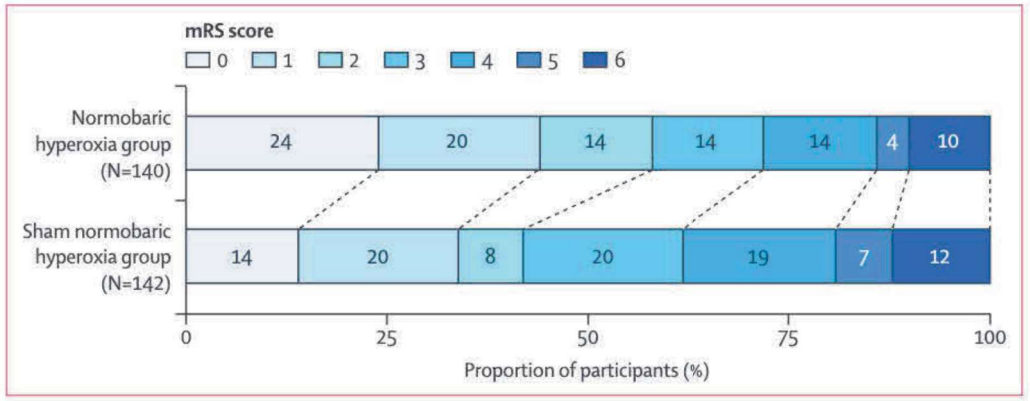
Normobaric hyperoxia combined with endovascular treatment for acute ischaemic stroke in China (OPENS-2 trial): a multicentre, randomised, single-blind, sham-controlled trial

Weili Li, Jing Lan*, Ming Wei*, Lan Liu, Chengbei Hou, Zhifeng Qi, Chuanhui Li, Liqun Jiao, Qi Yang, Wenhuo Chen, Shuling Liu, Xincan Yue, Qinglin Dong, Haicheng Yuan, Zongen Gao, Xiangbin Wu, Changming Wen, Tong Li, Changchun Jiang, Di Li, Zuoquan Chen, Junfeng Shi, Wanchao Shi, Jinglin Yuan, Yijie Qin, Binglong Li, Marc Fisher, Wuwei Feng, Ke Jian Liu, Xunming Ji, on behalf of the OPENS-2 Investigators†*

- FiO2 100% (VM 10 LPM ou via TET) vs sham (VM 1 LPM ou 30%) x 4h
  - 20% AG
- mRS médian 2 vs 3 à

(OR 1.65 IC 1.09-2.5)

- ↓ taille infarctus, NIHSS à 24h



OPENS-2 Li et al. Lancet 2025

A-B-C en AVC: BREATHING

- Normoventilation (PaCO2 35-45 mmHg)
  - Hyperventilation ➔ réduction du DSC
  - Hypoventilation ➔ phénomène de vol?
  - Impact différent pré vs post-reperfusion?
  - En absence de monitoring avancé ou d'engagement (bridge)

  ➔ pas de folies!

Robba et al. Crit Care 2019
Recommandations ESCIM Intensive Care Med 2020

A-B-C en AVC: CIRCULATION

- Éviter hypoTA, hypovolémie et hypoperfusion
- Éviter réduction rapide ou excessive de TA

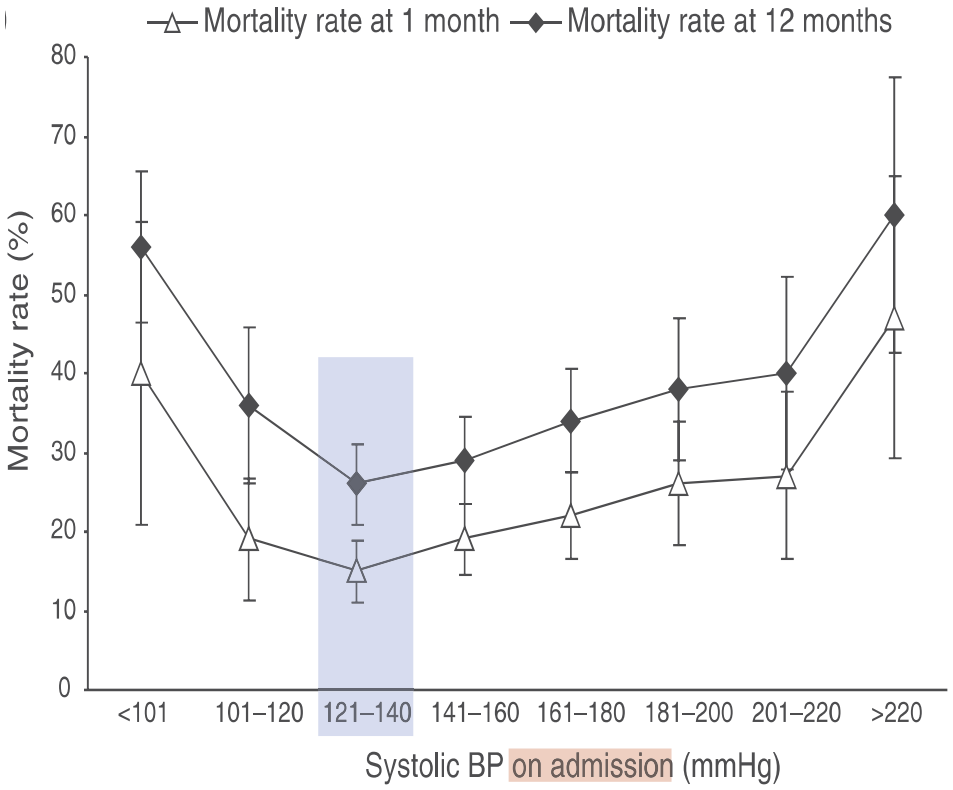
- PA marqueur d'ischémie-reperfusion ou cible thérapeutique?

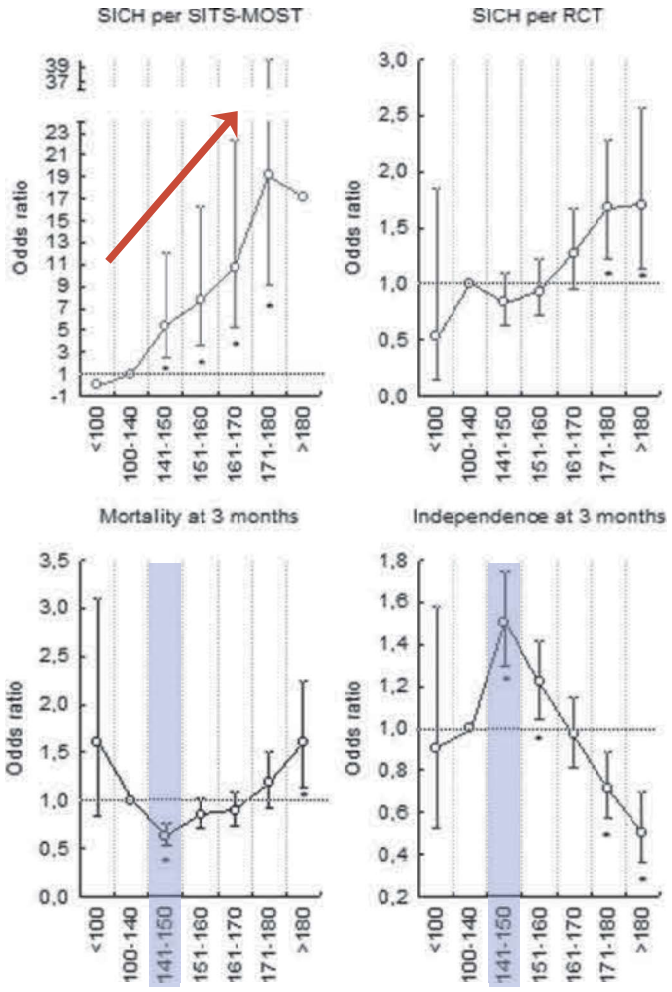
Heran et al. Can J Neurol Sci 2024
Prabhakaran et al. Stroke 2026

A-B-C en AVC: CIRCULATION

- Quoi viser – PAsyst, PAdia, PAM?
- Comment mesurer – PNI vs PI, MS plégique ou non?
- Quand la contrôler – hyper-aigu, pré-intervention, post-intervention?
- Degré de collatéralisation et/ou reperfusion? Microthrombose veneuse post-capillaire?
- Étendue de l'AVC établi?
- Comorbidités?
- Ajustement en fonction de neuromonitoring avancé?
- Contrôle pendant combien de temps?
- Effet de variabilité de TA…
- Effet différentiel selon l'agent?

PA en AVC: la fameuse courbe en U





Vemmos et al. J Int Med 2004
Ahmed et al. Stroke 2009

CIBLES DE PRESSION ARTÉRIELLE EN AVC AIGU

ABSENCE DE TRAITEMENT SPÉCIFIQUE

≥ 220 / 120 ➔ ↓ 15-25% au cours des 1ers 24-72 [1,2]
< 220 / 120 ➔ pas de Rx [1,2]
ÉVITER HYPOTENSION – THÉRAPIE HYPERTENSIVE CHEZ PATIENTS SÉLECTIONNÉES?[3]

PRÉ-THROMBOLYSE	POST-THROMBOLYSE
< 185 / 110 [1,2]	< 180 / 105 x 24h [1,2,4]

PRÉ-THROMBECTOMIE	DURANT THROMBECTOMIE	POST-THROMBECTOMIE
< 185 / 110 [1]	≤ 180/105 [1] **PAsyst entre 140-180** [5,6] PAM 70-90 ? [7]	TOUS: < 180 / 105 x 24h [1] TICI ≥ 2b: PAsyst > 130-140 [8,9]

1- Prabhakaran et al. Stroke 2026 (AHA/ASA)
2- Heran et al. Can J Neurol Sci 2024 (CAN)
3- Bang et al. Neurology 2019 (SETIN-HYPERTENSION)
4- Anderson et al. Lancet 2019 (SETIN-HYPERTENSION)
5- Sharma et al. J Neurosurg Anesthesiol 2020 (SNACC)
6- Chen et al. Stroke 2023 (INDIVIDUATE)
7- Espelund et al. Stroke Vasc Interv Neurol 2024
8- Yang et al. Lancet 2022 (ENCHANTED2/MT)
9- Nam et al. JAMA 2023 (OPTIMAL BP)

Durant thrombectomie: cibles individualisées

- **Espelund et al. Stroke Vasc Interv Neurol 2024 DK (GOLIATH)**
  - 60 pts LVO + throbectomie sous AG (étude faisabilité)
  - PAM +/- 10% pré-intervention vs PAM 70-90 mmHg (PI, LIDCOrapid)
  - mRS 0-2 à 90 jrs idem (70 vs 53%)
  - **Pas faisable > 50% du temps à l'extérieur de cible prévue malgré expertise**

- **INDIVIDUATE Chen et al. Stroke 2023 DE (SIESTA)**
  - 250 pts LVO + thrombectomie sous sédation (étude exploratoire)
  - TAsyst +/- 10% pré-intervention (urgence) vs TAsyst 140-180 mmHg
    - Écart de TAsyst moyen rapproché (155-175 vs 140-180 mmHg)
  - mRS 0-2 à 90 jrs idem (25 vs 24%), sICH et mortalité idem

- **DETERMINE Maïer et al. (non-publié, ESOC 2025) FR**
  - 433 pts LVO + thrombectomie
  - PAM ~ 10% pré-EVT vs TAs 140-180 mmHg (NA) ad reperfusion ou fermeture artère fémorale
  - mRS 0-2 à 90 jrs idem (~44 vs 48%)

Post-thrombectomie efficace

- 5 études complétées (TA_{syst} < 140 mmHg vs TA_{syst} < 180 mmHg)
  - **BP-TARGET Lancet Neurol 2021** FR négative
  - **ENCHANTED2/MT Lancet 2022** CN **DANGER**
  - **OPTIMAL BP JAMA 2023** KR **DANGER**
  - **BEST-II JAMA 2023** US probablement futile
  - **DETECT Stroke Vasc Interv Neurol 2024** CA pas faisable
  - **IDENTIFY Lancet Reg Health West Pac 2025** CN négative

« results strongly contribute to a dampened enthusiasm for spending limited research resources on a future, large, pivotal trial »

- ≥ 3 en cours…
  - CRISIS 1 NCT04775147 CN TAs <120 vs <140 post MT TICI ≥ 2b
    - (205 pts enrôlés, terminée 01/2023, pas publiée)
  - HOPE NCT04892511 ES TAs 100-140 (TICI 2c/3) 140-160 (TICI 2b) vs <180/105
    - (814 pts enrôlés, fin prévue 09/2024, pas publiée)
  - CLEVER NCT05175547 US TAs 90-120 vs 90-160 mmHg (mTICI ≥ 2c)
    - (80 pts enrolés, terminée 02/2024, pas publiée)

Post-thrombectomie efficace

- **BP-TARGET Lancet Neurol 2021** FR 324 pts LVO TICI ≥2b ➔ TAsyst 100-129 vs TAsyst 130-185 en < 1h x 24h (PNI, nicardipine, TAsyst moy de base~ 154 mmHg)
  - TAsyst moyenne dans 1er 24h: 128 vs 138 mmHg ➔ ICH idem, hypoTA idem
  - 30% des patients avaient TAsyst < 130 mmHg post reperfusion
  - Difficulté d'effectuer ces études: TAsyst dans les cibles 61-67% du temps, ~3h pour atteindre cible intensive
- **ENCHANTED2/MT Lancet 2022** CN 821/2257 pts LVO TICI ≥2b ➔ TAsyst 100-120 vs 140-180 en < 1h x 72h (PNI, MS parétique, urapidil, TAsyst moy de base ~ 159 mmHg)
  - TAsyst moyenne à 1h et 24h: 125 et 121 vs 143 et 139 mmHg (D = 18 mmHg)
  - DANGER: pire mRS shift (OR 1.37), augmentation mRS 3-6 53 vs 39%, sICH 6% idem
  - (interrompu pour motif de sécurité)
- **OPTIMAL BP JAMA 2023** KR 306/668 pts LVO TICI ≥2b ➔ TAsyst < 140 vs 140-180 en < 1h x 24h (PNI, MS non-parétique, nicardipine, TAsyst moy base ~ 155 mmHg)
  - TAsyst moyenne à 24h: 128 vs 139 mmHg (D = 10 mmHg)
  - DANGER: pire évolution (mRS 0-2 39 vs 54%), plus d'hypoTA < 100 (30 vs 17%), plus d'œdème malin (OR 6), sICH (9%) et mortalité idem
  - (interrompu suivant résultats ENCHANTED2/MT et futilité de rejeter hypothèse nulle) (pire si réduction de PA par Rx plutôt que spontanée)
- **BEST-II JAMA 2023** US 120 pts LVO TICI ≥2b ➔ TAsyst < 140 vs < 160 vs < 180 en < 1h x 24h (PNI, nicardipine, TAsyst moy base ~ 148 mmHg)
  - TAsyst moyenne à 24h: 122 vs 130 vs 129 mmHg, utilisation d'antiHTA IV à 24h: 73 vs 55 vs 25%
  - Étude de futilité: conclusion de futilité non-atteinte mais peu probable d'identifier un bénéfice de viser des TAsyst plus basses… (taille d'infarctus à 36h, UW-mRS)
  - « results strongly contribute to a dampened enthusiasm for spending limited research resources on a future, large, pivotal trial »
- **DETECT Stroke Vasc Interv Neurol 2024** CA 30 pts LVO TICI ≥2b ➔ TAsyst < 140 vs <180 x 48h (labetalol/hydralazine, TAsyst moyenne base ~ 159 mmHg)
  - TAsyst moyenne à 48h: 131 vs 139 mmHg,
  - Étude de faisabilité: 69% des pts exclus car TAsyst < 150, 48% du temps TAsyst < 140 dans groupe standard, HTA moins prévalente qu'attendu post-reperfusion, recrutement lent
- **IDENTIFY Lancet Reg Health West Pac 2025** CN 383/600 pts LVO TICI ≥2b ➔ TAsyst < 130 vs < 180 x 24h (urapidil et autres, PNI, TAsyst moyenne base ~ 151 mmHg)
  - TA moyenne à 24h
  - Évolution défavorable (mRS 3-6) à 90jrs idem, sICH, œdème cérébral, mortalité idem
  - (interrompue suivant résultats ENCHANTED2/MT et OPTIMAL BP)

A-B-C en AVC: CIRCULATION

Considérer la cause d'hypotension…
- Iatrogène (anticiper avec vasopresseurs)
- Hypovolémie
- Dépression myocardique
- Arythmie
- Saignement externe
- Saignement rétropéritonéal
- Dissection aortique

An intra-arterial cannula is useful if it can be placed without delaying the procedure.
(SNACC 2014)

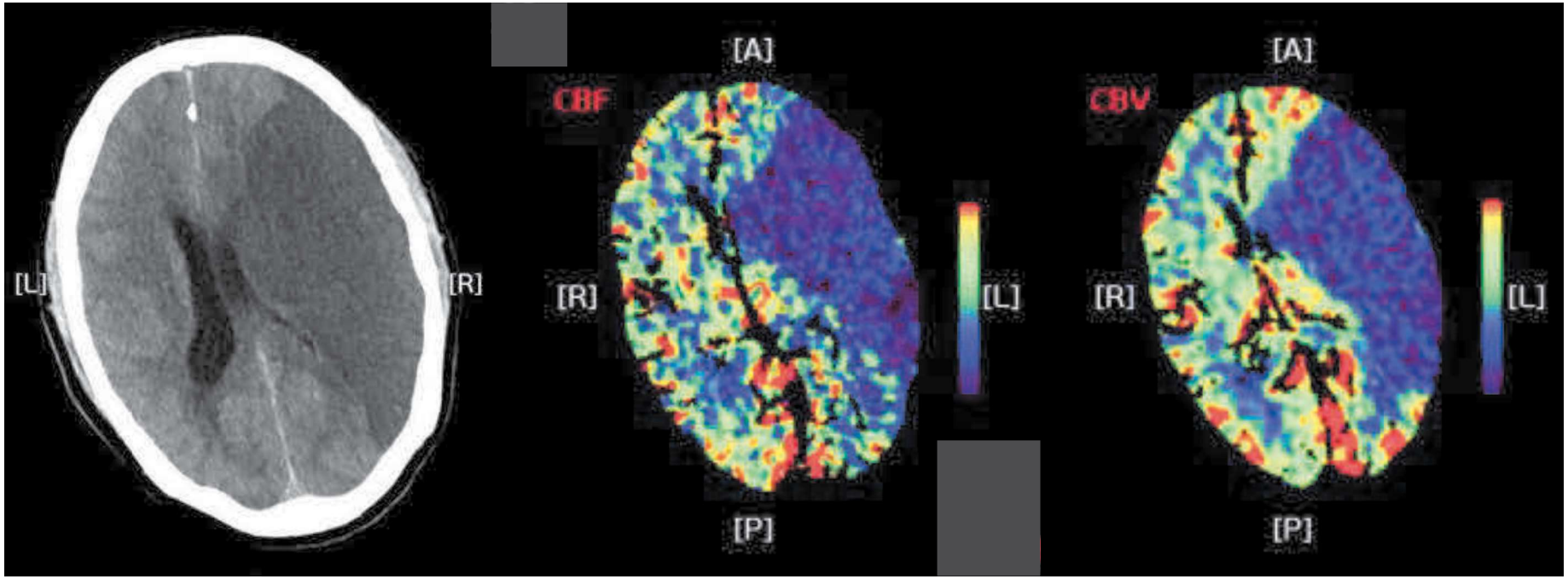
Thrombectomie – en résumé

- Situation d'urgence, hors bloc, peu de temps pour évaluer/optimiser
- Modalité anesthésique selon le contexte
- Intubation si indiqué par état clinique
- Normoventilation (pas d'hyper ou hypocapnie)
- Éviter hypoxémie (SpO2 > 94%), considérer hyperoxygénation en EVT
- Gestion de pression artérielle – éviter hypoTA, TAsyst 140-180 mmHg
- Normothermie
- Normoglycémie

Endovascular thrombectomy is a time-limited emergency procedure. Getting the procedure started (femoral arterial puncture for angiographic access) as soon as possible is a cardinal management goal. What is unknowable is when rapid workflow becomes unsafe. (Hindman et al. Anesth Analg 2018)

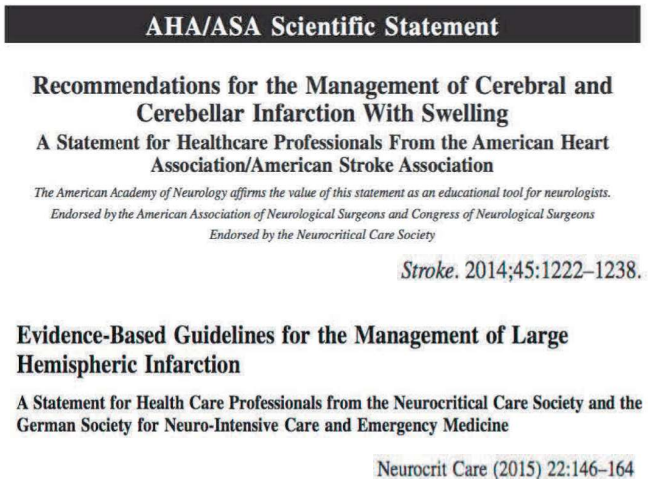
« Malignant MCA infarction »

AVC malin



Craniectomie décompressive en AVC « malin »

- **Identification précoce des patients à risque**
- Détérioration habituellement dans les 72-96 hrs post-AVC
  (ad 10 jours!)
- Seuil pour intervention (craniectomie décompressive) incertain
  - AEC
  - Imagerie: zone infarcie
    - Précoce ≤ 6h
    - Extensive > 50-67% territoire ACM, > 150 mL
    - Effet de masse = DLM
- Approche proactive vs réactive?



AHA/ASA Scientific Statement

Recommendations for the Management of Cerebral and Cerebellar Infarction With Swelling

A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association

The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists.
Endorsed by the American Association of Neurological Surgeons and Congress of Neurological Surgeons
Endorsed by the Neurocritical Care Society

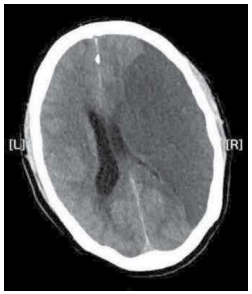
Stroke. 2014;45:1222–1238.

Evidence-Based Guidelines for the Management of Large Hemispheric Infarction

A Statement for Health Care Professionals from the Neurocritical Care Society and the German Society for Neuro-Intensive Care and Emergency Medicine

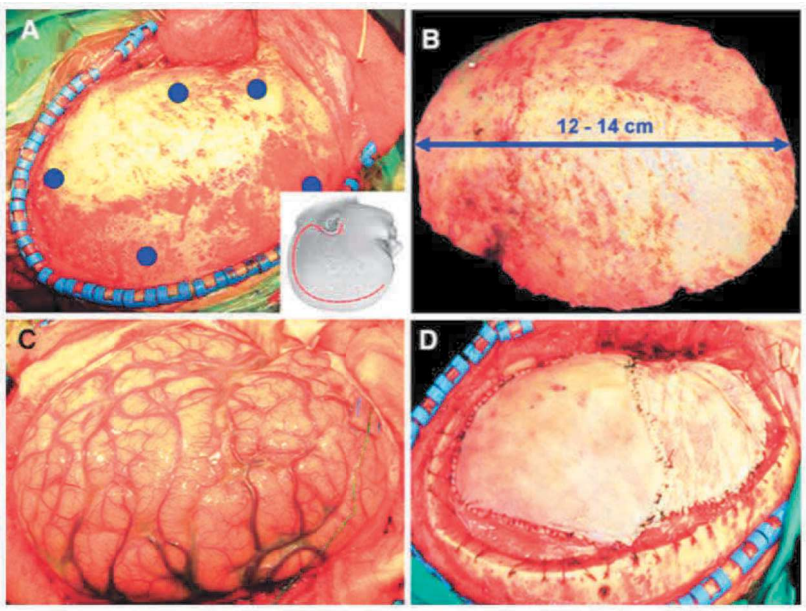
Neurocrit Care (2015) 22:146–164

Craniectomie décompressive en AVC malin



- Enjeux **éthiques**: degré d'handicap acceptable pour le patient
  - Aucun impact sur l'AVC établi
  - Diminution de mortalité
  - Outcome probable mRS 2-5

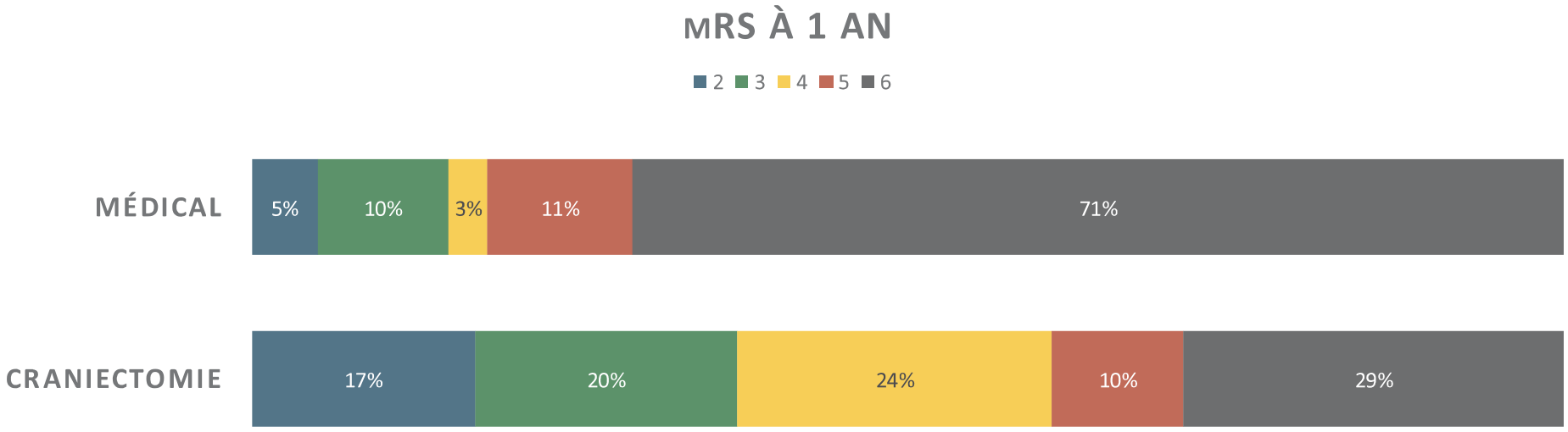
- 5 principales RCT ~2007-2014
  - Decimal
  - Hamlet
  - Destiny
  - Analyse groupée
  - Destiny II
  - **Méta-analyse de données individuelles**



Kurland et al. Neurocrit Care 2015

Méta-analyses: impact de la craniectomie

Vahedi et al. Lancet Neurol 2007
Reinink et al. JAMA Neurol 2020

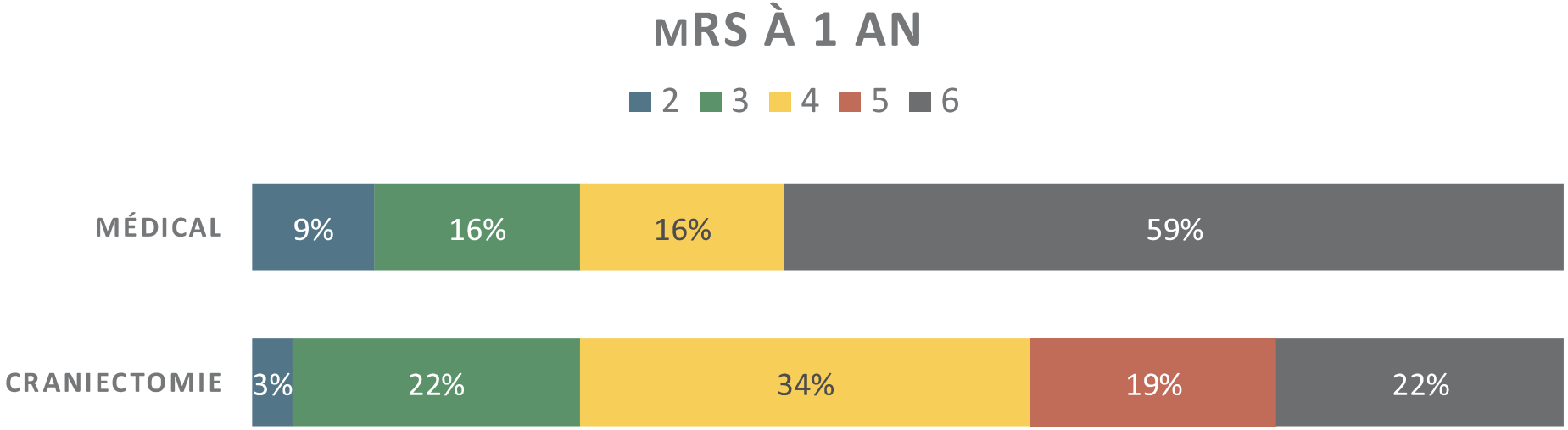


Survie NNT = 2.4
mRS ≤ 4 NNT = 2.6
mRS ≤ 3 NNT = 4.5

	No./total No. (%) of patients						
Outcome	Surgery population	Medical population	RD	Crude OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Primary outcome							
mRS score ≤3 at 1 y	87/234 (37)	37/254 (15)	(21)	3.23 (1.75-5.94)	<.001	2.95 (1.55-5.60)	.001
Secondary outcomes							
mRS score ≤2 at 1 y	39/234 (17)	12/254 (5)	(10)	2.91 (1.06-7.99)	.04	2.77 (0.97-7.88)	.06
mRS score ≤4 at 1 y	143/234 (61)	59/254 (23)	(38)	5.55 (3.42-9.00)	<.001	5.34 (3.26-8.74)	<.001
Death at 1 y	68/234 (29)	180/254 (71)	(-41)	0.16 (0.10-0.24)	<.001	0.16 (0.10-0.24)	<.001

HAMLET: impact du délai de traitement

Hofmeijer et al. Lancet Neurol 2009

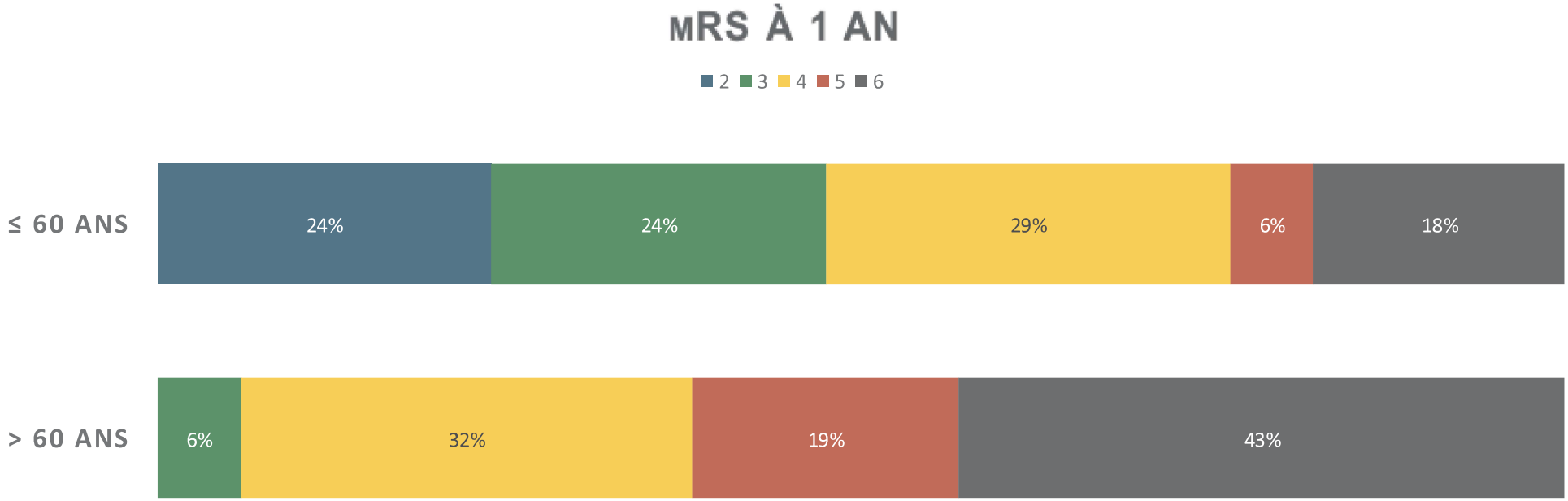


Randomisés ≤ 48hrs post AVC: mRS ≤ 4 = 52% vs 22%†

Randomisés > 48hrs post AVC: aucun effet de la chirurgie

DESTINY vs DESTINY-II: impact de l'âge

Jüttler et al. NEJM 2014
Jüttler et al. Stroke 2007



CD - modification des lignes directrices

2019 → **2026**

1. Although the optimal trigger for decompressive craniectomy is unknown, it is reasonable to use a decrease in level of consciousness attributed to brain swelling as selection criteria.	IIa	A
2. In patients ≤60 years of age who deteriorate neurologically within 48 hours from brain swelling associated with unilateral MCA infarctions despite medical therapy, decompressive craniectomy with dural expansion is reasonable.	IIa	A
3. In patients >60 years of age who deteriorate neurologically within 48 hours from brain swelling associated with unilateral MCA infarctions despite medical therapy, decompressive craniectomy with dural expansion may be considered.	IIb	B-R

CA "Surgery should be performed < 48h from stroke onset, ideally **before** clinal deterioration"
"The discussion with the patient and decision-makers should state more clearly that **there is a survival benefit**, but an **uncertain impact on quality of life and disability**. Furthermore that **even with treatment, a good outcome (MRS 0–2) is rare**."

COR	LOE	Recommendations
2a	B-NR	1. In patients with large territorial cerebral infarctions at high risk for developing brain swelling and herniation, decreased level of consciousness attributed to brain swelling is a reasonable trigger for decompressive hemicraniectomy selection.[1]
1	A	2. In patients ≤60 years of age with unilateral MCA infarctions who deteriorate neurologically within 48 hours from brain swelling despite medical therapy, decompressive craniectomy with dural expansion is beneficial to reduce mortality and improve functional outcome.[2–6]
2b	B-R	3. In patients >60 years of age with unilateral MCA infarctions who deteriorate neurologically within 48 hours from brain swelling despite medical therapy, decompressive craniectomy with dural expansion may be considered to reduce mortality.[3,7–9]
2b	B-NR	4. In patients with AIS who received IV tPA thrombolysis and develop malignant cerebral edema despite medical therapy, early decompressive craniectomy within 48 hours may still be considered without additional safety concerns.[10,11]

Powers et al. Stroke 2019, Prabhakaran et al. Stroke 2026
Boulanger et al. Int J Stroke 2018, Heran et al. Can J Neurol Sci 2024

Infarctus cérébelleux – recommandations

COR	LOE	Recommendations
1	C-LD	1. In patients with cerebellar infarction and obstructive hydrocephalus, ventriculostomy is recommended to improve neurological function and decrease mortality. Concomitant or subsequent decompressive craniectomy may or may not be necessary on the basis of factors such as the size of the infarction, neurological condition, degree of brainstem compression, and effectiveness of medical management.[1–3]
1	B-NR	2. In patients with cerebellar infarction causing neurological deterioration from brainstem compression or volumes ≥35 mL, decompressive suboccipital craniectomy with dural expansion should be performed to improve outcomes and decrease mortality.[1–7]

Prabhakaran et al. Stroke 2026

A-B-C en AVC malin & thérapies complémentaires

- Airway
  - Intubation si insuffisance respiratoire ou détérioration neurologique[3]
- Breathing
  - Pas d'hyperventilation prophylactique!
  - Hyperventilation brève, modérée (PaCO2 30-34) «bridge to definitive therapy»[1]
- Circulation
  - Pas de cible spécifique recommandable…[2]
  - PAM > 85, Pasyst < 220 (strong recommendation, low quality evidence)[3]
  - Hypotension inhabituelle, cause secondaire à éliminer
- Thérapies complémentaires – considérer HTIC!
  - Osmothérapie raisonnable si détérioration clinique[1]
  - Hypothermie, barbituriques, cortico non recommandés[1]
  - Monitorage de PIC de routine non-recommandé[3]

1- Powers et al. Stroke 2019 2- Wijdicks et al. Stroke 2014 3- Torbey et al. Neurocrit Care 2015

Hémorragie intracérébrale

AHA/ASA GUIDELINE

2022 Guideline for the Management of Patients With Spontaneous Intracerebral Hemorrhage: A Guideline From the American Heart Association/American Stroke Association

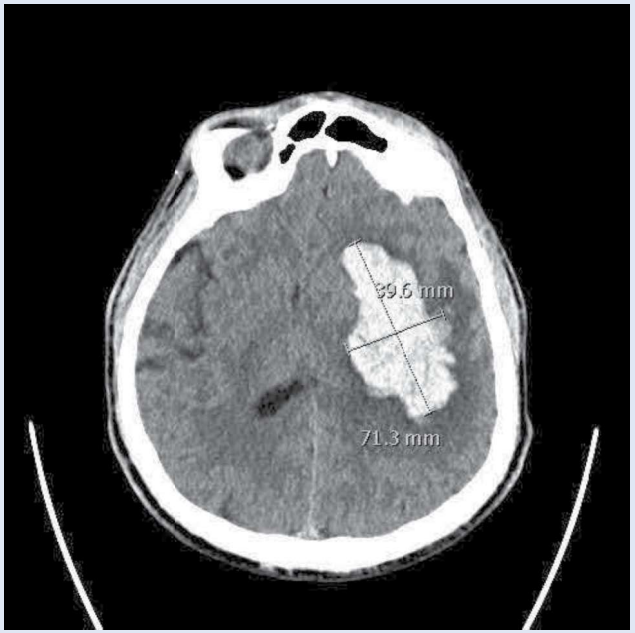
Reviewed for evidence-based integrity and endorsed by the American Asscciation of Neurological Surgeons and Congress of Neurological Surgeons.

Endcrsed by the Society of Vascular and Interventional Neurology

The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists.

Endcrsed by the Neurocritical Care Society

Stroke. 2022;53:e282–e361.



Canadian stroke best practice recommendations: *Management of Spontaneous Intracerebral Hemorrhage*, 7th Edition Update 2020

International Journal of Stroke
2021, Vol. 16(3) 321–341

DOI: 10.1177/1747493020968424
journals.sagepub.com/home/wso
SAGE

Ashkan Shoamanesh (Co-chair)[1,2], M Patrice Lindsay[3], Lana A Castellucci[4,5], Anne Cayley[6], Mark Crowther[7], Kerstin de Wit[8,9], Shane W English[10,11], Sharon Hoosein[12], Thien Huynh[13,14], Michael Kelly[15], Cian J O'Kelly[16], Jeanne Teitelbaum[17,18], Samuel Yip[19], Dar Dowlatshahi[20], Eric E Smith[21], Norine Foley[22], Aleksandra Pikula[6], Anita Mountain[23,24], Gord Gubitz[25] and Laura C Gioia[17,26] (Co-chair), on behalf of the Canadian Stroke Best Practices Advisory Committee in collaboration with the Canadian Stroke Consortium and the Canadian Hemorrhagic Stroke Trials Initiative Network (CoHESIVE)

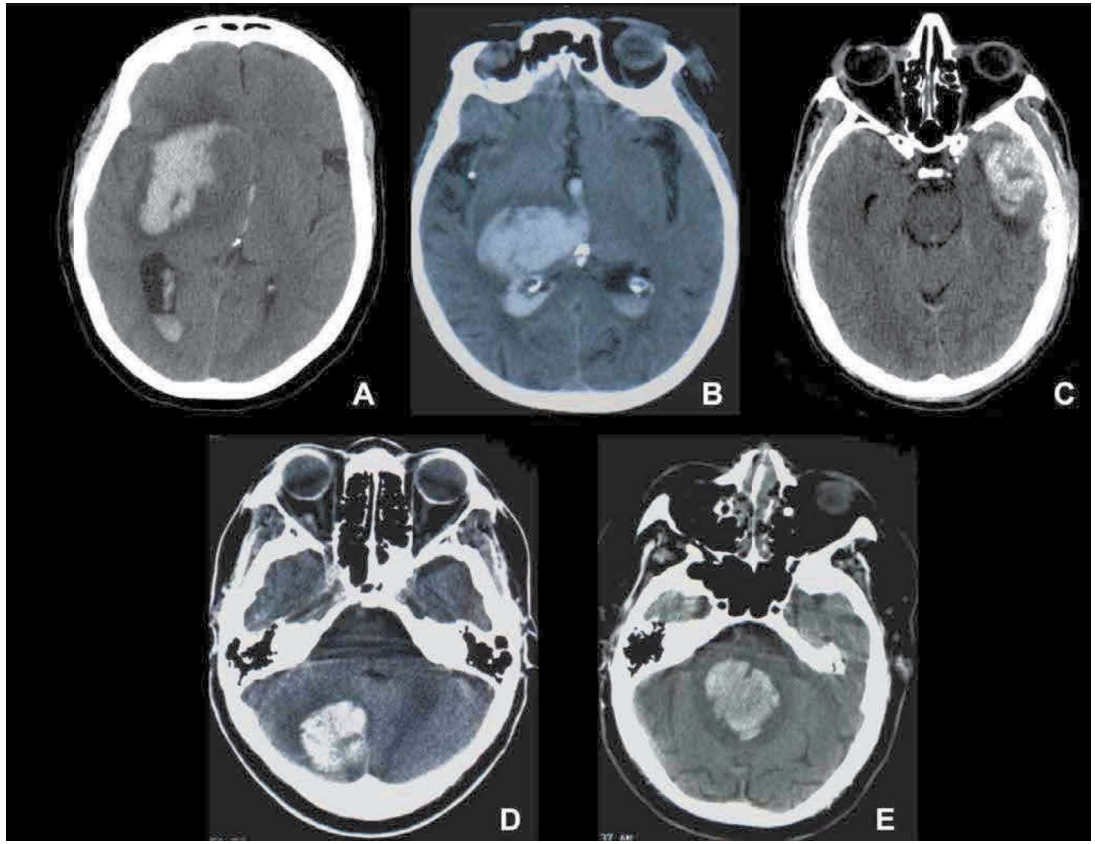
Hémorragie intracérébrale

- Hémorragie intracérébrale "primaire" non-traumatique
  - 2e cause d'accident vasculaire cérébral (10-25% des AVC)
  - Pire morbidité/mortalité
    - Taux de mortalité 40%
    - Évolution neurologique défavorable 60-70%

STITCH	Early surgery (n=503)	Initial conservative treatment (n=530)
Men	285 (57%)	306 (58%)
Age (years)	62 (52–70)	62 (53–71)
Any anticoagulation or thrombolytic treatment contributing to ICH	39 (8%)	55 (10%)
Past medical history*		
Hypertension	341 (69%)	378 (72%)
On antihypertensives	225 (46%)	263 (50%)
Previous myocardial infarction	28 (6%)	44 (8%)
Previous stroke	30 (6%)	43 (8%)
Smoker	146 (30%)	134 (26%)
Other medical disorders	132 (27%)	143 (27%)

- Étiologies multiples
  - Causes primaires (atteinte microvasculaire)
    - Artériosclérose artérioles perforantes (NGC, thalamus, tronc cérébrale, cervelet) – plus fréquente (HTA, Db, âge)
    - Angiopathie amyloïde (hémorragie lobaire) – patients plus âgés (âge > 60 ans, apolipoproteine E allèle ε2 ou ε4)
  - Causes secondaires
    - Malformation vasculaires (anévrysme, MAV, fistule durale)
    - Transformation hémorragique secondaire (AVC ischémique, thrombose veineuse cérébrale – infarctus veineux)
    - Néoplasie (primaire, métastase)
    - Infectieuses (embolie septique, anévrysme mycotique, encéphalite HSV, etc)
    - Coagulopathie (primaire, médicamenteuse, insuffisance hépatique)
    - Hyperperfusion cérébrale
    - Autres: Moyamoya, RCVS, drogues (cocaïne, amphétamines), vasculites

Hémorragie intracérébrale: localisation typique

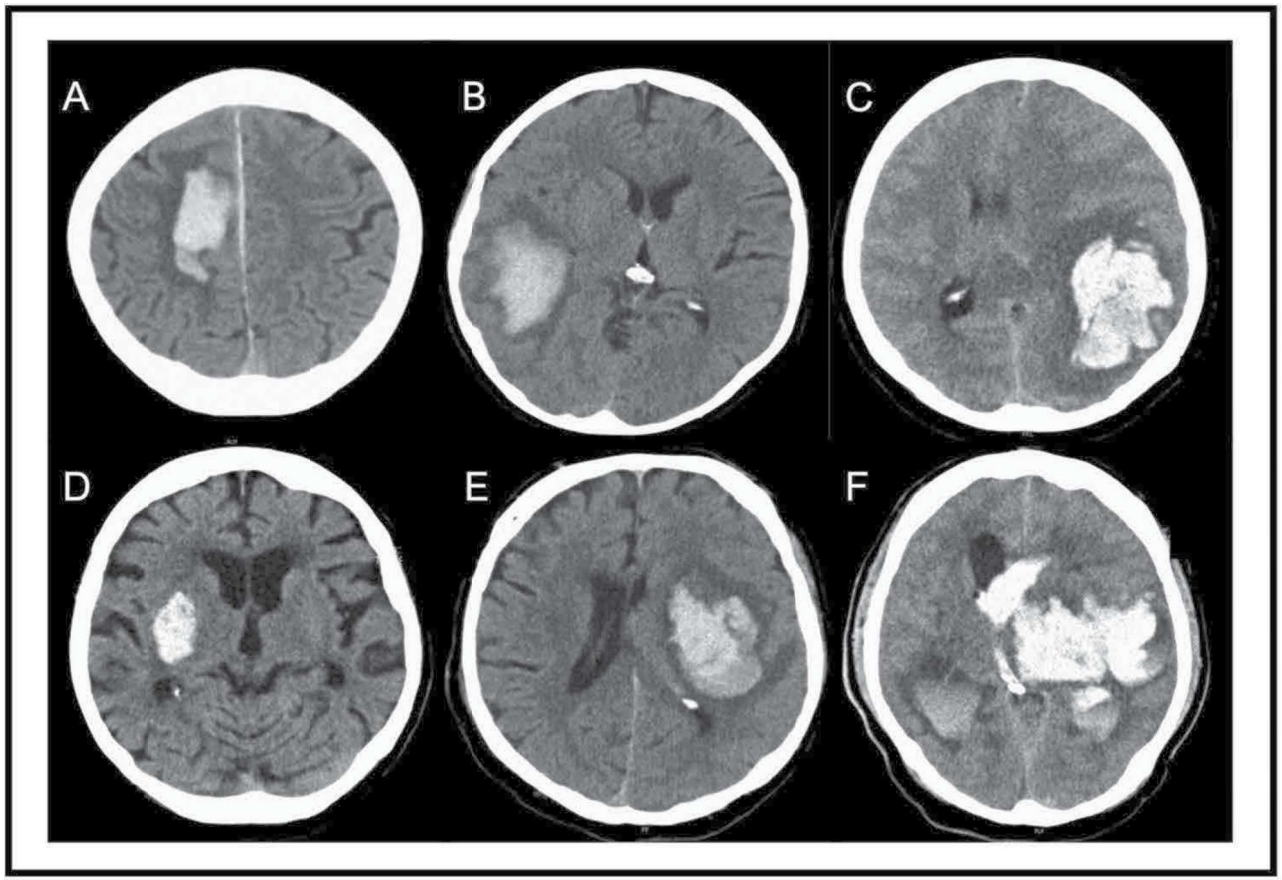


Hemphill et al. Neurocrit Care 2017

Taille d’hématome: 10 vs 30 vs 60 mL

LOBAIRE ➔

PROFOND ➔



Haupenthal et al. Neurol Res Pract 2023

Hémorragie intracérébrale

- Morbidité élevée (< 40% récupèrent indépendance fonctionnelle)
- Mortalité élevée (35% à 1 semaine, 59% à 1 an)

- Conséquences selon **volume**, **localisation** et **comorbidités**
  - Déficit focal ad altération d'état de conscience
  - HTIC – effet de masse régional, ischémie globale, engagement…
  - Déversement intraventriculaire ➔ hydrocéphalie
  - Convulsions (15%)
  - Extracrânien ➔ aspiration, cardiopathie
  - Comorbidités

Caractéristique	Points
GCS	
3-4	2
5-12	1
13-15	0
Âge	
≥ 80 ans	1
< 80 ans	0
Volume	
≥ 30 mL	1
< 30 mL	0
Hémorragie intraventriculaire	
Oui	1
Non	0
Localisation infratentorielle	
Oui	1
Non	0
Total	**0-6**
ICH Score Mortalité à 30 jrs	
0	0-10%
1	7-13%
2	30-44%
3	56-78%
4	70-100%
5-6	100%

Hemphill et al. Stroke 2001
de Oliveira Manoel et al. Crit Care 2016

Dommage cérébral

- Pression directe par l'hématome et **progression d'hématome**
- Effet d'HTIC régionale et globale (PPC, engagement)
- Hydrocéphalie
- Processus physiopathologiques secondaires
  - Neuroinflammation
  - Œdème cérébral
  - Toxicité biochimique produits de dégradation de l'hématome (Hb, Fe, trombine)

🙏 CIBLES THÉRAPEUTIQUES POTENTIELLEMENT NEUROPROTECTRICES 😌

Progression d'hématome = précoce

Progression d'hématome (> 40% ou > 10 mL)
Délai entre début des symptômes et 1er scan

0-3h	27/74	36%
3-6h	7/45	16%
6-12h	5/33	15%
12-24h	2/34	6%
> 24h	0/18	0%
Total	41/204	20%

Kazui et al. Stroke 1996

Progression d'hématome (> 33% ou > 6 mL)
Délai entre début des symptômes et 1er scan

0-3h	27/70	38,6%
3-6h	10/92	10,9%
> 6h	14/129	10,9%
Inconnu	20/100	20%
Total	71/391	18,2%

Brower et al. Neurocrit Care 2012

Répercussions sur

- Soins au patient
- Efficacité d'interventions

Brouwers et al. Neurocrit Care 2012
Kazui et al. Stroke 1996
Brott et al. Stroke 1997

Progression d'hématome = grave

- Progression d'HIC ➔ détérioration, mauvaise évolution, mortalité
  - 70% des patients vont avoir progression d'HIC, 30% progression significative (> 33%)[1]
  - Progression de 10% d'HIC ➔ ↑ 16% probabilité d'augmenter mRS de 1[1]
  - Progression de 1 mL d'HIC ➔ ↑ 5% probabilité d'évoluer vers mRS 3-5[2]
  - 25% nécessiteront intervention chirurgicale suite à progression HIC[3]

- Facteurs de risque
  - Délai début sx ➔ 1er CT (typiquement dans les 1ers 24hrs)
  - Spot sign, spot sign score et autres signes à l'imagerie
  - Volume initial de l'HIC
  - Warfarine

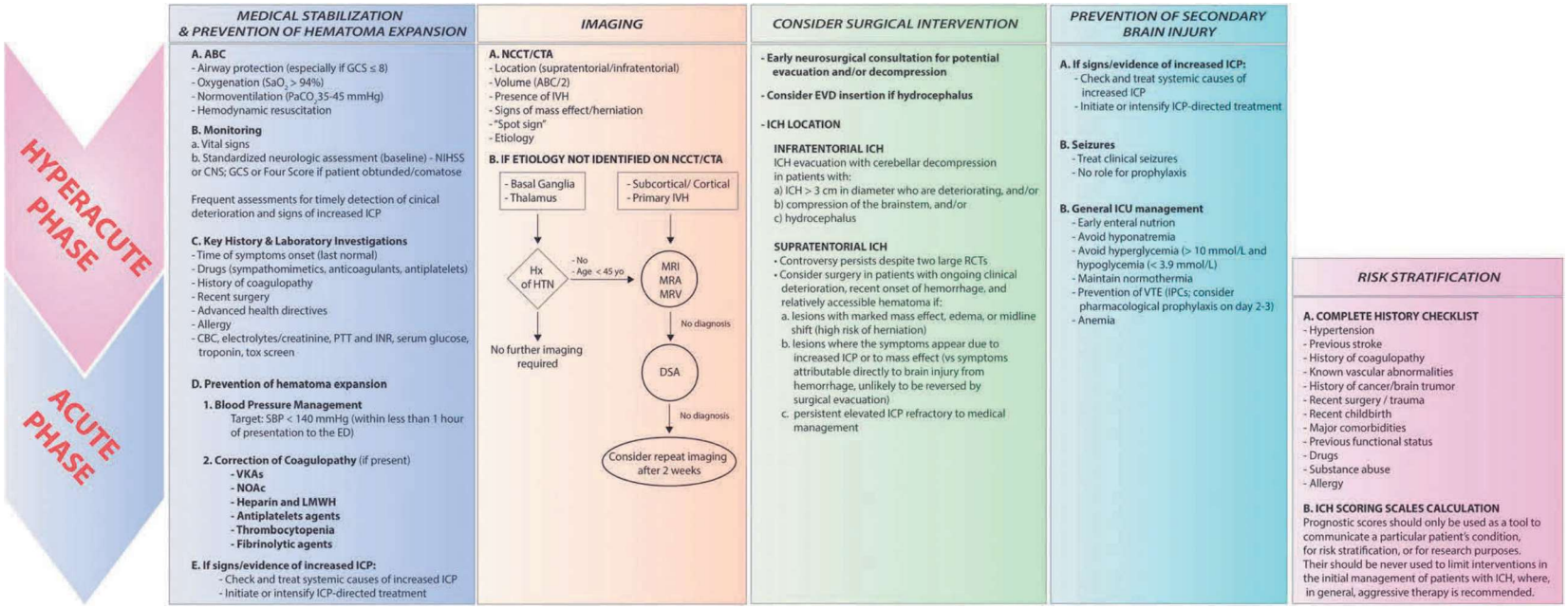
- Imagerie sériée? (p.ex. 6-24-48h après scan initial)
  - Identifier risque de progression d'hématome et triage, pronostic?

- Évaluation neurologique sériée

1- Davis et al. Neurology 2006
2- Delcourt et al. INTERACT1 Neurology 2012
3- Maas et al. Neurology 2013
4- Mayer et al. FAST NEJM 2008
5- Gioia et al. Curr Opin Crit Care 2015
6- Greenberg et al. Stroke 2022

Interventions thérapeutiques

- Traitements de support – ABC
- Identifier et prévenir progression d'hématome: ↓ PA, renverser coagulopathie
- Interventions neurochirurgicales
- Prévenir dommage secondaire par HTIC, convulsions, insultes secondaires...



de Oliveira Manoel et al. Crit Care 2016

Conclusion sur la réduction de PA en HIC

	INTERACT2 (NEJM 2013)	ATACH-2 (NEJM 2016)
Patients	**2839**	**1000** (/1280 - futilité)
PAs initiale	**179 mmHg**	**200 mmHg**
Délai HIC-traitement	**HIC-antiHTA ~ 4-4.5h**	**HIC-antiHTA ~ 2.5-2.75h**
Traitement	PAsyst < 180 mmHg PAsyst < 140 mmHg Délai ≤ 1 heure **Durée 7 jours** **Urapidil…**	PAsyst 140-170 mmHg Pasyst 110-139 mmHg Délai ≤ 2 heure **Durée 24 heures** **Nicardipine**
Taille HIC	**11 mL**	**10 mL**
Échec tx	**66% à 1h**	**12% à 2h**
Bénéfice mRS	**OUI**	**NON**
↓ progression	**POST-HOC**	**TENDANCE**
Effet adverse	**NON**	**OUI**

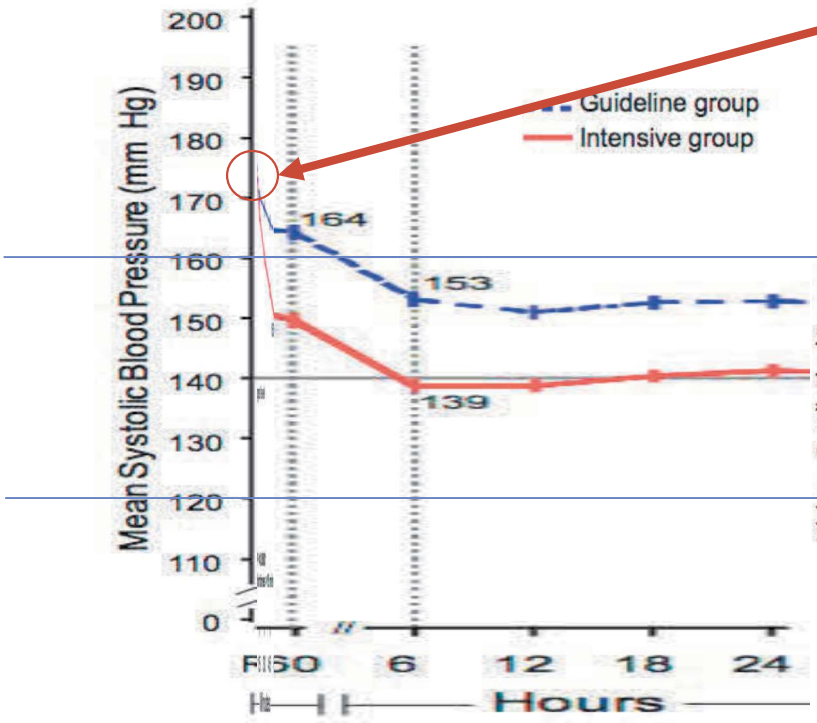
- Signaux divergents?
  - Trop vite
  - Trop intense
  - Trop bref
- Réduction ad 140 mmHg semble néanmoins sécuritaire
- Validité externe pour population SI questionnable
  - Taille d'hématome
  - Présence d'HTIC?
  - Intervention neurochirurgicale?

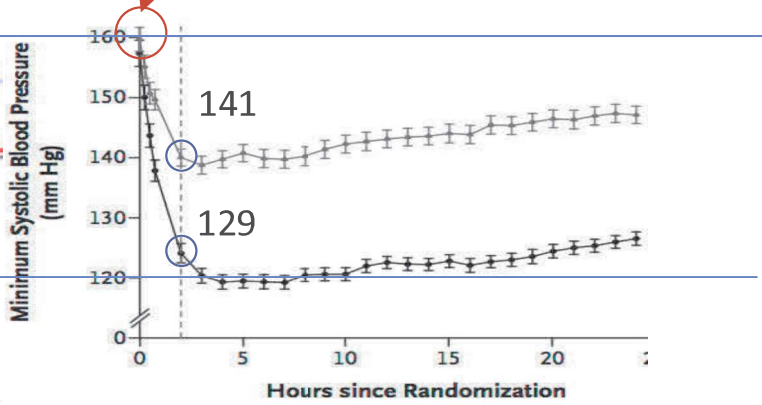
INTERACT2 vs ATACH-2

Anti-HTA pré-randomisation

INTERACT2 ➔ critère inclusion = PAsyst ≤ 220 mmHg

ATACH-2 ➔ tx IV permis pré-rando pour PAsyst < 180
(TAsyst moyenne à l'urgence ~ 200 mmHg)





Early lowering of blood pressure after acute intracerebral haemorrhage: a systematic review and meta-analysis of individual patient data

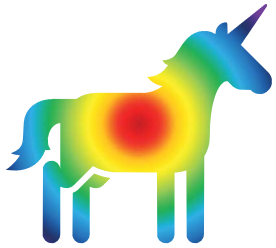
Moullaali TJ, *et al*. *J Neurol Neurosurg Psychiatry* 2022

Table 2 Effect of active/intensive versus placebo/guideline blood pressure lowering interventions on outcomes after acute intracerebral haemorrhage (ICH)

	Randomly allocated treatment group			
Outcome	**Active/intensive**	**Placebo/guideline**	**Adjusted OR* (95% CI)**	**P value**
Primary: unfavourable shift in modified Rankin Scale (mRS) scores	/3062	/3039	0.97 (0.88 to 1.06)	0.50
Secondary	/3062	/3039		
Dependency or death (mRS 3–6)	1735 (56.7)	1742 (57.3)	0.95 (0.84 to 1.08)	0.42
Severe dependency or death (mRS 4–6)	1214 (39.7)	1228 (40.4)	0.95 (0.84 to 1.08)	0.41
Death	411/3111 (13.2)	405/3087 (13.1)	1.01 (0.85 to 1.20)	0.91
Haematoma growth at 24 hours‡				
Mean growth (95% CI), mL	3.2 (2.5 to 3.9)	4.3 (3.4 to 5.2)	Absolute difference: –1.10 (–2.22 to 0.01)	0.05
Absolute growth ≥6 mL	212/1280 (16.6)	252/1230 (20.5)	0.75 (0.60 to 0.92)§	0.007
Relative growth ≥33%	296/1280 (23.1)	326/1230 (26.5)	0.82 (0.68 to 0.99)§	0.03

Lignes directrices: réduction PA

COR	LOE	Recommendation
2a	B-NR	1. In patients with spontaneous ICH requiring acute BP lowering, careful titration to ensure continuous smooth and sustained control of BP, avoiding peaks and large variability in SBP, can be beneficial for improving functional outcomes.[138]
2a	C-LD	2. In patients with spontaneous ICH in whom acute BP lowering is considered, initiating treatment within 2 hours of ICH onset and reaching target within 1 hour can be beneficial to reduce the risk of HE and improve functional outcome.[139,140]
2b	B-R	3. In patients with spontaneous ICH of mild to moderate severity presenting with SBP between 150 and 220 mm Hg, acute lowering of SBP to a target of 140 mm Hg with the goal of maintaining in the range of 130 to 150 mm Hg is safe and may be reasonable for improving functional outcomes.[139,141–147]
2b	C-LD	4. In patients with spontaneous ICH presenting with large or severe ICH or those requiring surgical decompression, the safety and efficacy of intensive BP lowering are not well established.[148]
3: Harm	B-R	5. In patients with spontaneous ICH of mild to moderate severity presenting with SBP >150 mm Hg, acute lowering of SBP to <130 mm Hg is potentially harmful.[146,149,150]



Greenberg et al. Stroke 2022

Réduction PA en HIC modérée-sévère

Characteristics	Moderate to severe grade (n = 682)
Age, mean (SD)	61.9 (13.1)
Male	426 (62.5%)
Race	
American Indian or Alaska Native	1 (0.1%)
Asian	382 (56.0%)
African American	86 (12.6%)
White	199 (29.2%)
Others or unknown	14 (2.1%)
Ethnicity	
Hispanic ethnic group	53 (7.8%)
Non-Hispanic ethnic group	610 (89.4%)
Unknown/not reported	19 (2.8%)
Baseline GCS score, mean (SD)	13.2 (2.3)
3–11	147 (21.6%)
12–14	247 (36.2%)
15	288 (42.2%)
Baseline NIHSS score, median (SD)	14.6 (6.2)
SBP mm Hg, mean (SD)[a]	174.7 (24.8)
Intracerebral hematoma volume mL, mean (SD)	17.2 (12.8)
Location of hemorrhage	
Basal ganglia	397/681 (58.3%)
Thalamus	217/681 (31.9%)
Cerebral lobe	67/681 (9.8%)

Qureshi et al. Cerebrovasc Dis 2020 (post-hoc ATACH-2)
Greenberg et al. Stroke 2022

2b	C-LD	4. In patients with spontaneous ICH presenting with large or severe ICH or those requiring surgical decompression, the safety and efficacy of intensive BP lowering are not well established.[148]

- Réduction PA intensive en HIC modérée-sévère
- Définition HIC modérée-sévère (1 critère)
  - GCS < 13
  - NIHSS ≥ 10
  - HIC ≥ 30 mL
  - Présence d'HIV*
- Issue principale = mRS 4-6 à 3 mois

UN PEU PLUS REPRÉSENTATIF DE NOS PATIENTS?

Nouvelles recommandations

Évolution moins favorable en général

2b	C-LD	4. In patients with spontaneous ICH presenting with large or severe ICH or those requiring surgical decompression, the safety and efficacy of intensive BP lowering are not well established.[148]

Table 2. Primary, secondary, and safety outcomes according to ICH severity[a]

Outcome	Moderate to severe (n = 682)	Mild (n = 318)	Relative risk or beta estimate (95% CI)	p value
Primary outcome: death or disability[b]	333/657 (50.7%)	34/304 (11.2%)	4.5 (3.3–6.3)	<0.0001
Hematoma expansion	160/662 (24.2%)	61/314 (19.4%)	1.2 (1.0–1.6)	0.1
Neurologic deterioration within 24 h	79 (11.6%)	16 (5.0%)	2.3 (1.4–3.9)	0.001
Treatment-related serious adverse event within 72 h[c]	10 (1.5%)	4 (1.3%)	1.2 (0.4–3.7)	1
Any serious adverse event within 3 mo	191 (28.0%)	36 (11.3%)	2.5 (1.8–3.4)	<0.0001
Hypotension within 72 h	9 (1.3%)	0 (0%)	–	–
EQ-5D utility index score, median (range)[d, e]	0.7 (−0.1 to 1)	0.8 (0.1–1)	0.4477 (0.39–0.52)	<0.0001
EQ-5D visual-analog scale score, median (range)[d, f]	65 (0–100)	70 (8–100)	0.9942 (0.99–0.99)	<0.0001

Qureshi et al. Cerebrovasc Dis 2020 (post-hoc ATACH-2)
Greenberg et al. Stroke 2022

Nouvelles recommandations

Effet du traitement intensif…

- **Évolution neuro défavorable idem**
- **↓ progression d'HIC**
- **↑ détérioration neuro précoce?**

2b	C-LD	4. In patients with spontaneous ICH presenting with large or severe ICH or those requiring surgical decompression, the safety and efficacy of intensive BP lowering are not well established.[148]

Table 3. Primary, secondary, and safety outcomes of the participants (moderate-to-severe ICH group) according to treatment group[a]

Outcome	Intensive SBP reduction (n = 336)	Standard SBP reduction (n = 346)	Relative risk or beta estimate (95% CI)	p value	Adjusted odds ratio[g] (95% CI)	p value after adjusted
Primary outcome: death or disability[b]	170/324 (52.5%)	163/333 (48.9%)	1.1 (0.9–1.2)	0.37	1.1 (0.8–1.5)	0.64
Hematoma expansion	67/329 (20.4%)	93/333 (27.9%)	0.7 (0.55–0.96)	0.02	0.6 (0.4–0.9)	0.02
Neurologic deterioration within 24 h	46 (13.7%)	33 (9.5%)	1.4 (0.9–2.2)	0.09	1.6 (0.9–2.6)	0.08
Treatment-related serious adverse event within 72 h[c]	6 (1.8%)	4 (1.2%)	1.5 (0.4–5.4)	0.54	1.4 (0.4–5.4)	0.63
Any serious adverse event within 3 mo	110 (32.7%)	81 (23.4%)	1.4 (1.1–1.8)	0.01	1.7 (1.2–2.5)	0.003
Hypotension within 72 h	6 (1.8%)	3 (0.9%)	2.1 (0.5–8.2)	0.33	3.0 (0.6–14.8)	0.19
EQ-5D utility index score, median (range)[d,e]	0.7 (−0.1-1)	0.7 (−0.04-1)	1.09 (0.99–1.21)	0.08	–	–
EQ-5D visual-analog scale score, median (range)[d,f]	60 (5–100)	70 (0–100)	1.0006 (0.9992–1.0021)	0.4	–	–

Qureshi et al. Cerebrovasc Dis 2020 (post-hoc ATACH-2)
Greenberg et al. Stroke 2022

Intracranial Pressure and Cerebral Perfusion Pressure in Large Spontaneous Intracranial Hemorrhage and Impact of Minimally Invasive Surgery

- Étude post-hoc exploratoire
  - Cohorte MISTIE III – 72 pts, lectures PIC/PPC ad 6 jrs
  - HIC moyen 44 mL
- HTIC ≥ 20 fréquente (> 40% pts)
- PPC < 70 fréquente (> 70% pts)
- Proportion PPC < 70 et 60 associée à mortalité à court terme
- Proportion PIC ≥ 20, ≥ 30 et PPC < 70 associée mortalité à long terme

Ziai et al. Crit Care Med 2019

Incertitudes…

- HIC avec HTA extrême (TAsyst > 220 mmHg)
- HIC sévères (>20-30 mL? HIV important? Décompression?)
- HIC lobaire (peu représentés dans INTRACT2 et ATACH-2)
- Agents de choix
- Réduction de PAsyst tardive (> 4-6h)
- Modalité de mesure de PA (PNI vs invasive)
  - Variabilité avec canule artérielle…
- Seuils thérapeutiques (PIC/PPC) en HTIC

CONSIDÉRATIONS SURREPRÉSENTÉES AUX SOINS INTENSIFS

Renverser la coagulopathie

AHA/ASA GUIDELINE

2022 Guideline for the Management of Patients With Spontaneous Intracerebral Hemorrhage: A Guideline From the American Heart Association/American Stroke Association

Reviewed for evidence-based integrity and endorsed by the American Association of Neurological Surgeons and Congress of Neurological Surgeons.

Endorsed by the Society of Vascular and Interventional Neurology

The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists.

Endorsed by the Neurocritical Care Society

Stroke. 2022;53:e282–e361.

Canadian stroke best practice recommendations: *Management of Spontaneous Intracerebral Hemorrhage*, 7th Edition Update 2020

International Journal of Stroke
2021, Vol. 16(3) 321–341

DOI: 10.1177/1747493020968424
journals.sagepub.com/home/wso
SAGE

Ashkan Shoamanesh (Co-chair)[1,2], M Patrice Lindsay[3], Lana A Castellucci[4,5], Anne Cayley[6], Mark Crowther[7], Kerstin de Wit[8,9], Shane W English[10,11], Sharon Hoosein[12], Thien Huynh[13,14], Michael Kelly[15], Cian J O'Kelly[16], Jeanne Teitelbaum[17,18], Samuel Yip[19], Dar Dowlatshahi[20], Eric E Smith[21], Norine Foley[22], Aleksandra Pikula[6], Anita Mountain[23,24], Gord Gubitz[25] and Laura C Gioia[17,26] (Co-chair), on behalf of the Canadian Stroke Best Practices Advisory Committee in collaboration with the Canadian Stroke Consortium and the Canadian Hemorrhagic Stroke Trials Initiative Network (CoHESIVE)

Guideline for Reversal of Antithrombotics in Intracranial Hemorrhage: Executive Summary. A Statement for Healthcare Professionals From the Neurocritical Care Society and the Society of Critical Care Medicine

Jennifer A. Frontera, MD, FNCS[1]; John J. Lewin III, PharmD, MBA, FASHP, FCCM, FNCS[2]; Alejandro A. Rabinstein, MD, FNCS[3]; Imo P. Aisiku, MD, MBA, FCCP[4]; Anne W. Alexandrov, PhD, RN, ANVP-BC, FAAN[5,6]; Aaron M. Cook, PharmD, BCPS[7]; Gregory J. del Zoppo, MD, MS[8]; Monisha Kumar, MD[9]; Ellinor I. B. Peerschke, PhD, FAHA[10]; Michael F. Stiefel, MD, PhD[11]; Jeanne S. Teitelbaum, MD[12,13]; Katja E. Wartenberg, MD[14]; Cindy L. Zerfoss, MSN, RN, ACNP-BC[15]

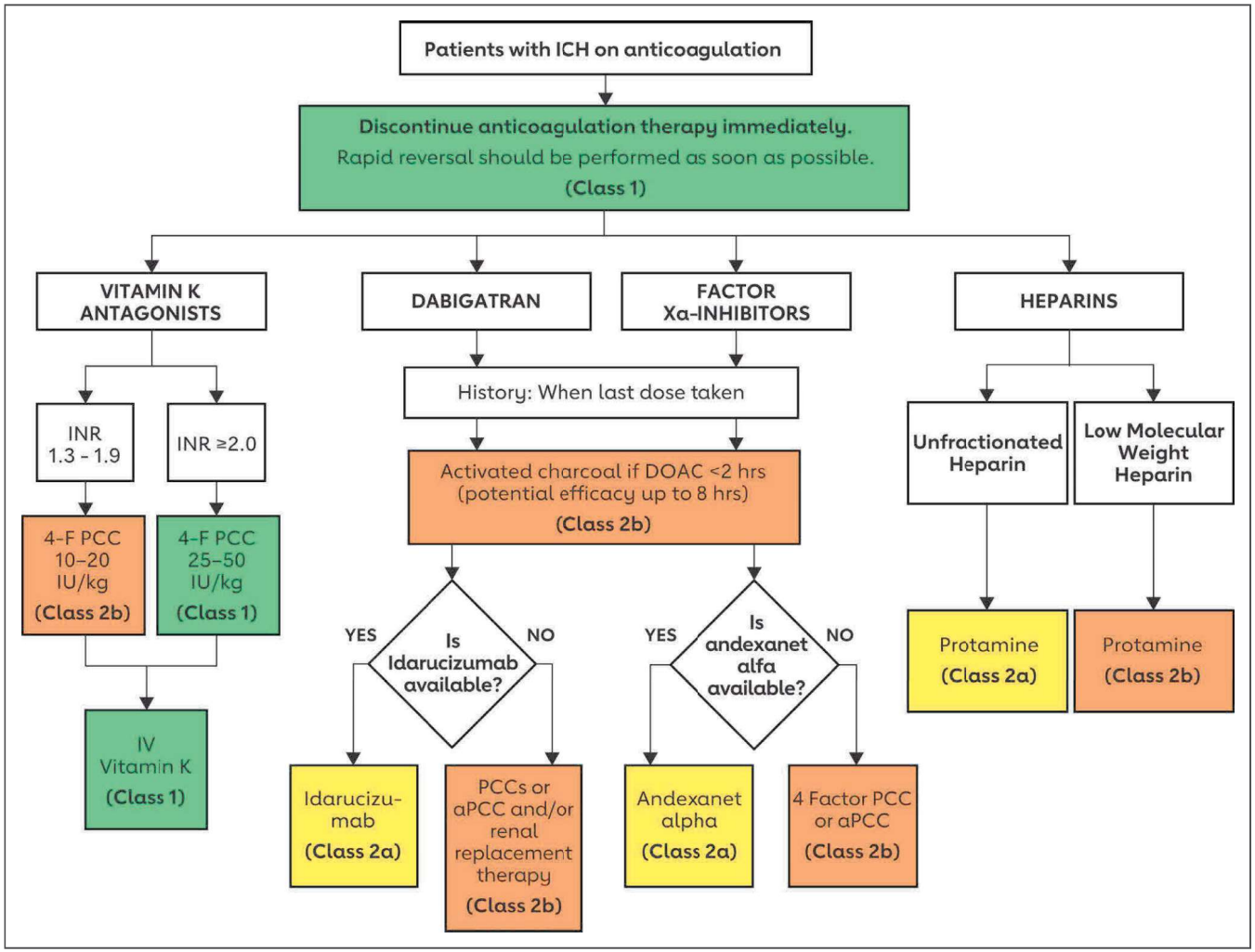
(*Crit Care Med* 2016; 44:2251–2257)

Lignes directrices: renverser coagulopathie

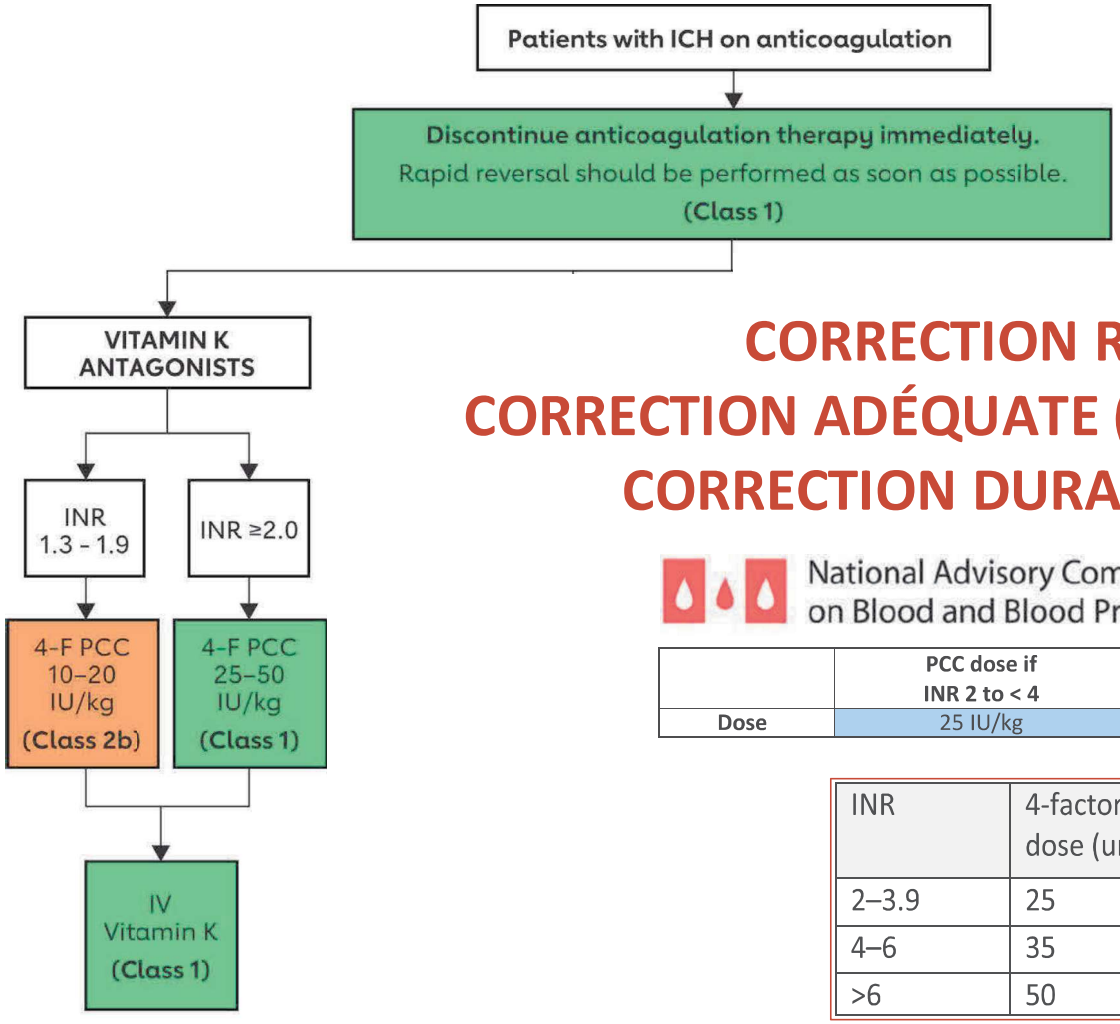
- HIC sous anticoagulants ou antithrombotiques
  - ↑ progression d'hématome
  - ↑ mortalité et de morbidité
- Ne pas attendre labo…
  - Délai depuis dernière dose
  - PK de l'agent
  - Fonction rénale

COR	LOE	Recommendations
1	C-LD	1. In patients with anticoagulant-associated spontaneous ICH, anticoagulation should be discontinued immediately and rapid reversal of anticoagulation should be performed as soon as possible after diagnosis of spontaneous ICH to improve survival.[162]
VKAs		
1	B-R	2. In patients with VKA-associated spontaneous ICH and INR ≥2.0, 4-factor (4-F) prothrombin complex concentrate (PCC) is recommended in preference to fresh-frozen plasma (FFP) to achieve rapid correction of INR and limit HE.[163] INCH Lancet Neurol 2016
1	C-LD	3. In patients with VKA-associated spontaneous ICH, intravenous vitamin K should be administered directly after coagulation factor replacement (PCC or other) to prevent later increase in INR and subsequent HE.[164,165]
2b	C-LD	4. In patients with VKA-associated spontaneous ICH with INR of 1.3 to 1.9, it may be reasonable to use PCC to achieve rapid correction of INR and limit HE.[162,164]
DOACs		
2a	B-NR	5. In patients with direct factor Xa inhibitor–associated spontaneous ICH, andexanet alfa is reasonable to reverse the anticoagulant effect of factor Xa inhibitors.[166,167]
2a	B-NR	6. In patients with dabigatran-associated spontaneous ICH, idarucizumab is reasonable to reverse the anticoagulant effect of dabigatran.[168]
2b	B-NR	7. In patients with direct factor Xa inhibitor–associated spontaneous ICH, a 4-F PCC or activated PCC (aPCC) may be considered to improve hemostasis.[169–171]
2b	C-LD	8. In patients with dabigatran- or factor Xa inhibitor–associated spontaneous ICH, when the DOAC agent was taken within the previous few hours, activated charcoal may be reasonable to prevent absorption of the DOAC.[172–174]
2b	C-LD	9. In patients with dabigatran-associated spontaneous ICH, when idarucizumab is not available, aPCC or PCCs may be considered to improve hemostasis.[175,176]
2b	C-LD	10. In patients with dabigatran-associated spontaneous ICH, when idarucizumab is not available, renal replacement therapy (RRT) may be considered to reduce dabigatran concentration.[177]
Heparins		
2a	C-LD	11. In patients with unfractionated heparin (UFH)–associated spontaneous ICH, intravenous protamine is reasonable to reverse the anticoagulant effect of heparin.[178]
2b	C-LD	12. In patients with low-molecular-weight heparin (LMWH)–associated spontaneous ICH, intravenous protamine may be considered to partially reverse the anticoagulant effect of heparin.[178]

Greenberg et al. Stroke 2022



Greenberg et al. Stroke 2022



Brophy et al. Neurocrit Care 2017
Frontera et al. Crit Care Med 2016
Greenberg et al. Stroke 2022

CORRECTION RAPIDE (ASAP < 4h)
CORRECTION ADÉQUATE (PCC >>> PFC, INR < 1.3, dose)
CORRECTION DURABLE (VITAMINE K q24h)

National Advisory Committee on Blood and Blood Products | Comité consultatif national sur le sang et les produits sanguins

	PCC dose if INR 2 to < 4	PCC dose if INR 4 to 6	PCC dose if INR > 6
Dose	25 IU/kg	35 IU/kg	50 IU/kg

INR	4-factor PCC dose (units/kg)	Max dose (units)
2–3.9	25	2500
4–6	35	3500
>6	50	5000

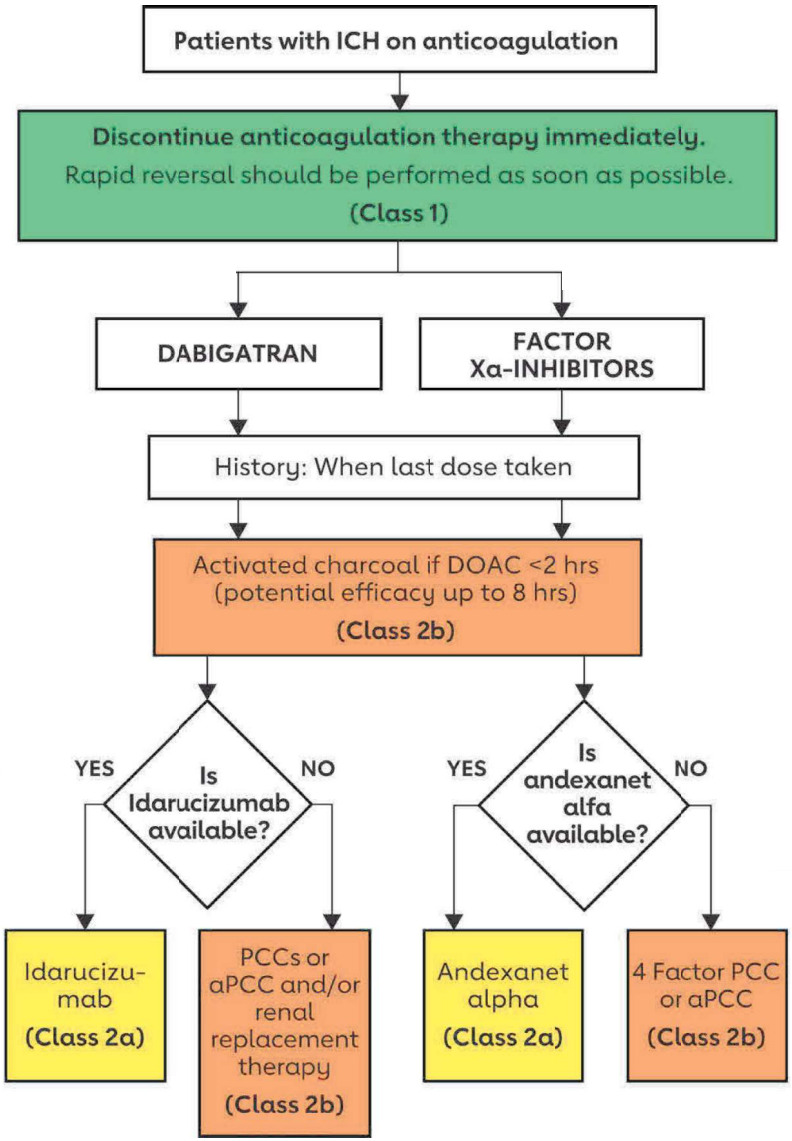
PFC MIEUX QUE RIEN (15 mL/kg)

Anticoagulants oraux (DOAC, NACO, etc)

Table 2 Pharmacokinetic parameters for selected anticoagulants and antiplatelet agents [161, 423]

Medication	Mechanism of action	Elimination	Half-life	Impairment affects excretion		Dialyzable
				Renal	Hepatic	
Direct factor Xa inhibitors						
Rivaroxaban	Prevents factor Xa-mediated conversion of prothrombin to thrombin	66 % renal; 28 % fecal	5 h	Yes	Yes	No
Apixaban	Prevents factor Xa-mediated conversion of prothrombin to thrombin	majority fecal; 27 % renal	12 h	Yes	Yes	Minimal, area under the curve decreased by 14 % over 4 h
Edoxaban	Prevents factor Xa-mediated conversion of prothrombin to thrombin	50 % renal	10–14 h	Yes	Yes	No
Direct thrombin inhibitors						
Dabigatran	Competitive direct inhibition of thrombin (factor IIa) including thrombin-mediated platelet activation and aggregation	>80 % renal	12–17 h 16.6 h in mild, 18.7 h in moderate, 27.5 h in severe renal failure, 34.1 h in patients on hemodialysis	Yes	No	Yes ~57 % over 4 h

Brophy et al. Neurocrit Care 2017



- Interrompre l'agent!
- Connaître PK de l'agent et dernière dose
- CBA 50 g STAT si ingestion < 2-8h
- Xaban : apixaban, rivaroxaban, edoxaban
  - Andexanet alpha ???
  - PCC 25-50 UI/kg (ad 3000 UI)
  - aPCC 20-50 UI/kg (ad 2000 UI)
- Dabigatran
  - Idarucizumab 5g IV en 10 mim
  - PCC 50 UI/kg (ad 3000 UI)
  - aPCC 50 UI/kg (ad 2000 UI)

Brophy et al. Neurocrit Care 2017
Frontera et al. Crit Care Med 2016
Greenberg et al. Stroke 2022

ANNEXA-I

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 MAY 16/23, 2024 VOL. 390 NO. 19

Andexanet for Factor Xa Inhibitor–Associated Acute Intracerebral Hemorrhage

S.J. Connolly, M. Sharma, A.T. Cohen, A.M. Demchuk, A. Członkowska, A.G. Lindgren, C.A. Molina, D. Bereczki, D. Toni, D.J. Seiffge, D. Tanne, E.C. Sandset, G. Tsivgoulis, H. Christensen, J. Beyer-Westendorf, J.M. Coutinho, M. Crowther, P. Verhamme, P. Amarenco, R.O. Roine, R. Mikulik, R. Lemmens, R. Veltkamp, S. Middeldorp, T.G. Robinson, T.J. Milling, Jr., V. Tedim-Cruz, W. Lang, A. Himmelmann, P. Ladenvall, M. Knutsson, E. Ekholm, A. Law, A. Taylor, T. Karyakina, L. Xu, K. Tsiplova, S. Poli, B. Kallmünzer, C. Gumbinger, and A. Shoamanesh, for the ANNEXA-I Investigators*

- RCT multicentrique internationale (23 pays) ➔ 550/900 pts
- HIC* (0,5-60 mL*, NIHSS < 36*), début sx < 6h* + Xaban ≤ 15h*
  - HIC multicausale, HIV, HSA, HSD
- Andexanet alpha (faible dose ou haute dose) vs tx standard
- Exclus: GCS < 7, **chx prévue dans < 12h**, thrombose < 2 sem
- Traitement administré relativement rapidement
  - Délai exact stroke-traitement? Médiane probablement ≥ 4h
  - Grande majorité ont reçu des PCC (3&4 facteurs 96%, FEIBA 4%)
- (interrompue pour efficacité)

*plusieurs modifications suite à amendements

Table 1. Baseline Characteristics of the Patients.*

Characteristic	Andexanet (N = 224)	Usual Care (N = 228)
Age — yr	78.9±8.5	78.9±8.5
Female sex — no. (%)	94 (42.0)	113 (49.6)
Body-mass index†	26.9±5.3	26.3±4.6
Medical history — no. (%)		
Myocardial infarction	24 (10.7)	33 (14.5)
Stroke	48 (21.4)	48 (21.1)
Deep-vein thrombosis	18 (8.0)	22 (9.6)
Pulmonary embolism	16 (7.1)	21 (9.2)
Atrial fibrillation	202 (90.2)	192 (84.2)
Congestive heart failure	34 (15.2)	44 (19.3)
Diabetes	82 (36.6)	59 (25.9)
Creatinine clearance <30 ml/min — no. (%)	10 (4.5)	9 (3.9)
Factor Xa inhibitor used — no. (%)		
Apixaban	140 (62.5)	135 (59.2)
Rivaroxaban	64 (28.6)	65 (28.5)
Edoxaban	20 (8.9)	25 (11.0)
Hemorrhage location — no. (%)		
Intracerebral	198 (88.4)	214 (93.9)
Intraventricular	3 (1.3)	1 (0.4)
Subarachnoid	9 (4.0)	8 (3.5)
Subdural	13 (5.8)	4 (1.8)
Hemorrhage preceded by trauma — no. (%)	26 (11.6)	33 (14.5)
Systolic blood pressure in patients with intracerebral hemorrhage — mm Hg	161.2±27.0	159.8±27.7
Median hematoma volume (IQR) — ml	10.5 (4.1–24.9)	9.0 (3.1–22.8)
Median Glasgow Coma Scale score (IQR)‡	15.0 (13.0–15.0)	15.0 (13.0–15.0)
Median NIHSS score (IQR)§	9.0 (5.0–16.0)	9.0 (4.0–14.0)
Median time from symptom onset to baseline scan (IQR) — hr	2.3 (1.5–4.0)	2.4 (1.4–3.8)
Median time from baseline scan to randomization (IQR) — hr	1.1 (0.7–1.5)	1.2 (0.7–1.7)
Median time from hospital presentation to receipt of treatment (IQR) — hr¶	2.1 (1.5–2.9)	2.3 (1.7–3.1)
Patients receiving high-dose andexanet — no. (%)	45 (20.1)	—
Patients receiving low-dose andexanet — no. (%)	175 (78.1)	—
Patients receiving PCC within 3 hr — no. (%)	—	195 (85.5)

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 MAY 16/23, 2024 VOL. 390 NO. 19

Andexanet for Factor Xa Inhibitor–Associated Acute Intracerebral Hemorrhage

S.J. Connolly, M. Sharma, A.T. Cohen, A.M. Demchuk, A. Członkowska, A.G. Lindgren, C.A. Molina, D. Bereczki, D. Toni, D.J. Seiffge, D. Tanne, E.C. Sandset, G. Tsivgoulis, H. Christensen, J. Beyer-Westendorf, J.M. Coutinho, M. Crowther, P. Verhamme, P. Amarenco, R.O. Roine, R. Mikulik, R. Lemmens, R. Veltkamp, S. Middeldorp, T.G. Robinson, T.J. Milling, Jr., V. Tedim-Cruz, W. Lang, A. Himmelmann, P. Ladenvall, M. Knutsson, E. Ekholm, A. Law, A. Taylor, T. Karyakina, L. Xu, K. Tsiplova, S. Poli, B. Kallmünzer, C. Gumbinger, and A. Shoamanesh, for the ANNEXA-I Investigators*

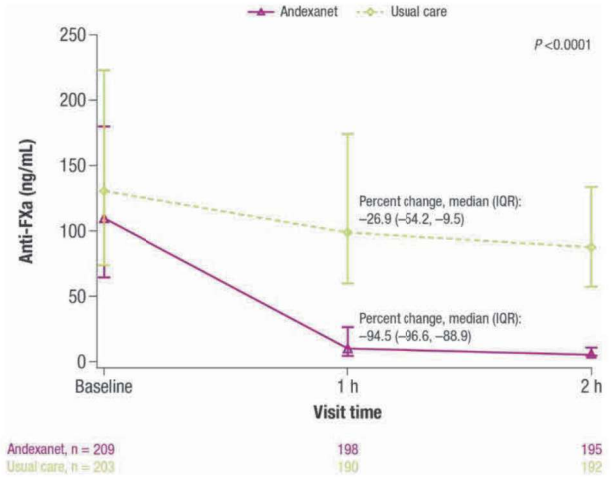
ANNEXA-I

- Effet hémostatique démontré…
  - Radiologiquement ↓ progression HIC
  - Biochimiquement ↓ activité anti-Xa
  - **Cliniquement ↑ évènements thrombotiques (2o AA vs retrait Xaban)**

Table 2. Efficacy End Points.

End Point	Andexanet (N=224)	Usual Care (N=228)	Adjusted Difference per 100 Patients (95% CI)*	P Value*
	no./total no. (%)		*percentage points*	
Hemostatic efficacy	150/224 (67.0)	121/228 (53.1)	13.4 (4.6 to 22.2)	0.003
→ Hematoma volume change ≤35%†	165/215 (76.7)	137/212 (64.6)	12.1 (3.6 to 20.5)	
NIHSS score change <7 points	188/214 (87.9)	181/218 (83.0)	4.6 (–2.0 to 11.2)	
No receipt of rescue therapy between 3 hr and 12 hr	218/224 (97.3)	213/228 (93.4)	3.8 (–7.6 to 0.0)	
Hematoma volume increase ≥12.5 ml‡	24/216 (11.1)	36/214 (16.8)	–5.6 (–12.0 to 0.8)	
Hemostatic efficacy, excluding patients nonevaluable for administrative reasons	150/218 (68.8)	121/225 (53.8)	14.5 (5.7 to 23.4)	

Figure S1. Reduction in Median Anti-FXa Activity From Baseline to Nadir at 2 Hours



The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 MAY 16/23, 2024 VOL. 390 NO. 19

Andexanet for Factor Xa Inhibitor–Associated Acute Intracerebral Hemorrhage

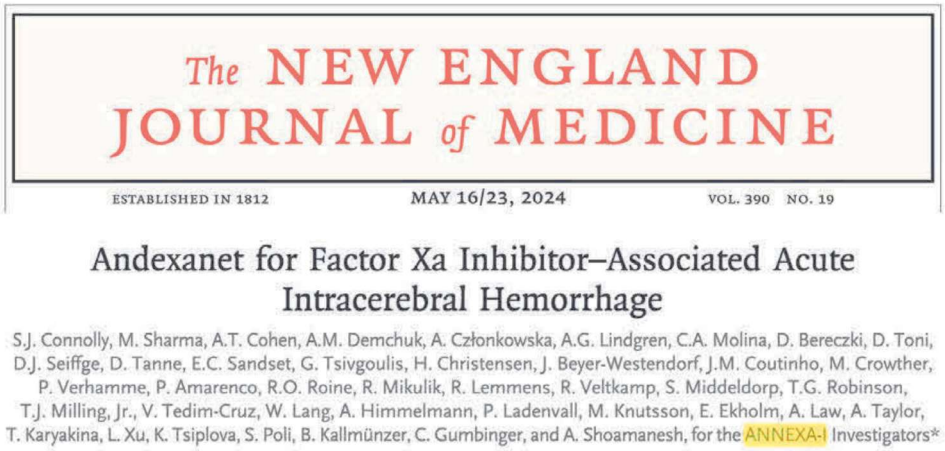
S.J. Connolly, M. Sharma, A.T. Cohen, A.M. Demchuk, A. Członkowska, A.G. Lindgren, C.A. Molina, D. Bereczki, D. Toni, D.J. Seiffge, D. Tanne, E.C. Sandset, G. Tsivgoulis, H. Christensen, J. Beyer-Westendorf, J.M. Coutinho, M. Crowther, P. Verhamme, P. Amarenco, R.O. Roine, R. Mikulik, R. Lemmens, R. Veltkamp, S. Middeldorp, T.G. Robinson, T.J. Milling, Jr., V. Tedim-Cruz, W. Lang, A. Himmelmann, P. Ladenvall, M. Knutsson, E. Ekholm, A. Law, A. Taylor, T. Karyakina, L. Xu, K. Tsiplova, S. Poli, B. Kallmünzer, C. Gumbinger, and A. Shoamanesh, for the ANNEXA-I Investigators*

ANNEXA-I

- Changement absolu/relatif de progression HIC?
- mRS ≤ 3 à 30 jrs idem (28 vs 31%)

Table 3. Thrombotic Events and Deaths at 30 Days.*

Event	Andexanet (N=263)	Usual Care (N=267)	Increase per 100 Patients (95% CI)†	P Value†
	no. of patients (%)		*percentage points*	
≥1 Thrombotic event	27 (10.3)	15 (5.6)	4.6 (0.1 to 9.2)	0.048
Transient ischemic attack	0	0	—	
Ischemic stroke	17 (6.5)	4 (1.5)	5.0 (1.5 to 8.8)	
Myocardial infarction	11 (4.2)	4 (1.5)	2.7 (–0.2 to 6.1)	
Deep-vein thrombosis	1 (0.4)	2 (0.7)	–0.4 (–2.4 to 1.5)	
Pulmonary embolism	1 (0.4)	6 (2.2)	–1.9 (–4.5 to 0.2)	
Arterial systemic embolism	3 (1.1)	2 (0.7)	0.4 (–1.7 to 2.7)	
Death	73 (27.8)	68 (25.5)	2.5 (–5.0 to 10.0)	0.51


The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 MAY 16/23, 2024 VOL. 390 NO. 19

Andexanet for Factor Xa Inhibitor–Associated Acute Intracerebral Hemorrhage

S.J. Connolly, M. Sharma, A.T. Cohen, A.M. Demchuk, A. Członkowska, A.G. Lindgren, C.A. Molina, D. Bereczki, D. Toni, D.J. Seiffge, D. Tanne, E.C. Sandset, G. Tsivgoulis, H. Christensen, J. Beyer-Westendorf, J.M. Coutinho, M. Crowther, P. Verhamme, P. Amarenco, R.O. Roine, R. Mikulik, R. Lemmens, R. Veltkamp, S. Middeldorp, T.G. Robinson, T.J. Milling, Jr., V. Tedim-Cruz, W. Lang, A. Himmelmann, P. Ladenvall, M. Knutsson, E. Ekholm, A. Law, A. Taylor, T. Karyakina, L. Xu, K. Tsiplova, S. Poli, B. Kallmünzer, C. Gumbinger, and A. Shoamanesh, for the ANNEXA-I Investigators*

ANNEXA-I

- Financé par Portola (AZ) et entente de confidentialité avec auteurs
- Devis par MD statisticien + employés du commanditaire, medical writer…
- Refus de partage de données
- Multiples amendements après 11 mo
- Critères d'inclusions initiaux questionnables
- Point d'aboutissement primaire inhabituel
- 78 patients enrôlés après analyse intérimaire – données d'efficacité?

Institut national d'excellence en santé et en services sociaux
Québec

ONDEXXYA[MC]

Neutralisation de l'effet anticoagulant des inhibiteurs du FXa

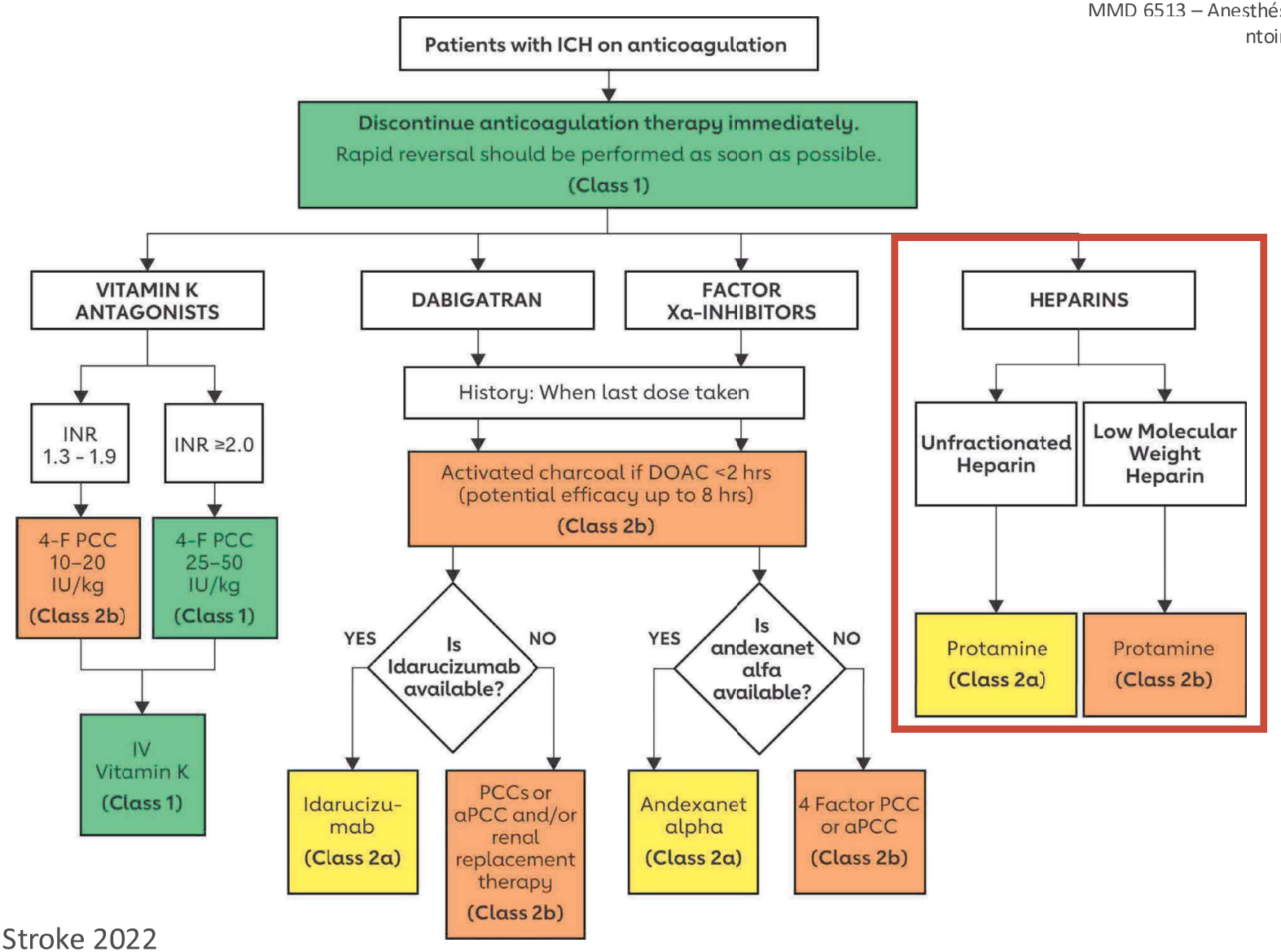
Avis transmis au ministre en juillet 2024

Marque de commerce : Ondexxya
Dénomination commune : Andexanet alfa
Fabricant : AZC
Forme : Poudre pour perfusion intraveineuse
Teneur : 200 mg

Refus d'inscription

RECOMMANDATION

L'Institut national d'excellence en santé et en services sociaux (INESSS) recommande au ministre de ne pas inscrire Ondexxya[MC] sur la *Liste des médicaments – Établissements*, pour les patients adultes traités par des inhibiteurs du FXa (rivaroxaban ou apixaban) lorsque la neutralisation rapide de l'anticoagulation est nécessaire, car la valeur thérapeutique n'est pas reconnue.



Greenberg et al. Stroke 2022

Antiplaquettaires

- Impact incertain sur évolution neuro
- Augmentation de mortalité
- Transfusions de plaquettes
  - Pas de craniotomie ➔ NON
  - Craniotomie ➔ considérer?
  - Autre procédures (DVE/MIS) ➔ ???
- Impact différent selon agents?
  - Inhibiteurs ADP P2Y12
  - Antidote ticagrelor?
- DDAVP 0,3-0,4 mcg/kg => équivoque
  - Études à venir

5.2.2. Antiplatelet-Related Hemorrhage

Recommendations for Antiplatelet-Related Hemorrhage
Referenced studies that support recommendations are summarized in Data Supplements 20 through 25.

COR	LOE	Recommendations
2b	C-LD	1. For patients with spontaneous ICH being treated with aspirin and who require emergency neurosurgery, platelet transfusion might be considered to reduce postoperative bleeding and mortality.[206]
2b	C-LD	2. For patients with spontaneous ICH being treated with antiplatelet agents, the effectiveness of desmopressin with or without platelet transfusions to reduce the expansion of the hematoma is uncertain.[207–209]
3: Harm	B-R	3. For patients with spontaneous ICH being treated with aspirin and not scheduled for emergency surgery, platelet transfusions are potentially harmful and should not be administered.[210]

Traitements hémostatiques

- FVIIa ➔ modeste HE
  - ↓ modeste progression hématome
  - ↑ thromboses artérielles?
  - Sous-groupe d'intérêt?

- Acide tranexamique
  - Sécuritaire
  - Pas d'effet sur l'évolution neuro
  - ↓ progression hématome?

5.2.3. General Hemostatic Treatments

Recommendations for General Hemostatic Treatments
Referenced studies that support recommendations are summarized in Data Supplements 26 and 27.

COR	LOE	Recommendations
2b	B-R	1. In patients with spontaneous ICH (with or without the spot sign), the effectiveness of recombinant factor VIIa to improve functional outcome is unclear.[218,219]
2b	B-R	2. In patients with spontaneous ICH (with or without the spot sign, black hole sign, or blend sign), the effectiveness of TXA to improve functional outcome is not well established.[220–222]

Greenberg et al. Stroke 2022

PIC, monitoring et traitements

- Incidence d'HTIC mal documentée
  - Jeunes patients, HIC supratentoriel
- HTIC, durée, variabilité, PPC réduite ➔ mauvais! (évolution et mortalité)
- Osmothérapie prophylactique
  - Mannitol ➔ pas de bénéfices
  - Salin 3% ➔ pas de données
- Principes de tx calqués sur TCC…
  - Monitoring si GCS 3-8
  - Tx si PIC ≥ 22
  - PPC 50-70 selon autorégulation

COR	LOE	Recommendations
1	B-NR	1. In patients with spontaneous ICH or IVH and hydrocephalus that is contributing to decreased level of consciousness, ventricular drainage should be performed to reduce mortality.[347–350]
2b	B-NR	2. In patients with moderate to severe spontaneous ICH or IVH with a reduced level of consciousness, ICP monitoring and treatment might be considered to reduce mortality and improve outcomes.[159,351–356]
2b	B-NR	3. In patients with spontaneous ICH, the efficacy of early prophylactic hyperosmolar therapy for improving outcomes is not well established.[357–361]
2b	C-LD	4. In patients with spontaneous ICH, bolus hyperosmolar therapy may be considered for transiently reducing ICP.[362–364]
3: No Benefit	B-R	5. In patients with spontaneous ICH, corticosteroids should not be administered for treatment of elevated ICP.[365–369]

Greenberg et al. Stroke 2022

Convulsions et anticonvulsivants

- Incidence de convulsions 2,8-28%
- Risque plus élevé – premières 24h
- Monitoring EEG 24h probablement raisonnable
  - Plus long si comateux?
  - 28% détectées dans 1ères 24h
  - 94% détectées avec monitoring 48h
- Incertitude d'implication pronostique d'un tracé anormal
  - Dx difficile, contexte clinique essentiel

COR	LOE	Recommendations
1	C-LD	1. In patients with spontaneous ICH, impaired consciousness, and confirmed electrographic seizures, antiseizure drugs should be administered to reduce morbidity.[325,326]
1	C-EO	2. In patients with spontaneous ICH and clinical seizures, antiseizure drugs are recommended to improve functional outcomes and prevent brain injury from prolonged recurrent seizures.
2a	C-LD	3. In patients with spontaneous ICH and unexplained abnormal or fluctuating mental status or suspicion of seizures, continuous electroencephalography (≥24 hours) is reasonable to diagnose electrographic seizures and epileptiform discharges.[327]
3: No Benefit	B-NR	4. In patients with spontaneous ICH without evidence of seizures, prophylactic antiseizure medication is not beneficial to improve functional outcomes, long-term seizure control, or mortality.[328–331]

Greenberg et al. Stroke 2022

Safety and efficacy of prophylactic levetiracetam for prevention of epileptic seizures in the acute phase of intracerebral haemorrhage (PEACH): a randomised, double-blind, placebo-controlled, phase 3 trial

Laure Peter-Derex, Frédéric Philippeau, Pierre Garnier, Nathalie André-Obadia, Sébastien Boulogne, Hélène Catenoix, Philippe Convers, Laure Mazzola, Michel Gouttard, Maud Esteban, Julia Fontaine, Laura Mechtouff, Elodie Ong, Tae-Hee Cho, Norbert Nighoghossian, Nathalie Perreton, Anne Termoz, Julie Haesebaert, Anne-Marie Schott, Muriel Rabilloud, Christine Pivot, Carole Dhelens, Andrea Filip, Yves Berthezène, Sylvain Rheims, Florent Boutitie, Laurent Derex

Lancet Neurol 2022; 21: 781–91

- 50/104 pts (interrompue – arrêt financement, faible recrutement COVID)
- HIC non-traumatique < 24h ➔ LEV 500 BID vs placebo x 6 sem
- Groupe placebo désavantagé (HIC 9 vs 18 mL, lobaire vs profond, NIHSS 8 vs 13)
- EEG continu précoce (24-72h post HIC)
- Installé ~ 25h post HIC, 1ère crise documentée ~ 47h
- Toutes les crises = électriques

	Levetiracetam group (n=24)	Placebo group (n=26)	Effect size (95% CI)	p value
Primary efficacy outcome				
Clinical or electrographic seizure in the first 72 h after inclusion	3/19 (16%)	10/23 (43%)	0·16 (0·03 to 0·94)*	0·043
Secondary efficacy outcomes				
Number of seizures on cEEG	6	158	0·07 (0·01 to 0·38)†	0·0021
Median duration of seizures on cEEG in all patients, s	0 (0–0)‡; n=19	0 (0–540)‡; n=23	..	0·023
Median duration of seizures on cEEG in patients with seizures, s	67 (46–300); n=3	780 (380–1980); n=10	..	0·028

Traitements chirurgicaux

Recommendations for MIS Evacuation of ICH
Referenced studies that support recommendations are summarized in Data Supplements 55 and 56.

COR	LOE	Recommendations
2a	B-R	1. For patients with supratentorial ICH of >20- to 30-mL volume with GCS scores in the moderate range (5–12), minimally invasive hematoma evacuation with endoscopic or stereotactic aspiration with or without thrombolytic use can be useful to reduce mortality compared with medical management alone.[379–388]
2b	B-R	2. For patients with supratentorial ICH of >20- to 30-mL volume with GCS scores in the moderate range (5–12) being considered for hematoma evacuation, it may be reasonable to select minimally invasive hematoma evacuation over conventional craniotomy to improve functional outcomes.[382,383,385–387,389,390]
2b	B-R	3. For patients with supratentorial ICH of >20- to 30-mL volume with GCS scores in the moderate range (5–12), the effectiveness of minimally invasive hematoma evacuation with endoscopic or stereotactic aspiration with or without thrombolytic use to improve functional outcomes is uncertain.[379–385,387,388]

Greenberg et al. Stroke 2022

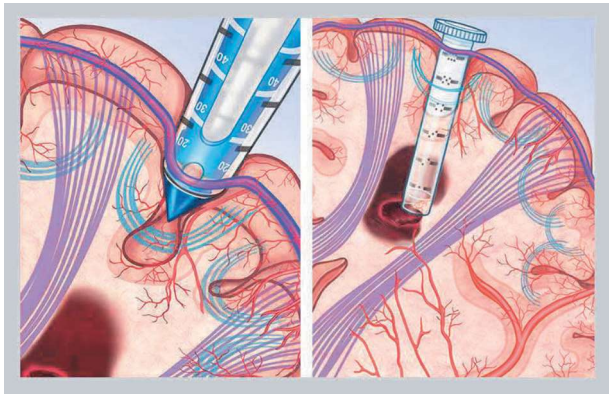
- MISTIE III (Lancet 2019) Cathéter CMI + tPA, HIC supratentorielle ≥ 30 mL
  - Aucun bénéfice mRS (primaire)
  - Réduction de mortalité (outcome secondaire)
  - Sous-groupe HIC < 15 mL post-procédure ➔ amélioration mRS
- **ENRICH (NEJM 2024) MIPS ≤ 24h en HIC 30-80 mL NGC + lobaire**
- CMI en centre d'expertise pour appliquer ces recommandations…
- Meilleure sélection de patients?

ORIGINAL ARTICLE

N Engl J Med 2024;390:1277-89.
DOI: 10.1056/NEJMoa2308440

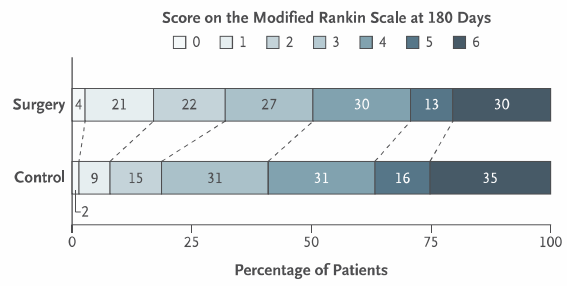
Trial of Early Minimally Invasive Removal of Intracerebral Hemorrhage

G. Pradilla, J.J. Ratcliff, A.J. Hall, B.R. Saville, J.W. Allen, G. Paulon, A. McGlothlin, R.J. Lewis, M. Fitzgerald, A.F. Caveney, X.T. Li, M. Bain, J. Gomes, B. Jankowitz, G. Zenonos, B.J. Molyneaux, J. Davies, A. Siddiqui, M.R. Chicoine, S.G. Keyrouz, J.A. Grossberg, M.V. Shah, R. Singh, B.N. Bohnstedt, M. Frankel, D.W. Wright, and D.L. Barrow, for the ENRICH trial investigators*



- **MIPS = minimaly invasive trans-sulcal para-fascicular surgery (tractography)**
- **HIC supratentorielle spontanée 30-80 mL (55), lobaire ou NGC antérieurs, LKW-tx < 24h**

- **<u>Bénéfice évolution fonctionnelle UW-mRS (lobaire)</u> et mRS ≤ 3 à 180 jrs**
- **Diminution mortalité et durée séjour USI + hospitalisation ~ 3 jours**
- **Diminution convulsions et craniectomie décompressive (3 vs 20%)**



Traitements chirurgicaux

Recommendations for Craniotomy for Supratentorial Hemorrhage
Referenced studies that support recommendations are summarized in Data Supplements 63 and 64.

COR	LOE	Recommendations
2b	A	1. For most patients with spontaneous supratentorial ICH of moderate or greater severity, the usefulness of craniotomy for hemorrhage evacuation to improve functional outcomes or mortality is uncertain.[380,382,384,393,429–431]
2b	C-LD	2. In patients with supratentorial ICH who are deteriorating, craniotomy for hematoma evacuation might be considered as a lifesaving measure.[382,384,429,432]

Recommendations for Craniectomy for ICH
Referenced studies that support recommendations are summarized in Data Supplements 66 through 68.

COR	LOE	Recommendations
2b	C-LD	1. In patients with supratentorial ICH who are in a coma, have large hematomas with significant midline shift, or have elevated ICP refractory to medical management, decompressive craniectomy with or without hematoma evacuation may be considered to reduce mortality.[453–460]
2b	C-LD	2. In patients with supratentorial ICH who are in a coma, have large hematomas with significant midline shift, or have elevated ICP refractory to medical management, effectiveness of decompressive craniectomy with or without hematoma evacuation to improve functional outcomes is uncertain.[458–462]

Greenberg et al. Stroke 2022

- STITCH (Lancet 2005) HIC supratentorielle: chx < 24h vs conservateur
- STITCH II (Lancet 2013) HIC superficielle lobaire: chx < 12h rando vs conservateur
  - Aucun bénéfice sur GOS-E
  - Bénéfice pour patients jugés à mauvais Px (GCS/âge/taille HIP)?
  - Taux élevé de croisement ~ 20%
  - Bénéfice d'une chirurgie plus précoce (< 12 hrs du saignement)?
- **SWITCH (Lancet 2024) CD pour HIC profonds 30-100 mL**
- Fosse postérieure: aucune ERC, manque d'équipose?

Recommendations for Craniotomy for Posterior Fossa Hemorrhage
Referenced studies that support recommendations are summarized in Data Supplement 65.

COR	LOE	Recommendation
1	B-NR	1. For patients with cerebellar ICH who are deteriorating neurologically, have brainstem compression and/or hydrocephalus from ventricular obstruction, or have cerebellar ICH volume ≥15 mL, immediate surgical removal of the hemorrhage with or without EVD is recommended in preference to medical management alone to reduce mortality.[442–444]

Decompressive craniectomy plus best medical treatment versus best medical treatment alone for spontaneous severe deep supratentorial intracerebral haemorrhage: a randomised controlled clinical trial

Lancet 2024; 403: 2395–404

*Jürgen Beck, Christian Fung, Daniel Strbian, Lukas Bütikofer, Werner J Z'Graggen, Matthias F Lang, Seraina Beyeler, Jan Gralla, Florian Ringel, Karl Schaller, Nikolaus Plesnila, Marcel Arnold, Werner Hacke, Peter Jüni, Alexander David Mendelow, Christian Stapf, Rustam Al-Shahi Salman, Jenny Bressan, Stefanie Lerch, Arsany Hakim, Nicolas Martinez-Majander, Anna Piippo-Karjalainen, Peter Vajkoczy, Stefan Wolf, Gerrit A Schubert, Anke Höllig, Michael Veldeman, Roland Roelz, Andreas Gruber, Philip Rauch, Dorothee Mielke, Veit Rohde, Thomas Kerz, Eberhard Uhl, Enea Thanasi, Hagen B Huttner, Bernd Kallmünzer, L Jaap Kappelle, Wolfgang Deinsberger, Christian Roth, Robin Lemmens, Jan Leppert, Jose L Sanmillan, Jonathan M Coutinho, Katharina A M Hackenberg, Gernot Reimann, Mikael Mazighi, Claudio L A Bassetti, Heinrich P Mattle, Andreas Raabe, Urs Fischer, on behalf of the SWITCH study investigators**

- **HIC profond (NGC/thalamus) sévère (NIHSS ≥ 10, volume ≥ 30 mL, GCS < 14), CHX < 72 h**
- **197/300 pts (2014-2023)**
- **NIHSS ~ 18, volume 55-59 mL, IVH 30%,**
- **↓ mRS 5-6 à 180 jrs 44 vs 58% aRR 0.77 (0.59-1.01)**

- **(Interrompue manque de financement)**

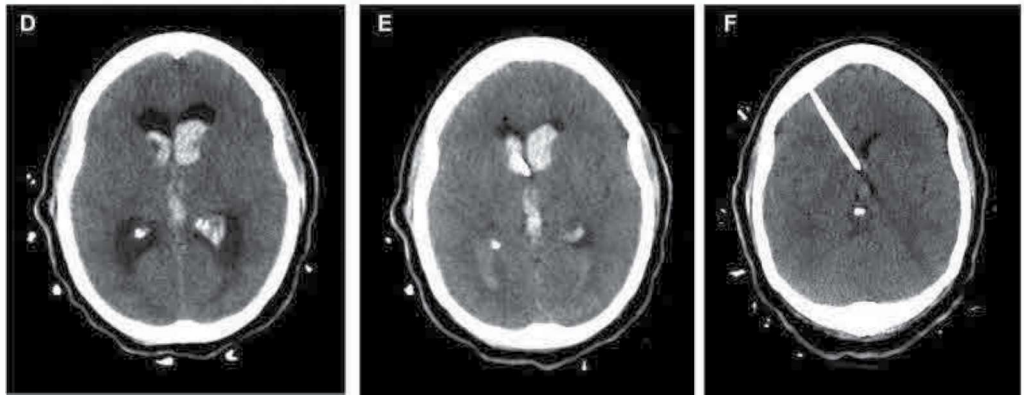
Traitements chirurgicaux

Recommendations for MIS Evacuation of IVH
Referenced studies that support recommendations are summarized in Data Supplements 57 through 62.

COR	LOE	Recommendations
1	B-NR	1. For patients with spontaneous ICH, large IVH, and impaired level of consciousness, EVD is recommended in preference to medical management alone to reduce mortality.[347–349]
2a	B-R	2. For patients with a GCS score >3 and primary IVH or IVH extension from spontaneous supratentorial ICH of <30-mL volume requiring EVD, minimally invasive IVH evacuation with EVD plus thrombolytic is safe and is reasonable compared with EVD alone to reduce mortality.[415–418]
2b	B-R	3. For patients with a GCS score >3 and primary IVH or IVH extension from spontaneous supratentorial ICH of <30-mL volume requiring EVD, the effectiveness of minimally invasive IVH evacuation with EVD plus thrombolytic use to improve functional outcomes is uncertain.[382,407,415–419]
2b	B-NR	4. For patients with severe spontaneous ICH, large IVH, and impaired level of consciousness, the efficacy of EVD for improving functional outcomes is not well established.[347–349]
2b	C-LD	5. For patients with spontaneous supratentorial ICH of <30-mL volume and IVH requiring EVD, the usefulness of minimally invasive IVH evacuation with neuroendoscopy plus EVD, with or without thrombolytic, to improve functional outcomes and reduce permanent shunt dependence is uncertain.[419,420]

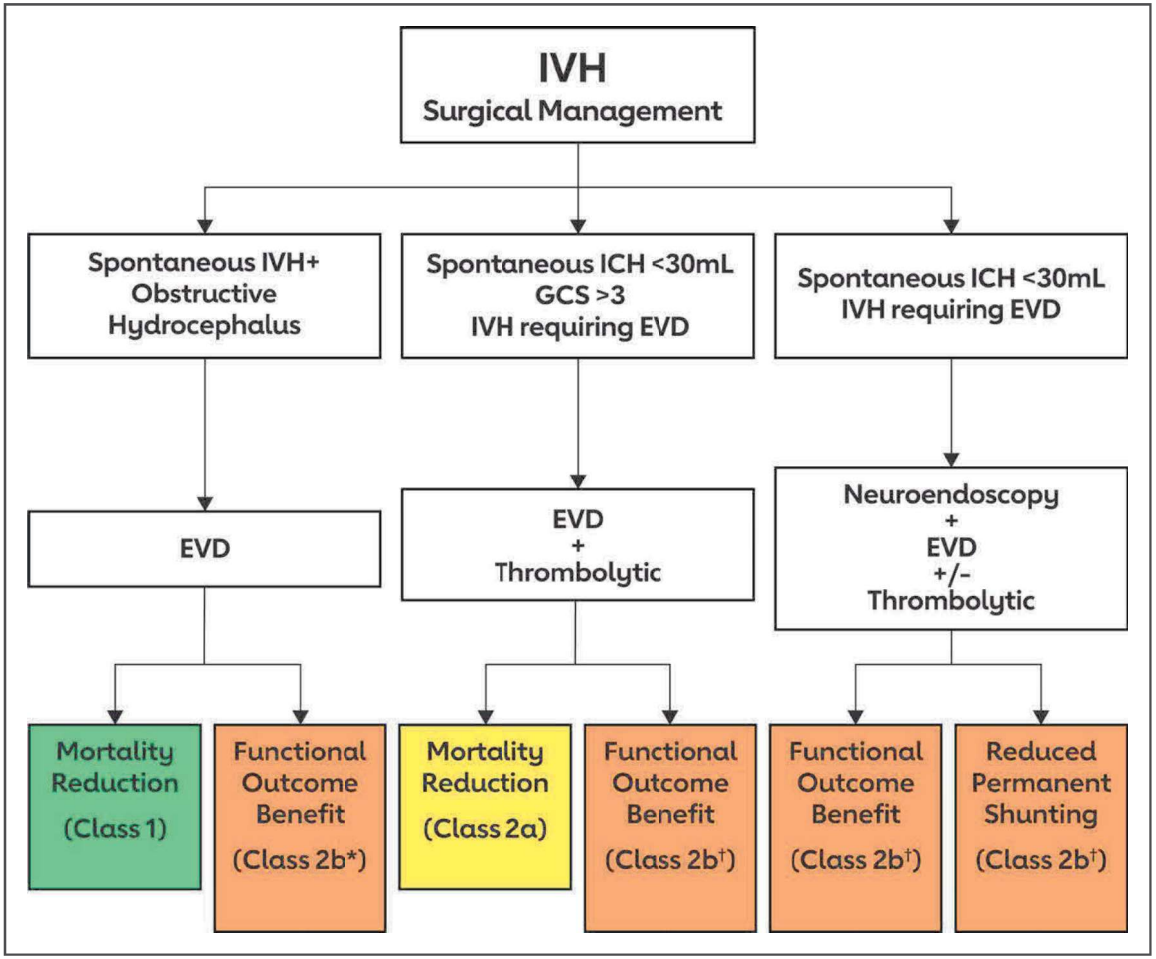
Greenberg et al. Stroke 2022

- Déversement intraventriculaire chez 30-50% HIC
- CLEAR III (Lancet 2017) tPA via DVE en HIC ≤ 30 mL stable avec HIV
  - Aucun bénéfice mRS
  - Diminution mortalité (mais plus de mRS 5)
  - Moins de ventricules, DVP idem
  - Saignement symptomatique idem (~2%)
  - ~ 60% HIC thalamique ➔ moins bon pronostic
- Meilleure sélection de patients?



Polster et al. Oper Neurosurg 2021

Traitements chirurgicaux



Greenberg et al. Stroke 2022

Conclusion

- Peu d'interventions démontrant bénéfices sur évolution neurologique
  - Validité externe douteuse chez population chirurgicale (HTIC, taille d'hématome)
    - Réduction agressive de pression artérielle
    - Renversement de coagulopathie
    - Thérapies hémostatiques

- Utilité d'approches chirurgicales demeurent mal définies
  - Détérioration neurologique
  - HTIC réfractaire, HIP volumineux, patient comateux
  - Identification de sous-groupe de patients ayant bénéfice

- Considérations anesthésiques demeurent relativement non-spécifiques
  - Urgence, patient instable – ABC (considérer estomac plein)
  - Anticiper et traiter HTIC, convulsions, insultes secondaires...
    - Maintenir PPC adéquate (considérer altération d'autorégulation cérébrale)
    - Éviter hypertension extrême (validité de cible INTERACT2, ATACH-2 douteuse)
    - Réduire PIC – algorithme HTIC/relaxation cérébrale (TIVA, osmothérapie, +/- hyperventilation si engagement imminent) (cours HTIC)
  - Renverser coagulopathie
  - Considérer atteintes extracrâniennes (CMP, IM, œdème pulmonaire)
  - Considérer co-morbidités associées

Hémorragie sous-arachnoïdienne

AHA/ASA GUIDELINE

2023 Guideline for the Management of Patients With Aneurysmal Subarachnoid Hemorrhage: A Guideline From the American Heart Association/ American Stroke Association

Stroke. 2023;54:e314–e370.

NCS GUIDELINES

Guidelines for the Neurocritical Care Management of Aneurysmal Subarachnoid Hemorrhage

Miriam M. Treggiari[1*], Alejandro A. Rabinstein[2], Katharina M. Busl[3], Meghan M. Caylor[11], Giuseppe Citerio[12,13], Steven Deem[4], Michael Diringer[5], Elizabeth Fox[6], Sarah Livesay[7], Kevin N. Sheth[8], Jose I. Suarez[9] and Stavropoula Tjoumakaris[10]

Neurocrit Care (2023) 39:1–28

"there is insufficient evidence"

Picetti *et al. Journal of Anesthesia, Analgesia and Critical Care* (2022) 2:13
https://doi.org/10.1186/s44158-022-00042-x

SIAARTI

Journal of Anesthesia, Analgesia and Critical Care

ORIGINAL ARTICLE Open Access

Early management of patients with aneurysmal subarachnoid hemorrhage in a hospital with neurosurgical/ neuroendovascular facilities: a consensus and clinical recommendations of the Italian Society of Anesthesia and Intensive Care (SIAARTI)–Part 1

Delphi – recommandations d'experts

Hémorragie sous-arachnoïdienne

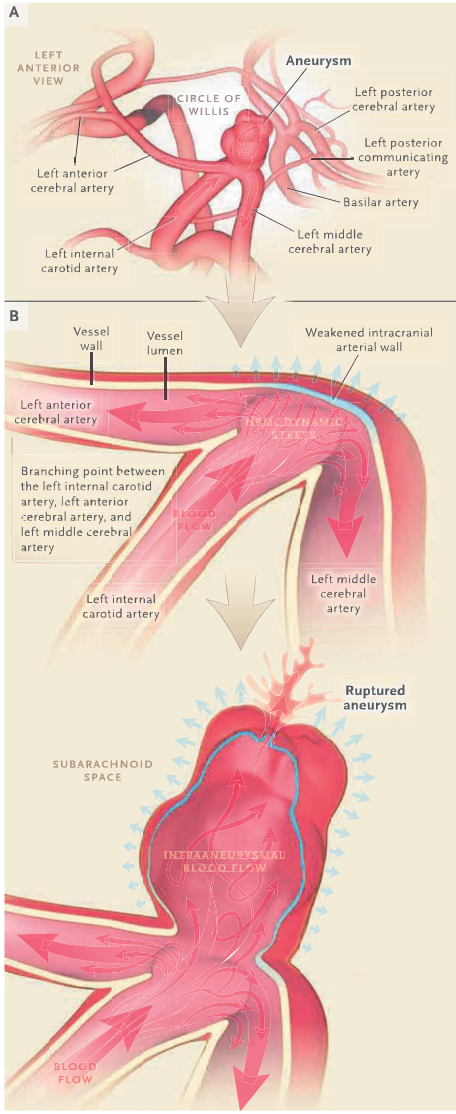
- HSA non-traumatiques (~ 5-10% AVC)
  - Incidence mondiale variable 9-23/100,000 JPFI
  - Population typiquement plus jeune (40-60 ans)
  - Origine **anévrysmale** chez 80%, autres causes non-anévrysmales (MAV, idiopathique, etc)
  - Morbidité/mortalité élevée
    - Mortalité 15% avant admission, 30-40% à 30 jours
    - Morbidité/mortalité augmente selon sévérité de l'atteinte initiale, re-saignement, DCI, âge et comorbidités

- Anévrysme intracrânien 1-2%
  - Habituellement asymptômatiques
  - Circulation antérieure > 80%
  - Sacculaire 90%, fusiforme 10%
  - Multiples anévrysmes 35%

TABLE 2. Clinical Features of Intracranial Aneurysms Based on Location

Location of the Aneurysm	Clinical Features
Anterior communicating artery	Bilateral temporal hemianopsia Bilateral lower extremity weakness
Posterior communicating artery	Third nerve palsy
Intercavernous internal carotid artery	Facial or orbital pain Epistaxis Progressive vision loss and/or opthalmoplegia
Posterior circulation aneurysms	Brainstem dysfunction

- FR anévrysme: femmes, HTA, tabagisme, ROH, reins polykystiques, syndrome Ehlers-Danlos, syndrome Marfan, NF type 1, dysplasie fibromusculaire
- FR rupture: femmes, HTA, tabagisme, âge avancé, ROH, drogues sympathomimétiques, origines (afroaméricains, hispanoaméricains, JP, FI), caractéristiques d'anévrysme (circulation postérieure, > 7-10 mm, anévrysmes géants > 20-25 mm)



Lawton et al. NEJM 2017
D'Souza S. J Neurosurg Anesthesiol 2015

HSA: trajectoire intra-hospitalière typique

- Présentation immédiate
  - Diagnostic HSA anévrysmale
  - Stabilisation initiale
- Pré-sécurisation
  - Prévenir re-saignement
    - Sécurisation précoce, contrôle pression artérielle
  - Prévenir dommage cérébral secondaire
    - DVE, anticonvulsivants, complications intra/extracrânienne
- Post-sécurisation
  - Anticiper et prévenir dommage cérébral secondaire
  - Anticiper et traiter ischémie cérébrale retardée
- Plus tardivement
  - DVP, remise volet
  - Sevrage trachéostomie
  - Réadaptation et orientation

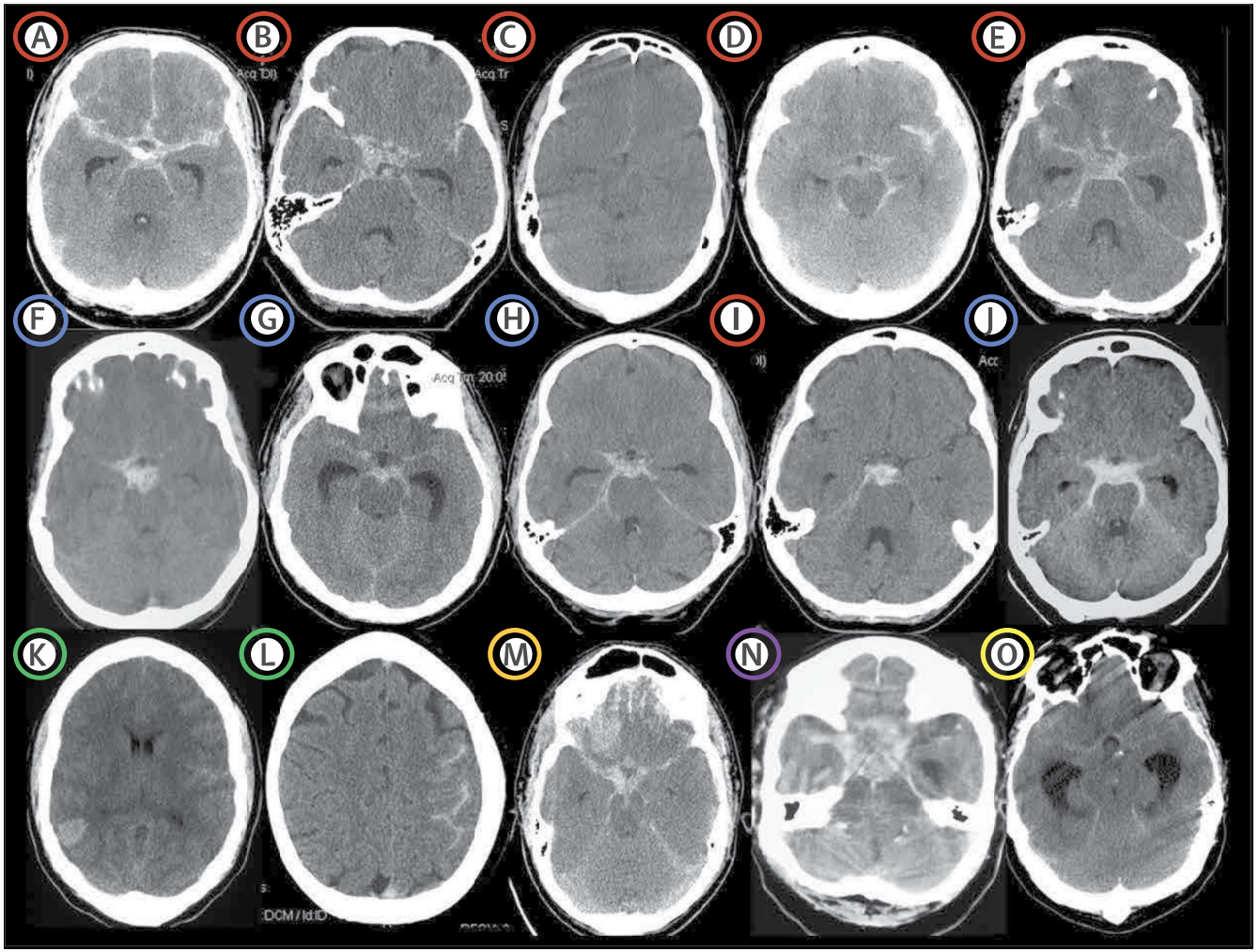
Étiologie

- HSA anévrysmale
- Périmésencéphalique
- Thrombose veineuse
- Trauma
- Apoplexie hypophysaire
- Pseudo-HSA

- Distribution du sang**
  - Citernes de la base
  - Vallée sylvienne
  - Citerne interpédonculaire
  - Sillon interhémisphérisque

  OUI, mais…

  CTA, DSA nécessaire!

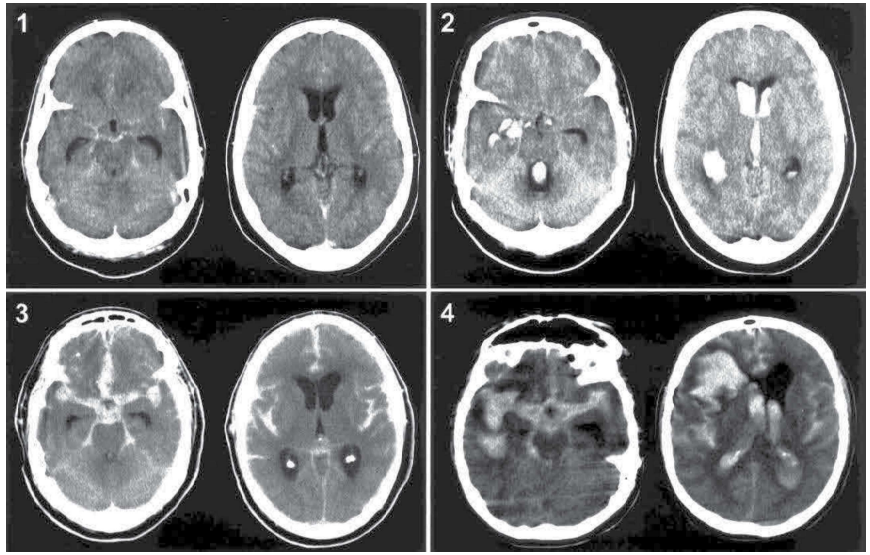


Macdonald RL et al. Lancet 2017

Présentation clinique et pronostication

- Céphalée brutale (thunderclap) ad décès
  - 10-40% céphalée « sentinelle » 2-8 sem pré-HSA
  - Altération de l'état de conscience
  - Déficit neurologique focal
  - Convulsions ad 20%

- Échelles pronostiques
  - Cliniques (Hunt and Hess, WFNS)
  - Radiologique (Fisher modifié, Hijdra score)
  - Combinés (VASOGRADE)



VASOGRADE	WFNS	mFisher	OR DCI
Green	1-2	1-2	
Yellow	1-3	3-4	1.31 (0,77-2,23)
Red	4-5	any	3.19 (2,07-4,50)

D'Souza S. J Neurosurg Anesthesiol 2015

Letters

Claassen et al. Stroke 2001
Hijdra et al. Stroke 1990
Teasdale et al. J Neurol Neurosurg Psychiatr 1988
de Oliviera Manoel et al. Stroke 2015

Présentation clinique et pronostication

	Hunt and Hess[41]	WFNS[42]	mRS 4-6
Grade #1	Asymptomatic or mild headache and slight nuchal rigidity	GCS 15	15%
Grade #2	Moderate to severe headache, nuchal rigidity, no focal neurological deficit other than cranial nerve palsy	GCS 14–13 without major focal deficit (aphasia or hemiparesis/hemiplegia)	30%
Grade #3	Confusion, lethargy, or mild focal neurological deficit other than cranial nerve palsy	GCS 14–13 with major focal deficit	50%
Grade #4	Stupor or moderate to severe hemiparesis	GCS 12–7 with or without major focal deficit	60%
Grade #5	Coma, extensor posturing, moribund appearance	GCS 6–3 with or without major focal deficit	90%

Autres caractéristiques défavorables

- Resaignement
- Âge
- Comorbidités
- Œdème cérébral
- HIV/HIP
- DCI
- Complications extra-cérébrales

Macdonald et al. Lancet 2017

Hunt et al. J Neurosurg 1968
Drake et al. J Neurosurg 1988
Van Heuven et al. Stroke 2008

Présentation clinique et pronostication

	Fisher scale[44]	Claassen scale[46]	Modified Fisher scale[47]	Ischémie cérébrale retardée
Grade #0	..	No SAH or intraventricular haemorrhage	No SAH or intraventricular haemorrhage	
Grade #1	No SAH or intraventricular haemorrhage	Minimum or thin SAH, no intraventricular haemorrhage in either lateral ventricle	Localised or diffuse thin SAH with no intraventricular haemorrhage	12%
Grade #2	Diffuse deposition of thin layer with all vertical layers of blood (interhemispheric fissure, insular cistern, ambient cistern) <1 mm thick	Minimal or thin SAH, with intraventricular haemorrhage in both lateral ventricles	No or localised or diffuse thin SAH but with intraventricular haemorrhage	21%
Grade #3	Vertical layers of blood ≥1 mm thick or localised clots (clots defined as >3 × 5 mm)	Thick SAH completely filling two or more cisterns or fissures, no intraventricular haemorrhage in both lateral ventricles	Localised or diffuse thick SAH with no intraventricular haemorrhage	19%
Grade #4	Diffuse or no subarachnoid blood, but with intracerebral or intraventricular clots	Thick SAH completely filling two or more cisterns or fissures, with intraventricular haemorrhage in both lateral ventricles	Localised or diffuse thick SAH with intraventricular haemorrhage	40%

The severity of subarachnoid and intraventricular haemorrhage on the initial CT scan is the most important factor predicting delayed cerebral ischaemia and cerebral infarction and is a prognostic factor for outcome.[47] Qualitative, semiquantitative, and quantitative scales have been proposed to measure the extent of damage.[49,50] SAH=subarachnoid haemorrhage.

Table 2: **Scales used to determine severity of SAH and intraventricular haemorrhage using the Fisher, Claassen, Modified Fisher, and Hijdra scales**

Macdonald et al. Lancet 2017

Fisher et al. Neurosurgery 1980
Claassen et al. Stroke 2001
Frontera et al. Neurosurgery 2006

Pronostic: HSA « bas grades »

- Données prospectives (ISAT) – 88% « bas grades »
  - mRS 0-2 ➔ 73%
  - mRS 3 ➔ 12%
  - mRS 4-5 ➔ 6.5%
  - mRS 6 ➔ 9%

- Mais, limites des échelles d'évaluation pronostique…
  - Dysfonction cognitive ~ 20%
  - Troubles de l'humeur
  - Trouble du sommeil
  - Troubles de comportement
  - Répercussions sociales
  - Qualité de vie

Pronostic: HSA « hauts grades »

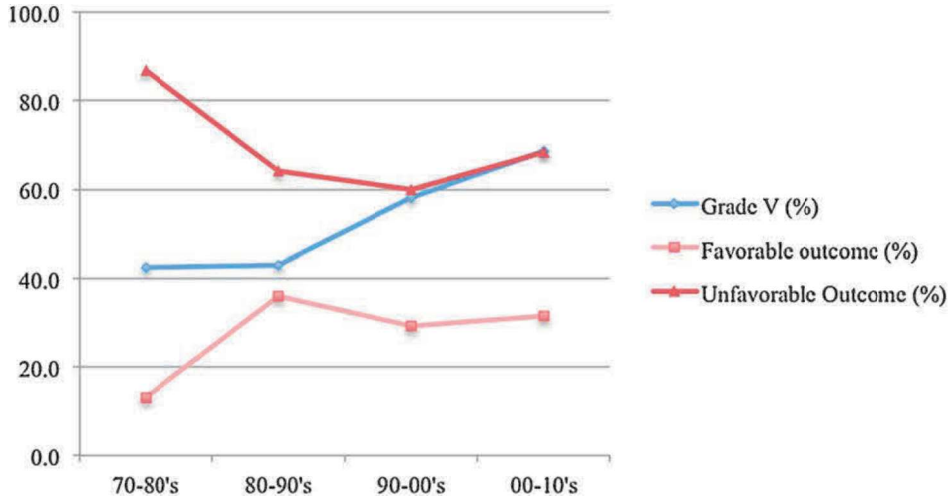


Fig. 3 Chart of favorable versus unfavorable functional outcome. This chart shows the functional outcome trends according to different decades of patients' enrollment in the included articles. Also, the percentage of Grade 5 patients included was plotted, showing a trend to increase inclusion of Grade 5 patients. The definition of favorable outcome varies according to study, including GOS 4–5, mRS 0–2, ability to live independently (for full detail, please refer to Table 2)

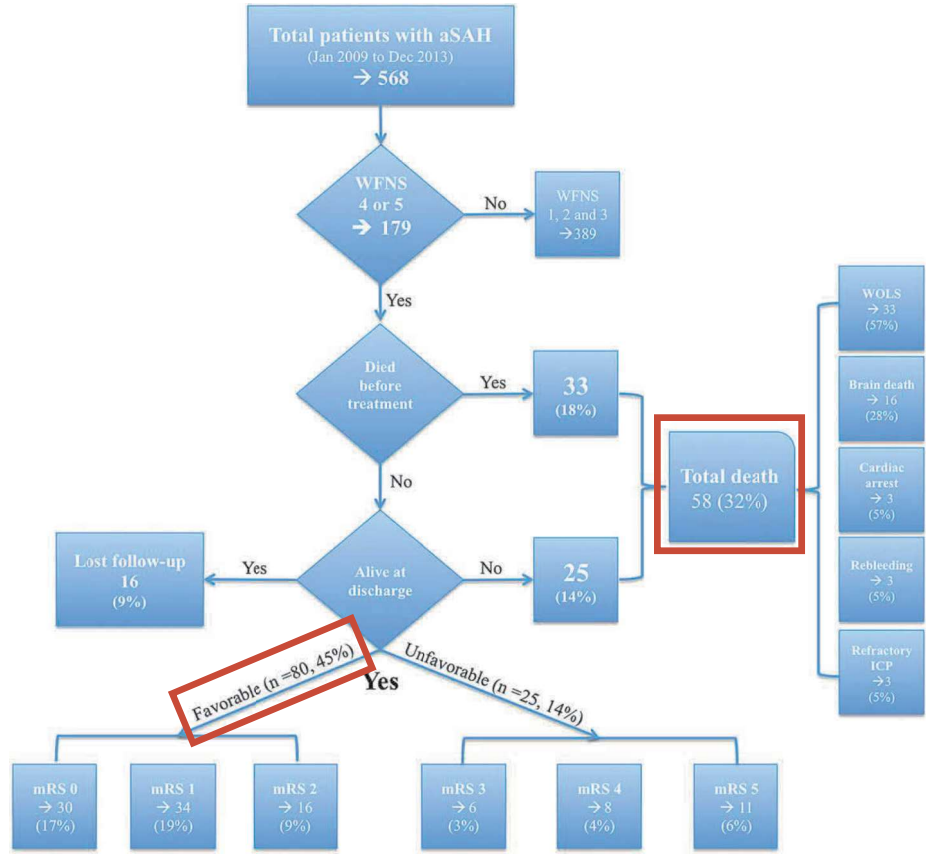
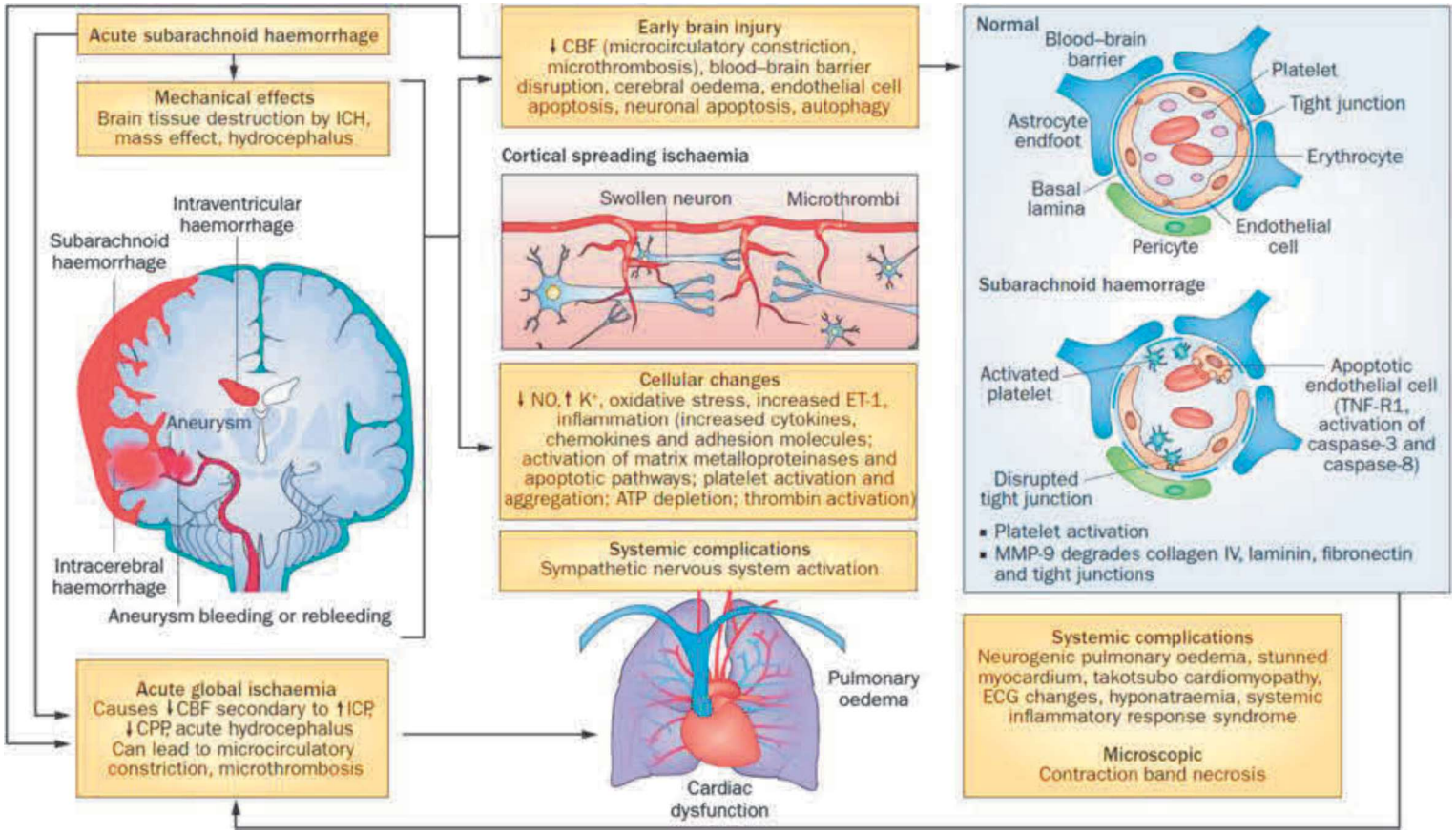


Fig. 1 Flowchart of the entire cohort admitted from January 2009 to December 2013. *aSAH* aneurysmal subarachnoid hemorrhage, *WOLS* withdrawal of life support, *WFNS* World Federation of Neurosurgical Societies, *ICP* intracranial pressure, *mRS* modified Rankin Scale

de Oliveira Manoel et al. Neurocrit Care 2016

Dommage cérébral précoce *(early brain injury)*

- **EBW = J0-J3**
- ↑↑↑ brutale de PIC ➔ hypoperfusion globale transitoire
- Sang sous-arachnoïdien
- Re-saignement
- Contribution de complications extracrâniennes
  - Activation adrénergique
  - Vasoconstriction microcirculation
  - Microthromboses
  - Altération BHE
  - Œdème cytotoxique
  - Œdème vasogénique
  - Altération autorégulation cérébrale
- ↑ secondaire de la PIC
  - HCP (communicante, non-communicante)
  - Effet de masse (HIP, HSD)
  - Œdème cérébral



Macdonald RL. Nat Rev Neurol 2014
de Oliveira Manoel et al. Crit Care 2016

Prévenir resaignement

- Resaignement jusqu'à 20% dans 1ers 72 hrs ➔ mortalité 20-70%
  - 50-90% dans les 1ers 6 hrs
  - FR: grade élevé, inconscience ou convulsions à l'ictus, gros anévrysmes, saignement sentinel, HIP, HIV, possiblement HTA et antiplaquettaires

- **Sécurisation le plus tôt possible (< 72 hrs)**
  - Ultra rapide (< 24 hrs) vs rapide (24-72 hrs) – bénéfices incertains, stabiliser pt avant
  - **LIGNES DIRECTRICES ≤ 24 hrs**
  - « As early as feasible » « as early as logistically and technically possible »
  - Modalité thérapeutique: « clip vs coil? »
  - Transfert dans un centre d'expertise (high-volume > 35 aSAH/an)

AHA/ASA Hoh et al. Stroke 2023
Oudshoorn et al. Neurocrit Care 2014
Naidech et al. Arch Neurol 2005
Lawton et al. NEJM 2017
Muehlschlegel et al. Continuum 2018
Macdonald RL et al. Lancet 2017
D'Souza S. J Neurosurg Anesthesiol 2015

Prévenir resaignement: pression artérielle

- Limiter poussées hypertensives
  - ASA/AHA 2012 ➔ PAsyst < 160 mmHg (Classe IIa, Niveau C)
  - NCS 2011 ➔ PAsyst < 160 mmHg, PAM < 110 mmHg
  - ESO 2013 ➔ PAsyst < 180 mmHg, PAM > 90 mmHg
  - SIAARTI 2022 ➔ PAsyst entre 120-160 mmHg

NCS 2023

There is insufficient evidence to recommend a blood pressure reduction goal for the treatment of hypertension before aneurysm treatment in aSAH. Lack of evidence to recommend a specific blood pressure reduction goal does not necessarily imply that blood pressure reduction is not helpful before aneurysm treatment*

Connolly et al. Stroke 2012
Diringer et al. Neurocrit Care 2011
Steiner et al. Cerebrovasc Dis 2013

Picetti et al. J Anesth Analg Crit Care 2022
Treggiari et al. Neurocrit Care 2023

Prévenir resaignement: pression artérielle

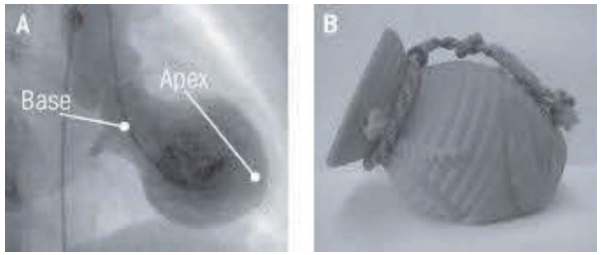
COR	LOE	Recommendations
1	C-EO	1. In patients with aSAH and unsecured aneurysm, frequent blood pressure (BP) monitoring and BP control with short-acting medication(s) is recommended to avoid severe hypotension, hypertension, and BP variability.
1	C-EO	2. In patients with aSAH who are receiving anticoagulants, emergency anticoagulation reversal with appropriate reversal agents should be performed to prevent rebleeding.
3: No benefit	A	3. In patients with aSAH, routine use of antifibrinolytic therapy is not useful to improve functional outcome.[85–87]

- Manque de données pour recommander cible précise
- Variabilité PA associée à évolution défavorable
- **↓ PA excessive pourrait compromettre PPC**
- **Réduction graduelle d'HTA excessive (> 180-200 mmHg)**
- **Éviter hypoTA (PAM < 65 mmHg)**
- Surveillance neurologique
- À considérer: PA à la présentation, œdème cérébral, HCP, HTA chronique, insuffisance rénale

AHA/ASA Hoh et al. Stroke 2023

Complications extra-crâniennes

- Effets cardiaques
  - Changements ECG (Δ ST-T, prolongation QT, ondes Q, ondes U)
  - Élévation de biomarqueurs (troponines, NT-proBNP)
  - Dysrythmies (supraventriculaires, ventriculaires)
  - Dysfonction myocardique – dysfonction globale, ARC
    - STEMI / NSTEMI type I surajouté
    - NSTEMI type II 2^{o} stress adrénergique
    - Changement ECG sans infarctus
  - Cardiopathie de stress (“axe neuro-cardiaque”)
    - Poussée adrénergique (haut grade)
    - Tachycardie sinusale, changements ST-T
    - Élévation importante des biomarqueurs
    - Hypotension inhabituelle… 🤔



http://www.health.harvard.edu/heart-health/takotsubo-cardiomyopathy-broken-heart-syndrome
Van der Bilt et al. Neurosurgery 2015

Complications extra-crâniennes

- Complications respiratoires
  - Œdème pulmonaire (neurogénique, cardiogénique, ARDS)
  - Aspiration / surinfection
- Volémie et électrolytes
  - Hypovolémie – polyurie (CSW, HTA, osmothérapie)
  - Dysnatrémie (CSW, SIADH >> DI; osmothérapie)
  - HypoMg*
  - HypoK, HypoCa
- Autres
  - Hyperthermie – viser normothermie, éviter frissons
  - Hyperglycémie – viser normoglycémie
  - Infections, sepsis
  - **Anémie – SaHARA, TRAIN**
  - TVP et thromboembolies

AHA/ASA Hoh et al. Stroke 2023

COR	LOE	Recommendations
Pulmonary management		
1	B-NR	1. In patients with aSAH who require mechanical ventilation for >24 hours, implementation of a standardized ICU care bundle is recommended to reduce the duration of mechanical ventilation and hospital-acquired pneumonia.[177,178]
2b	B-NR	2. In patients with aSAH who develop severe acute respiratory distress syndrome (ARDS) and life-threatening hypoxemia, rescue maneuvers such as prone positioning and alveolar recruitment maneuvers with ICP monitoring may be reasonable to improve oxygenation.[179–182]
Intravascular volume and electrolyte management		
2a	B-R	3. In patients with aSAH, close monitoring and goal-directed treatment of volume status are reasonable to maintain euvolemia.[183–185]
2a	B-R	4. In patients with aSAH, use of mineralocorticoids is reasonable to treat natriuresis and hyponatremia.[186,187]
3: Harm	B-R	5. In patients with aSAH, induction of hypervolemia is potentially harmful because of the association with excess morbidity.[188–190]
Other		
1	C-LD	6. In patients with aSAH whose ruptured aneurysm has been secured, pharmacological or mechanical venous thromboembolism (VTE) prophylaxis is recommended to reduce the risk for VTE.[191–193]
2a	B-NR	7. In patients with aSAH, effective glycemic control, strict hyperglycemia management, and avoidance of hypoglycemia are reasonable to improve outcome.[141,142,194,195]
2b	C-LD	8. In patients with aSAH with fever refractory to antipyretic medications, the effectiveness of therapeutic temperature management (TTM) during the acute phase of aSAH is uncertain.[196–198]

Seuil transfusionnel en HSA

- 3 RCT multicentrique qui remettent en cause seuil restrictif
- **TRAIN Taccone et al. JAMA 2024**
  - 850 pts (22% HSA), seuil transfusionnel < 90 vs < 70
  - **Évolution défavorable (GOSE 1-5) 63% vs 73%**
- **SAHARA English et al. NEJM 2024**
  - 742 pts (100% HSA), seuil transfusionnel < 100 vs < 80
  - Évolution défavorable (mRS > 4) 34 vs 38% NS
  - Nouvel infarctus cérébral 16 vs 18% NS
  - DCI 18 vs 20% NS
  - **Vasospasme radiologique 32% vs 41%**

Taccone et al. Intensive Care Med 2025
SAHARA English et al. NEJM 2024
TRAIN Taccone et al. JAMA 2024
HEMOTION Turgeon et al. NEJM 2024

International Subarachnoid Aneurysm Trial (ISAT)

	ISAT (Lancet 2002)
Devis	RCT multicentrique pragmatique (RU, Suède, Finlande, Canada, Allemagne, France, Australie, Danemark, Suisse, ÉUA) 1994-2002
Patients	**2143** / 2500
Inclusion	HSA anévrysmale Traitement envisagé **Équipoise** p/r modalité tx
Exclusion	HSA > 28 jrs 1 ou 2 tx inappropriés
Traitement	Clip vs coil
Issue primaire	**mRS ≥ 3 à 1 an**

78% exclus (validité externe?)

	Endovascular treatment (n=1073)	**Neurosurgery (n=1070)**
Male sex	400 (37%)	399 (37%)
Age (years)*	52 (44–60, 18–87)	52 (43–60, 18–84)
WFNS grade		
1	674 (63%)	661 (62%)
2	269 (25%)	280 (26%)
3	66 (6%)	68 (6%)
4	38 (4%)	36 (3%)
5	11 (1%)	9 (1%)
6 (not assessable)†	15 (1%)	16 (1%)
Maximum target aneurysm lumen size (mm)		
⩽5	552 (51%)	572 (53%)
6–10	438 (41%)	426 (40%)
⩾11	83 (8%)	72 (7%)
Number of aneurysms detected		
1	836 (78%)	850 (79%)
2	173 (16%)	170 (16%)
3	44 (4%)	35 (3%)
⩾4	20 (2%)	15 (1%)
Time between SAH and randomisation (days)*	2 (1–4, 0–26)	2 (1–5, 0–28)

WFNS=World Federation of Neurological Surgeons clinical grading scale.[18]
*Median (IQR, range). †Patient ventilated and clinical state could not be assessed.

Table 1: **Baseline characteristics**

75% < 60 ans

88%

93%

Molyneux et al. Lancet 2002

International Subarachnoid Aneurysm Trial (ISAT)

	ISAT (Lancet 2002)
Devis	RCT multicentrique pragmatique (RU, Suède, Finlande, Canada, Allemagne, France, Australie, Danemark, Suisse, ÉUA) 1994-2002
Patients	**2143** / 2500
Inclusion	HSA anévrysmale Traitement envisagé Équipoise p/r modalité tx
Exclusion	HSA > 28 jrs 1 ou 2 tx inappropriés
Traitement	Clip vs coil
Issue primaire	**mRS ≥ 3 à 1 an**

	Right	Midline	Left	Total
Anterior cerebral artery				
Anterior communicating	219	549	205	973
Proximal to anterior communicating	9	..	7	..
Pericallosal	46	..	49	..
Subtotal	..	..	..	1084 (50·5%)
Internal carotid artery				
Proximal or ophthalmic region	12	..	18	30
Posterior communicating region	313	..	223	536
Bifurcation	34	..	45	79
Other internal carotid	27	..	26	53
Subtotal	286	..	304	698 (32·5%)
Middle cerebral artery				
Proximal to bifurcation	14	..	14	..
Bifurcation	163	..	94	..
Distal to main bifurcation	7	..	11	..
Subtotal	184	..	119	303 (14·1%)
Posterior circulation				
Basilar bifurcation	..	17	..	..
Basilar trunk	..	1	..	..
Superior cerebellar	..	5	..	..
Posterior cerebral	1	..	3	..
Posterior inferior cerebellar	9	..	22	..
Subtotal	..	..	..	58 (2·7%)
Total	..	..	..	2143 (100%)

Table 2: **Aneurysm locations**

97%

Molyneux et al. Lancet 2002

International Subarachnoid Aneurysm Trial (ISAT)

- Traitement par voie endovasculaire…
  - ↓ dépendance et mortalité (mRS ≥ 3) 23.5 vs 30,9% (p=0.0001)
  - ↓ risque absolu de 7,4%, NNT ~ 14
  - Plus de récidives de saignement à 1 an (2,6% vs 1%)
    - Oblitération complète de l'anévrysme 66% vs 82%
  - Moins de convulsion à 1 an (1% vs 2%)
  - Évolution fonctionnelle chez < 40 ans similaires dans les 2 groupes

- Petits anévrysmes (< 1 cm)
- Circulation antérieure (97%)
- Bas grades (WFNS I-II 88%)
- Patients relativement jeunes

	Endovascular treatment (n=801)	Neurosurgery (n=793)
Modified Rankin scale		
0 No symptoms	207 (25·8%)	152 (19·2%)
1 Minor symptoms	217 (27·1%)	220 (27·7%)
2 Some restriction in lifestyle	187 (23.4%)	178 (22·4%)
(0–2 inclusive)	*611 (76·3%)*	*550 (69·4%)*
3 Significant restriction in lifestyle	80 (10·0%)	106 (13·4%)
4 Partly dependent	24 (3·0%)	32 (4·0%)
5 Fully dependent	21 (2·6%)	25 (3·2%)
6 Dead	65 (8·1%)	80 (10·1%)
(3–6 inclusive)	*190 (23·7%)*	*243 (30·6%)*

Data in Italics are primary outcome.

Table 6: **Outcome at 1 year in 1594 patients (primary outcome)**

Molyneux et al. Lancet 2002
Molyneux et al. Lancet 2005
Molyneux et al. Lancet Neurol 2009
Molyneux et al. Lancet 2015

International Subarachnoid Aneurysm Trial (ISAT)

- Traitement par voie endovasculaire…

- À 5 ans
  - Mortalité diminuée (11% vs 14%, p= 0,03)
  - Autonomie (mRS ≤ 2) idem (83% vs 82%)
  - Moins de convulsions
  - Plus de resaignement de l'anévrysme traité

- À 10 ans
  - Mortalité idem (17% vs 21%)
  - Autonomie (mRS ≤ 2) idem (82% vs 78%)
  - Plus de survivant et autonome OR 1,34 (1,07-1,67)

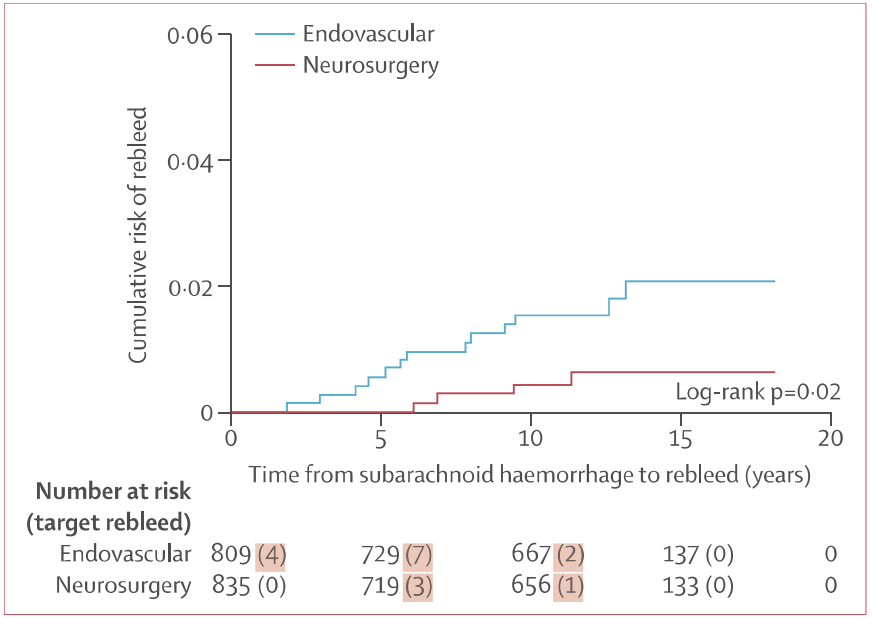


Figure 1: **Kaplan-Meier plot of cumulative risk of rebleeding from target (treated) aneurysm later than 1 year after subarachnoid haemorrhage**

Molyneux et al. Lancet 2002
Molyneux et al. Lancet 2005
Molyneux et al. Lancet Neurol 2009
Molyneux et al. Lancet 2015

The Barrow Ruptured Aneurysm Trial (BRAT)

	BRAT (J Neurosurg 2012)
Devis	Pseudo-randomisée monocentrique 2003-2007
Patients	**472** 57 – absence d'anévrysme
Inclusion	Age 18-80 ans HSA non-traumatique aux SI
Exclusion	HSA > 14 jrs HSA traumatique
Traitement	Clip vs coil
Issue primaire	**mRS ≥ 3 à 1 an**

- Étude pilote
- Devis ajusté à réalité de pratique
  - Politique d'alternance de traitement
  - Intent-to-treat
  - Droit de premier regard aux traitement alloué
  - 4 neurochirurgiens (2 endovasc, 2 chx)
- Absence d'anévrysme 57 patients

McDougall et al. J Neurosurg 2012

The Barrow Ruptured Aneurysm Trial (BRAT)

TABLE 2: Hunt and Hess grades at presentation in 471 patients in the BRAT*

Hunt & Hess Grade	No. Assigned to Clip Group (%)	No. Assigned to Coil Group (%)
I	32 (13.4)	31 (13.3)
II	92 (38.7)	93 (39.9)
III	71 (29.8)	61 (26.2)
IV	29 (12.2)	34 (14.6)
V	14 (5.9)	14 (6.0)

~ 50%

* The number originally assigned to surgical clipping was 238; the number originally assigned to coil therapy was 233.

TABLE 1: Patient and aneurysm characteristics in the BRAT*

Characteristic	No. Assigned to Clip Group (%)	No. Assigned to Coil Group (%)	p Val-ue†
total no. of patients	238	233	
mean age in yrs	53.1 ± 12.8	54.3 ± 12.0	0.33
female	166 (69.7)	166 (71.2)	0.72
status at presentation			
mean GCS score	12.3 ± 3.6	12.5 ± 3.6	0.75
mean Hunt & Hess grade	2.6 ± 1.1	2.6 ± 1.1	0.94
mean Fisher grade	2.7 ± 0.7	2.7 ± 0.6	0.77
aneurysm feature			
size in mm§			0.61
mean	6.8 ± 4.1	6.6 ± 4.0	
median; IQR	6.0; 4–8	6.0; 4–8	
location			0.62‡
posterior circulation	38 (16.0)	32 (13.7)	
anterior circulation	174 (73.1)	169 (72.5)	
angiography negative	26 (10.9)	31 (13.3)	
other	not applicable	1 (0.4)	

Ant 83%
Post 17%

* IQR = interquartile range.
† Continuous variables were analyzed using the Wilcoxon test, and nominal variables using chi-square tests, unless otherwise noted. The means are expressed ± SD throughout.
‡ Analyzed using the Fisher exact test.
§ Calculated based on 212 cases for the surgical clipping group and 201 for the coil embolization group.

McDougall et al. J Neurosurg 2012

The Barrow Ruptured Aneurysm Trial (BRAT)

- Traitement par voie endovasculaire…
  - ↓ dépendance et mortalité (mRS ≥ 3) 23.2 vs 33.7% (p=0.02)
  - ↓ risque absolu de 10,5%, NNT ~ 10
  - Même lorsque ajusté pour grade > 2 ou âge > 50 ans
  - Même lorsque analysé par traitement reçu et lorsque « cross-over » exclus

TABLE 4: Multivariable analysis of patients with poor outcome (mRS score > 2) at 1 year in the BRAT

Characteristic	OR (95% CI)	p Value
clipping*	1.72 (1.09–2.76)	0.020
age >50 yrs	2.03 (1.23–3.42)	0.007
Hunt & Hess grade >II†	3.51 (2.21–5.68)	<0.0001

* Includes all patients assigned to surgical clipping (intent to treat).
† The Hunt and Hess grade is entered into the regression as a binary variable.

McDougall et al. J Neurosurg 2012

Choix de modalité de sécurisation

- Devis différent mais signal idem favorisant traitement endovasculaire
- Si traitable par 2 approches, embolisation généralement privilégié
- Anatomie de l'anévrysme
  - Non favorable à embolisation: géant, collet large (ratio > 0,5), fusiforme
- Condition clinique + comorbidités du patient
- Évaluation multidisciplinaire

Preference for Treatment of Unsecured Aneurysms[a] TABLE 3-5

Treatment Type	Clinical or Aneurysm Factors Supporting Treatment Type
Endovascular coiling	Older age, poor clinical grade, multiple comorbidities, top of the basilar aneurysm, high surgical risk, aneurysm suitable for coiling or clipping
Surgical clipping	Aneurysm with wide neck-to-body ratio, crucial arteries arising from aneurysm dome, middle cerebral artery aneurysm, aneurysm with large parenchymal hematoma

Muehlschlegel et al. Continuum 2018

TABLE 3. Choice of Technique for Intracranial Aneurysms

Endovascular coiling	Posterior circulation aneurysms
	Basilar tip aneurysms
	Intercavernous internal carotid artery aneurysms
	Elderly patients
	Patients with comorbid conditions
Surgical clipping	Middle cerebral artery aneurysms
	Fusiform aneurysms
	Giant aneurysms
	Aneurysms with wide neck
	Aneurysms at arterial bifurcations
	Ruptured aneurysms
	Younger patients

D'Souza S. J Neurosurg Anesthesiol 2015

A randomized trial comparing endovascular and surgical management of ruptured intracranial aneurysms excluded from previous trials

Tim E. Darsaut, MD,[1] Nicolas Lecaros, MD,[2] Pierre-Olivier Comby, MD,[2] Roland Jabre, MD,[3] Daniela Iancu, MD,[2] Daniel Roy, MD,[2] Alain Weill, MD,[2] Michel W. Bojanowski, MD,[3] Chiraz Chaalala, MD,[3] Gilles El Hage, MD,[3] Alain Bilocq, MD,[4] Eric Truffer, MD,[4] J. Max Findlay, MD, PhD,[1] Jeremy L. Rempel, MD,[5] Michael M. C. Chow, MD,[1] Cian J. O'Kelly, MD,[1] Robert A. Ashforth, MD,[5] Owen Stechishin, MD,[5] Thomas Gaberel, MD,[6] Charlotte Barbier, MD,[7] Fuat Arikan, MD, PhD,[8] Ignacio Arrese, MD,[9] Rosario Sarabia, MD,[9] David J. Altschul, MD,[10] Miguel Chagnon, MSc,[11] Justine Zehr, MSc,[11] Jai J. S. Shankar, MD,[12] François Proust, MD,[13] Guylaine Gevry, BSc,[14] and Jean Raymond, MD[2,14]

ISAT-2

- RCT multicentrique pragmatique
- Inclusion: HSA < 30 jrs, WFNS 1-4, adressable par ligature et embolisation
- Exclusion: anévrysme associé à MAV, apex basilaire
- But: inclure des patients qui auraient été exclus de ISAT
- Exemples:
  - Anévrysme > 1 cm
  - Circulation postérieure
  - WFNS III-IV
  - Âge > 70 ans

Darsaut et al. J Neurosurg 2025

A randomized trial comparing endovascular and surgical management of ruptured intracranial aneurysms excluded from previous trials

Tim E. Darsaut, MD,[1] Nicolas Lecaros, MD,[2] Pierre-Olivier Comby, MD,[2] Roland Jabre, MD,[3] Daniela Iancu, MD,[2] Daniel Roy, MD,[2] Alain Weill, MD,[2] Michel W. Bojanowski, MD,[3] Chiraz Chaalala, MD,[3] Gilles El Hage, MD,[3] Alain Bilocq, MD,[4] Eric Truffer, MD,[4] J. Max Findlay, MD, PhD,[1] Jeremy L. Rempel, MD,[5] Michael M. C. Chow, MD,[1] Cian J. O'Kelly, MD,[1] Robert A. Ashforth, MD,[5] Owen Stechishin, MD,[5] Thomas Gaberel, MD,[6] Charlotte Barbier, MD,[7] Fuat Arikan, MD, PhD,[8] Ignacio Arrese, MD,[9] Rosario Sarabia, MD,[9] David J. Altschul, MD,[10] Miguel Chagnon, MSc,[11] Justine Zehr, MSc,[11] Jai J. S. Shankar, MD,[12] François Proust, MD,[13] Guylaine Gevry, BSc,[14] and Jean Raymond, MD[2,14]

ISAT-2

- 270/1896 pts en 10 ans – cessé prématurément
- mRS >2 à 1 an 30 vs 27% (NS)
- **Ligature: trajectoire plus compliquée**
  - **↑ durée de séjour (29 vs 19 jrs)**
  - **↑ DVE (42 vs 24%) et DVP (19 vs 7%)**
  - **↑ craniectomie décompressive (12 vs 5%)**
  - **↑ vasospasme symptômatique (29 vs 18%)**
- **Embolisation: ↑ anévrysme résiduel (20 vs 8%)**

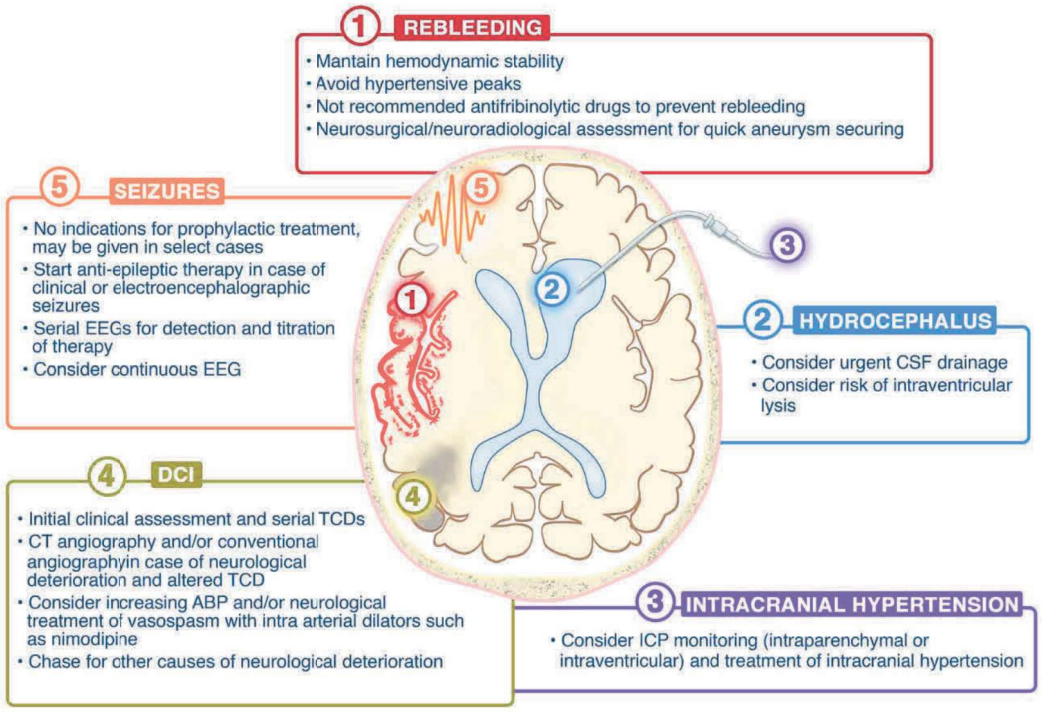
TABLE 1. Patient and aneurysm characteristics

Characteristic	Surgical	EVT
No. of patients	133	130
Mean age at treatment ± SD, yrs	57.5 ± 12.5)	57.1 ± 11.6
Age ≥70 yrs	19 (14)	17 (13)
Female sex	94 (71)	86 (66)
Prerupture mRS score		
0	117 (88)	116 (89)
1	15 (11)	11 (8)
2	1 (1)	3 (2)
WFNS grade		
I–III	111 (83)	107 (82)
IV	22 (17)	23 (18)
Index aneurysm location		
Anterior circulation	124 (93)	123 (95)
Ophthalmic/paraophthalmic artery	4 (3)	1 (1)
PCoA/AChA	20 (15)	19 (15)
Carotid terminus	1 (1)	3 (2)
MCA	56 (42)	50 (38)
ACoA	33 (25)	39 (30)
Pericallosal artery	10 (8)	11 (8)
Posterior circulation	9 (7)	7 (5)
Aneurysm size, mm		
Mean	7.5	6.6
Median (range)	6 (1–48)	6 (2–25)
≤3	32 (24)	29 (22)
4–9	72 (54)	79 (61)
≥10	29 (22)	22 (17)
Wide neck, ≥ 4 mm	43 (32)	40 (31)
Recurrent, previously treated index aneurysm	6 (5)	4 (3)
Multiple aneurysms	24 (18)	28 (22)
Intraparenchymal hematoma >2 cm	22 (17)	27 (21)
Pretreatment infarction	6 (5)	4 (3)
Fisher grade		
0–2	45 (34)	38 (29)
3 or 4	88 (66)	92 (71)
Treatment		
Mean (median) time from SAH to treatment, days	4 (1)	2 (1)
Adherence to allocated treatment	124 (93)	127 (98)
Aneurysm rerupture after randomization, prior to treatment*	4 (3)	4 (3)
Received stent or flow diverter	1 (1)	17 (13)
Received parent vessel occlusion	0	4 (3)

Darsaut et al. J Neurosurg 2025

Complications intracrâniennes

- Priorité de prévenir le dommage cérébral secondaire
- Hydrocéphalie
- Convulsions
- Hypertension intracrânienne
- Ischémie cérébrale retardée



Robba et al. Intensive Care Med 2024

Prévenir dommage cérébral secondaire

- Hydrocéphalie
  - 20% des HSA
  - Résolution spontanée en 24h - 30%
  - Risques DVE
    - Infection 7.9%
    - Hémorragie (HIV, HIP) 8.4%
      - Symptomatique 0.7%
    - **Resaignement 0-43% - précipité par DVE?**
  - Dérivation permanente 7%

- **Possibilité d'amélioration grade clinique post-DVE**
- Évolution fonctionnelle corrélée avec ce « nouveau » grade clinique

Ransom et al. Neurocrit Care 2007
Macdonald RL et al. Lancet 2017

Prévenir dommage cérébral secondaire

- Convulsions
  - Ictus 4-26%, durant hospitalisation 1-28%
  - Épilepsie à long terme ~ 2%
  - FR: jeunes, inconscience @ ictus, HTA, MCA, haut grade radiologique, HIP, HSD, ligature chirurgicale, DCI
  - Pas d'ERC
  - Phénytoïne associée à mauvaise évolution neurologique

Lignes directrice NCS en cours de révision

COR	LOE	Recommendations
Patients who present without seizures		
2a	B-NR	1. In patients with aSAH and either fluctuating neurological examination, depressed mental state, ruptured MCA aneurysm, high-grade SAH, ICH, hydrocephalus, or cortical infarction, cEEG monitoring is reasonable to detect seizures.[291,405,406]
2b	B-NR	2. In patients with aSAH and high-seizure-risk features (ie, ruptured MCA aneurysm, high-grade SAH, ICH, hydrocephalus, and cortical infarction), use of prophylactic antiseizure medication(s) may be reasonable to prevent seizures.[407–413]
3: No benefit	B-R	3. In patients with aSAH without high-seizure-risk features (ie, ruptured MCA aneurysm, high-grade SAH, ICH, hydrocephalus, and cortical infarction), prophylactic treatment with antiseizure medication is not beneficial.[392]
3: Harm	B-NR	4. In patients with aSAH, phenytoin for seizure prevention and/or antiseizure prophylaxis is associated with excess morbidity and mortality.[407–411,413–415]
Patients who present with seizures		
2a	B-NR	5. In patients with aSAH who present with seizures, treatment with antiseizure medications for ≤7 days is reasonable to reduce seizure-related complications in the perioperative period.[411,416,417]
3: No benefit	B-NR	6. In patients with aSAH without prior epilepsy who present with seizures, treatment with antiseizure medications beyond 7 days is not effective for reducing future SAH-associated seizure risk.[408,410,411]

AHA/ASA Hoh et al. Stroke 2023

Prévenir dommage cérébral secondaire

- Hypertension intracrânienne - 50% des HSA

- Mécanismes d'hypertension intracrânienne
  - Œdème cérébral (ischémie focale / globale)
  - HIP ➔ effet de masse
  - HCP aigu (communicante / non-communicante)
  - Vasospasme ➔ vasodilatation en aval
  - Perte d'autorégulation
  - Convulsions
  - Causes extracrâniennes (hypercapnie, hypoxémie, hypo/hypertension, hyperthermie, …)
  - **Marqueur de dommage cérébral extensif?**

- Traitement HTIC en HSA - principes largement extrapolé de TCC
  - Viser PIC < 20 mmHg
  - Viser PPC entre 50-70 mmHg
  - **Lignes directrices restent muettes…**

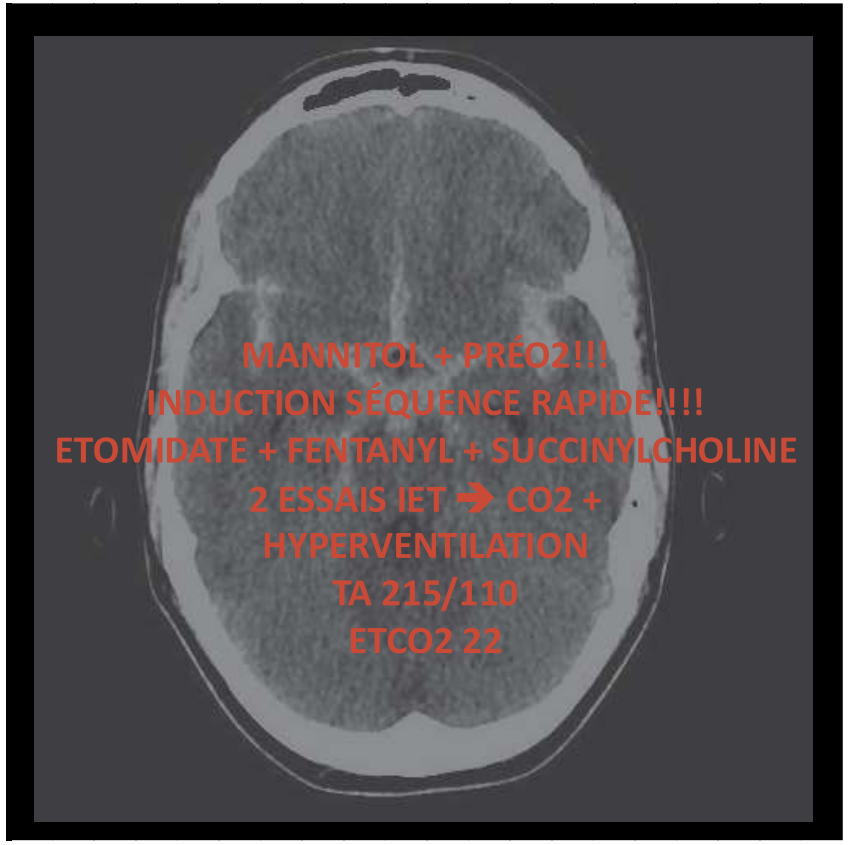
SIAARTI Picetti et al. J Anesth Analg Crit Care 2022

Macdonald RL et al. Lancet 2017

HSA non-sécurisée: induction / intubation

48 ans, pas ATCD, céphalée brutale

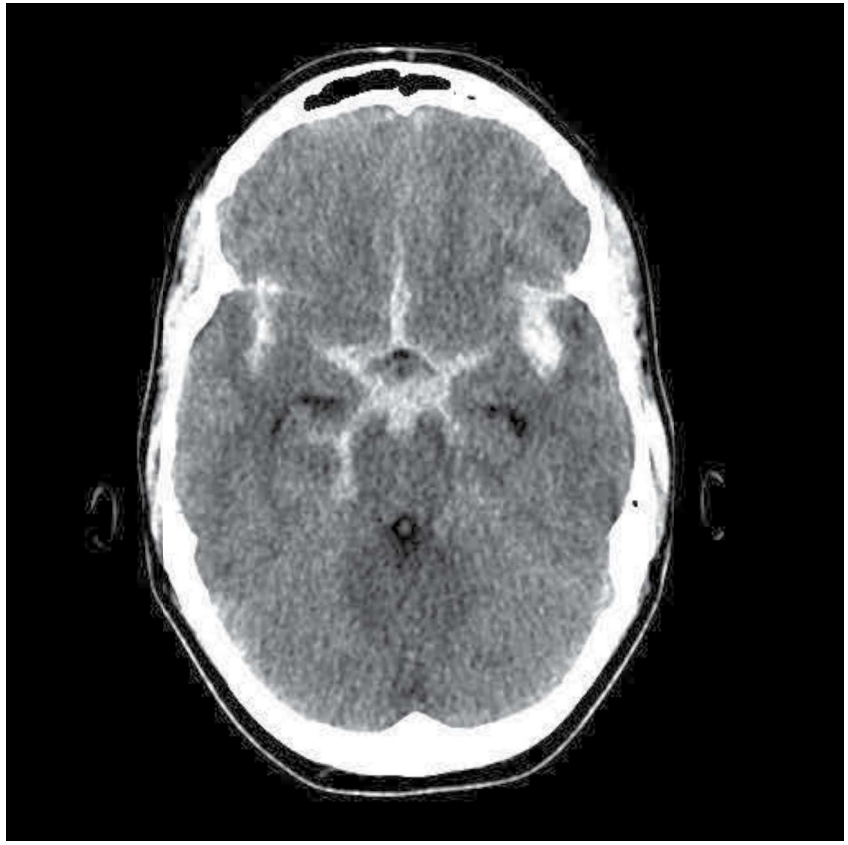
- AEC au retour du scan
- TA 180/95 FC 75 SpO2 95%



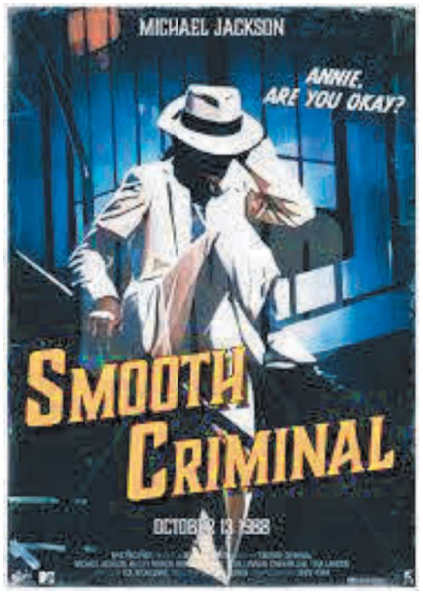
HSA non-sécurisée: induction / intubation

37 ans, G1 37+, céphalée brutale

- AEC au retour du scan
- TA 165/90 FC 92 SpO2 94%
- Pupilles isocores



HSA non-sécurisée: induction / intubation



HSA non-sécurisée: induction / intubation

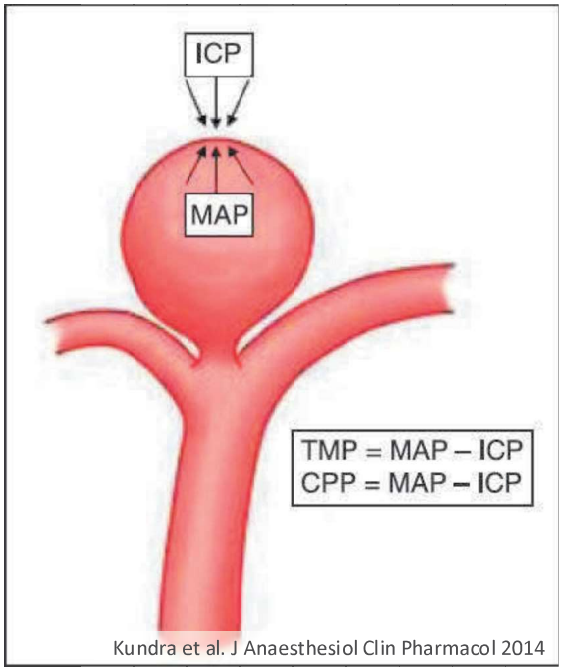
25 ans, pas ATCD, céphalée brutale

- AEC au retour du scan
- TA 200/105 FC 45 SpO2 92%

HSA non-sécurisée: induction / intubation

- Prévenir réponse adrénergique à laryngoscopie
- Titration d'agents – éviter variation HD brusques
- Malgré HTA et agents anti-HTA, anticiper hypoTA
- HSA haut grade non-HTA ➔ 💔
- Canule artérielle avant induction
- Si DVE in situ ➔ lecture PIC (présence ou absence d'HTIC?)

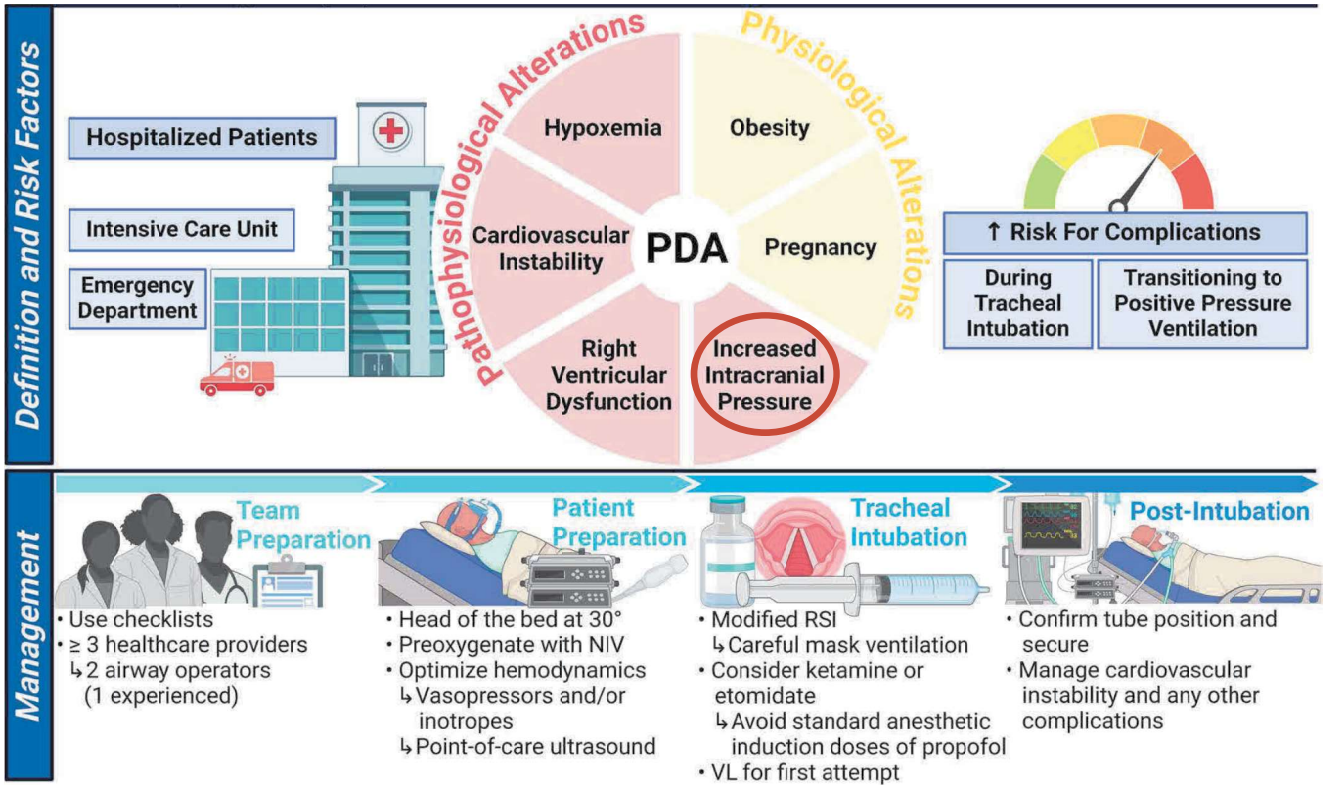
- Éviter interventions qui vont…
  - ↑↑↑ PA (sauf si hypoTA sévère)
  - ↓↓↓ PIC (sauf si « brain code »)



Kundra et al. J Anaesthesiol Clin Pharmacol 2014

CONFERENCE REPORTS AND EXPERT PANEL

Tracheal intubation in critically ill adults with a physiologically difficult airway. An international Delphi study



Hemodynamic Monitoring and Optimization	The minimum mandatory monitoring in patients with a PDA undergoing tracheal intubation should include non-invasive blood pressure, continuous electrocardiogram, and pulse oximetry.
	Hemodynamics should be optimized prior to tracheal intubation in patients with a PDA. Interventions such as vasopressor and/or inotrope infusion administration can help prevent and/or minimize peri-intubation cardiovascular collapse.
	Use of peri-procedural point-of-care ultrasound, when feasible, can improve the safety of the tracheal intubation by aiding the assessment and management of cardio-respiratory compromise.

Karamchandani et al. Intensive Care Med 2024

Recommandations intra-opératoires limitées…

COR	LOE	Recommendations
2a	B-R	1. In patients with aSAH, the intraoperative use of mannitol or hypertonic saline can be effective in reducing ICP and cerebral edema.[135,136]
2a	B-NR	2. In patients with aSAH, anesthetic goals should include minimizing postprocedural pain, nausea, and vomiting.[137–140]
2a	B-NR	3. In patients with aSAH, prevention of intraoperative hyperglycemia and hypoglycemia during aneurysm surgery is reasonable to improve outcomes.[141–147]
2a	C-LD	4. In patients with aSAH and an unsecured ruptured aneurysm, frequent intraoperative BP monitoring and BP control are reasonable to prevent ischemia and rerupture.[148–153]
2b	B-NR	5. In patients with aSAH, intraoperative neuromonitoring may be reasonable to guide anesthetic and operative management.[154–159]
2b	C-LD	6. In patients with aSAH and an uncontrolled intraoperative aneurysmal rupture, adenosine may be considered to facilitate aneurysm clip placement by inducing cardiac standstill and temporary profound pause.[160,161]
3: No benefit	B-R	7. In patients with good-grade aSAH, the routine use of induced mild hypothermia during aneurysm surgery is not beneficial.[147,162–168]

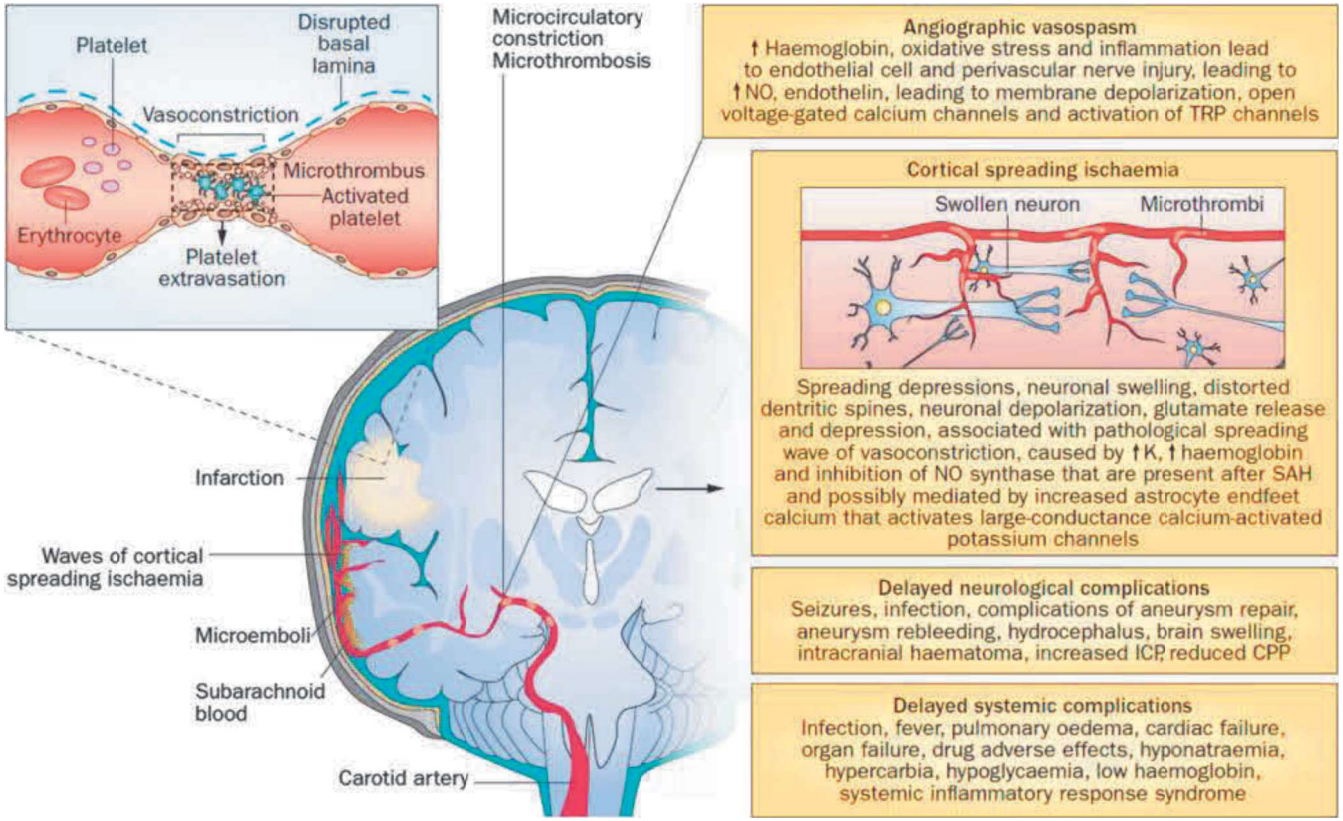
AHA/ASA Hoh et al. Stroke 2023

Ischémie cérébrale retardée *(delayed cerebral ischaemia)*

- <u>Détérioration neurologique retardée</u>
  - Progression EBI
  - Hydrocéphalie
  - Re-saignement
  - Convulsions
  - Cause extra-crânienne
  - **Ischémie cérébrale retardée (DCI)**

- Période à risque J3-J14

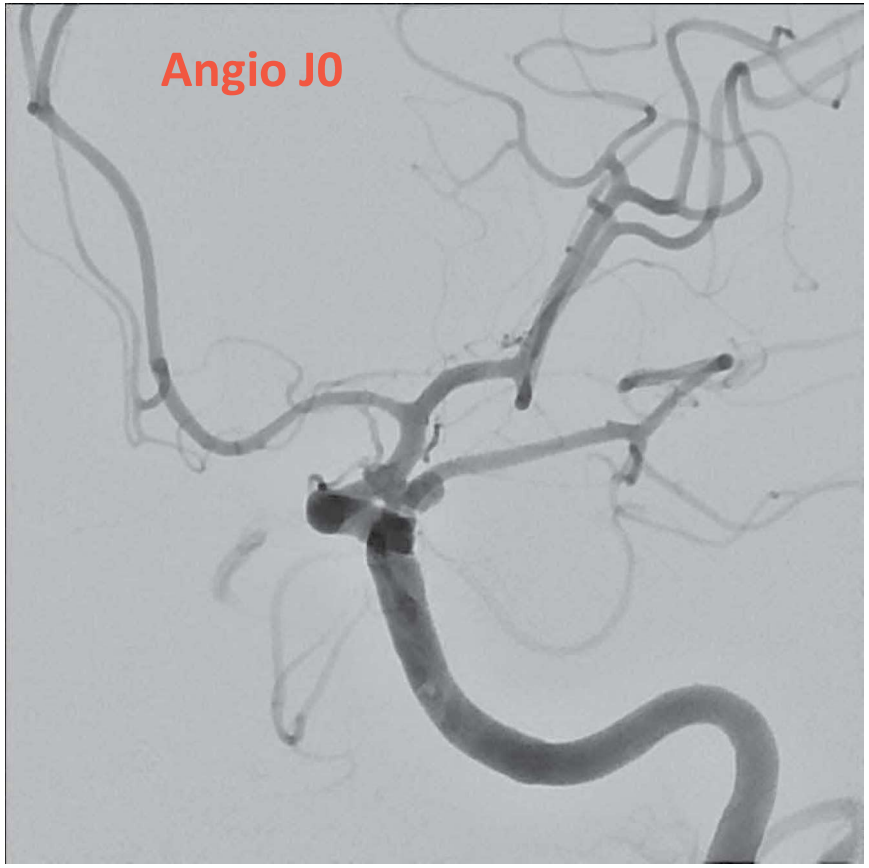
- **Vasospasme** angiographique
- Microthromboses
- Vasoconstriction microvasculaire
- Dysfonction endothéliale
- Altération autorégulation cérébrale
- Dépression corticale propagée
- Contribution de complications extracrâniennes



Macdonald RL. Nat Rev Neurol 2014
de Oliveira Manoel et al. Crit Care 2016

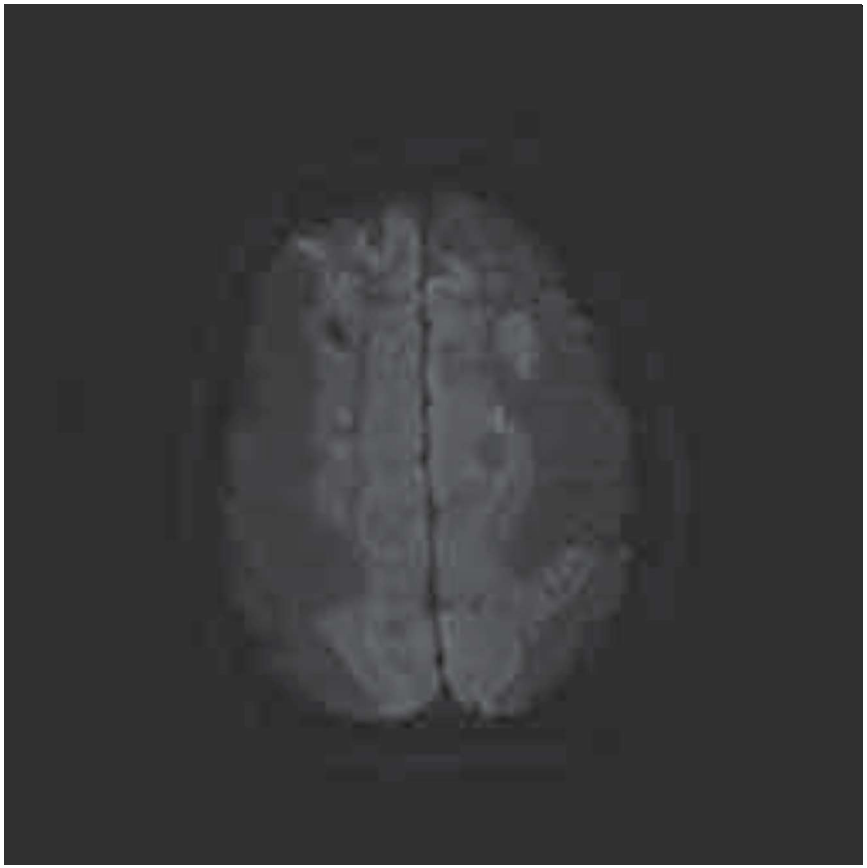
Conséquences de dommage cérébral retardé

- ♀53A WFNS 5 (4), mF 4 (HCP)
- DVE frontale D J0 (PIC 14)
- Anévrysme Pcomm G – embolisée J0
- Extubée J1 ➔
  - Ralentissement psychomoteur
  - Désorientée
  - Communique par phrases simples
  - Parésie MSD 4/5
  - IRM ~N J2



Conséquences de dommage cérébral retardé

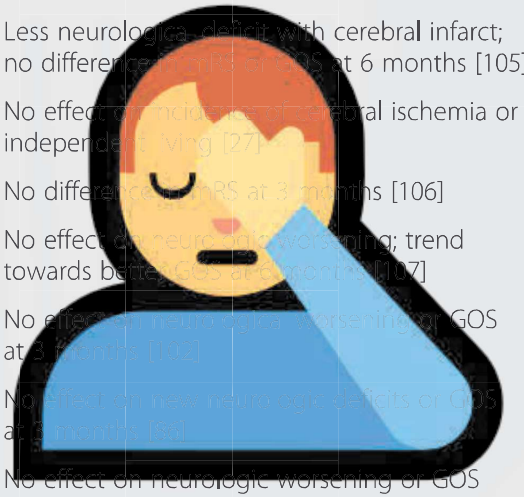
- ♀53A WFNS 5 (4), mF 4 (HCP)
- Détérioration J6
  - DCI et vasospasme sévère
  - Traitement médical
  - Traitement endovasculaire
- IRM catastrophique J14
- Soins palliatifs subséquemment



Prévention

Table 2 Selected pharmacologic interventions that have been evaluated for DCI prevention[a]

Intervention	Effect
Aspirin	No effect on new lesion associated with neurological worsening [103]
Clazosentan	No effect on mortality or vasospasm-related morbidity [5]
Enoxaparin	No effect on DCI or GOS at 3 months [104]
Erythropoietin	Less neurological deficit with cerebral infarct; no difference in mRS or GOS at 6 months [105]
Fludrocortisone	No effect on angiographic cerebral ischemia or independent living [27]
Magnesium	No difference in mRS at 3 months [106]
Methylprednisolone	No effect on neurologic worsening; trend towards better GOS at 3 months [107]
Nicardipine	No effect on neurologic worsening or GOS at 3 months [102]
Prophylactic angioplasty	No effect on new neurologic deficits or GOS at 3 months [92]
Prophylactic hypervolemia	No effect on neurologic worsening or GOS at 3 months [69]
Statins	No effect on DCI, death or mRS at 6 months [108]



Hormis nimodipine (et euvolémie), aucun traitement prophylactique ne semble efficace…

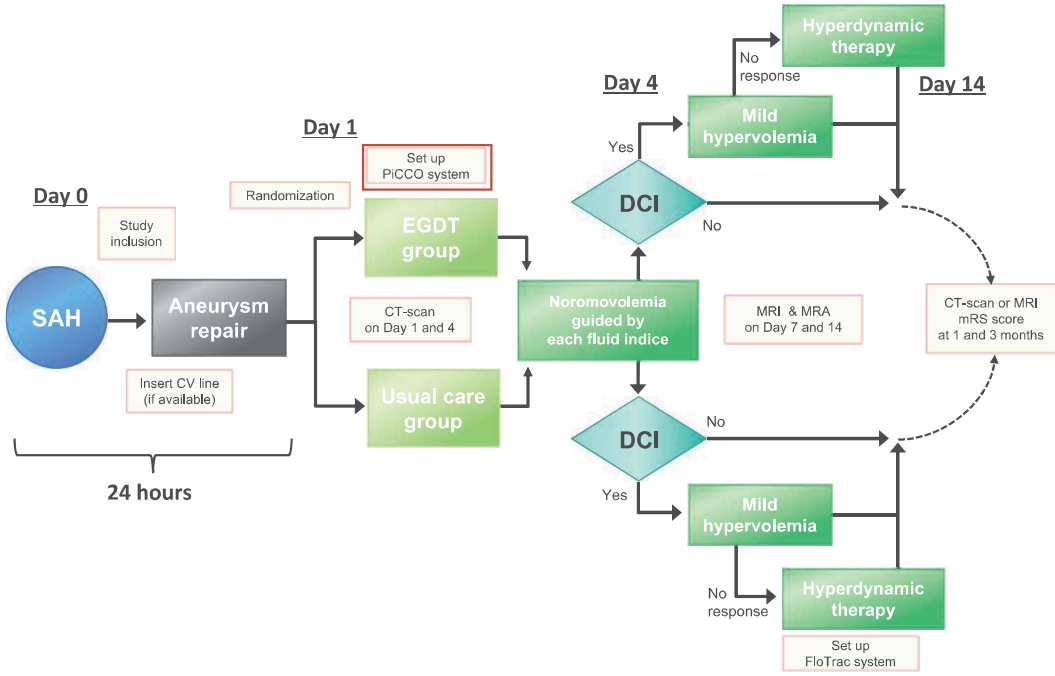
COR	LOE	Recommendations
1	A	1. In patients with aSAH, early initiation of enteral nimodipine is beneficial in preventing DCI and improving functional outcomes.[316–319]
2a	B-NR	2. In patients with aSAH, maintaining euvolemia can be beneficial in preventing DCI and improving functional outcomes.[320,321]
3: No benefit	A	6. In patients with aSAH, routine use of statin therapy to improve outcomes is not recommended.[345,346]
3: No benefit	A	7. In patients with aSAH, routine use of intravenous magnesium to improve neurological outcomes is not recommended.[347,348]
3: Harm	B-R	8. For patients with aSAH at risk of DCI, prophylactic hemodynamic augmentation should not be performed to reduce iatrogenic patient harm.[189,211,349,350]

Francoeur et al. Crit Care 2016
Macdonald RL. Nat Rev Neurol 2014
de Oliveira Manoel et al. Crit Care 2016
Hoh et al. Stroke 2023
Treggiari et al. Neurocrit Care 2023

Gestion volémique en HSA

Impact favorable de thérapie dirigée (EGDT) chez patients à haut risque

- HSA haut grades (WFNS IV-V)
  - ↓ DCI (5 vs 14% p=0.036)
  - ↑ mRS 0-3 (52 vs 36% p=0.026)
  - ↓ séjour USI (14 vs 17j p=0.043)
  - ↑ réponse au tx hyperdynamique
  - ↓ volume et OAP (tendance)
- Complication cardiopulmonaires
  - ↑ mRS 0-3 (63 vs 38% p=0.045)
  - ↓ séjour USI réduite (tendance)



Mutoh et al. Stroke 2014

Gestion volémique en HSA

Impact favorable de thérapie dirigée (EGDT)

- ↓ DCI (13 vs 32% p=0.021)
- Vasospasme idem (50 vs 59%)
- ↓ hypoNa (11 vs 31% p=0.01)
- ↓ œdème cérébral (15 vs 30% p=0.064)
- ↓ infarctus non-DCI (2 vs 11% p=0.051)
- ↑ GOS=5 @ 3 mo (66 vs 44% p=0.025)

- Globalement même quantité de volume…
  - Impact de le donner au bon moment?

Anetsberger et al. Stroke 2020

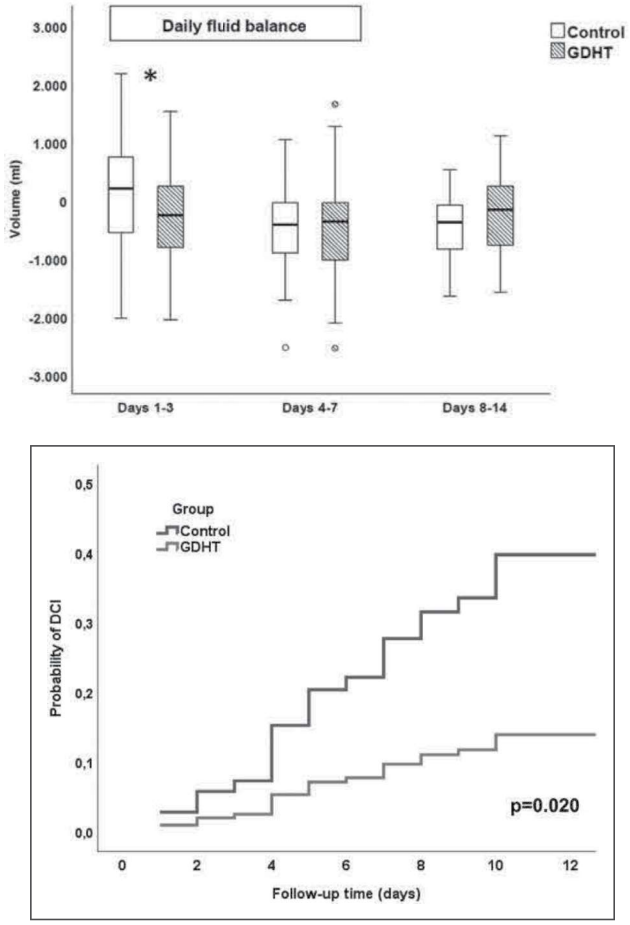


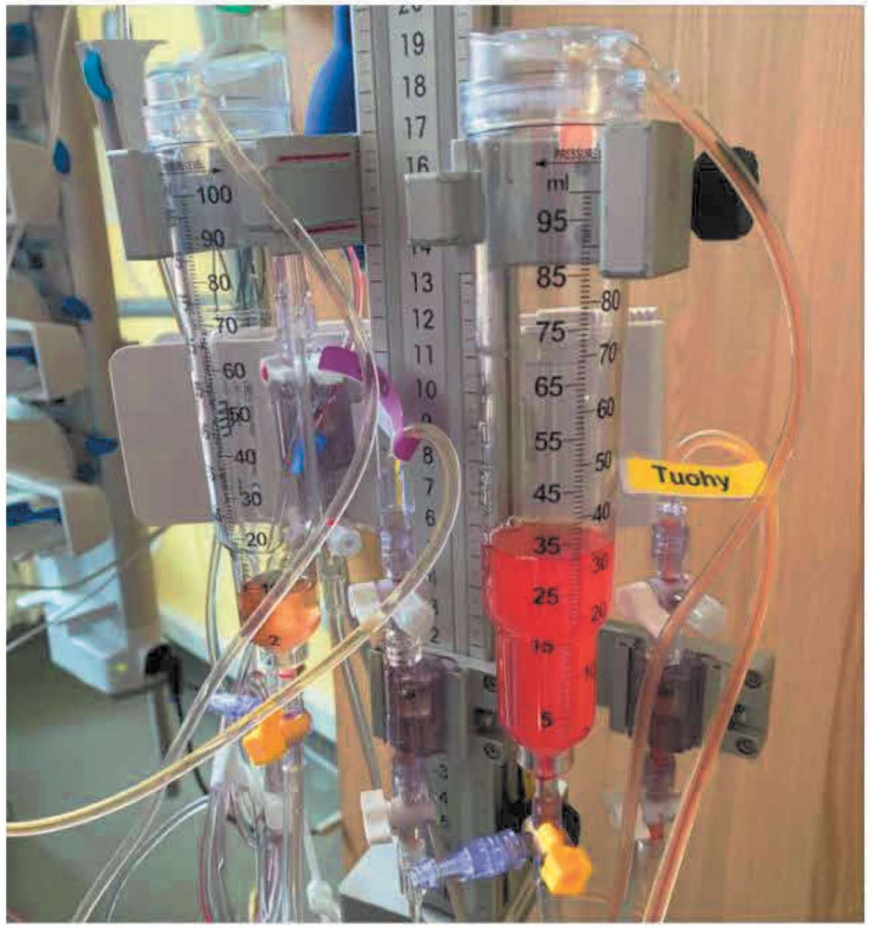
Figure 3. Cox proportional hazards model for goal-directed hemodynamic therapy (GDHT) vs control group.

JAMA Neurology | Original Investigation

Effectiveness of Lumbar Cerebrospinal Fluid Drain Among Patients With Aneurysmal Subarachnoid Hemorrhage
A Randomized Clinical Trial

Stefan Wolf, MD; Dorothee Mielke, MD; Christoph Barner, MD; Vesna Malinova, MD; Thomas Kerz, MD; Maria Wostrack, MD; Patrick Czorlich, MD; Farid Salih, MD; Doortje C. Engel, MD; Angelika Ehlert, MD; Dimitre Staykov, MD; Abdulrahman Y. Alturki, MD; Ulrich Sure, MD; Jürgen Bardutzky, MD; Henry W. S. Schroeder, MD; Ludwig Schürer, MD; Jürgen Beck, MD; Tareq A. Juratli, MD; Michael Fritsch, MD; Johannes Lemcke, MD; Anne Pohrt, Dipl-Math; Bernhard Meyer, MD; Stefan Schwab, MD; Veit Rohde, MD; Peter Vajkoczy, MD; for the EARLYDRAIN Study Group

- RCT multicentrique 19 unités DECA
- 287 pts drain lombaire ≤ 72h HAS
- Drainage LCR 5 mL/h x 8 jrs
- WFNS 1 ~ 33% WFNS 3-5 ~ 50%
- **mRS 3-6 (3mo) 33 vs 45%**
- Vasospasme idem
- ↓ infarctus secondaire 29 vs 40%



Wolf et al. EARLYDRAIN JAMA Neurol 2023

Changement de paradigme

↓ VASOSPASME

ÉVOLUTION FAVORABLE

Etminan et al. J Cereb Blood Flow Metab 2011

Surveillance DCI/vasospasme

COR	LOE	Recommendations
2a	B-NR	1. In patients with aSAH with suspected vasospasm or limited neurological examination, CTA or CT perfusion (CTP) can be useful to detect vasospasm and predict DCI.[270–275]
2a	B-NR	2. In patients with aSAH, transcranial Doppler (TCD) ultrasound monitoring is reasonable to detect vasospasm and predict DCI.[253,276–280]
2a	B-NR	3. In patients with high-grade aSAH, continuous EEG (cEEG) monitoring can be useful to predict DCI.[276,280–292]
2b	B-NR	4. In patients with high-grade aSAH, invasive monitoring of brain tissue oxygenation, lactate/pyruvate ratio, and glutamate may be considered to predict DCI.[293–305]

AHA/ASA Hoh et al. Stroke 2023

Traitements possibles

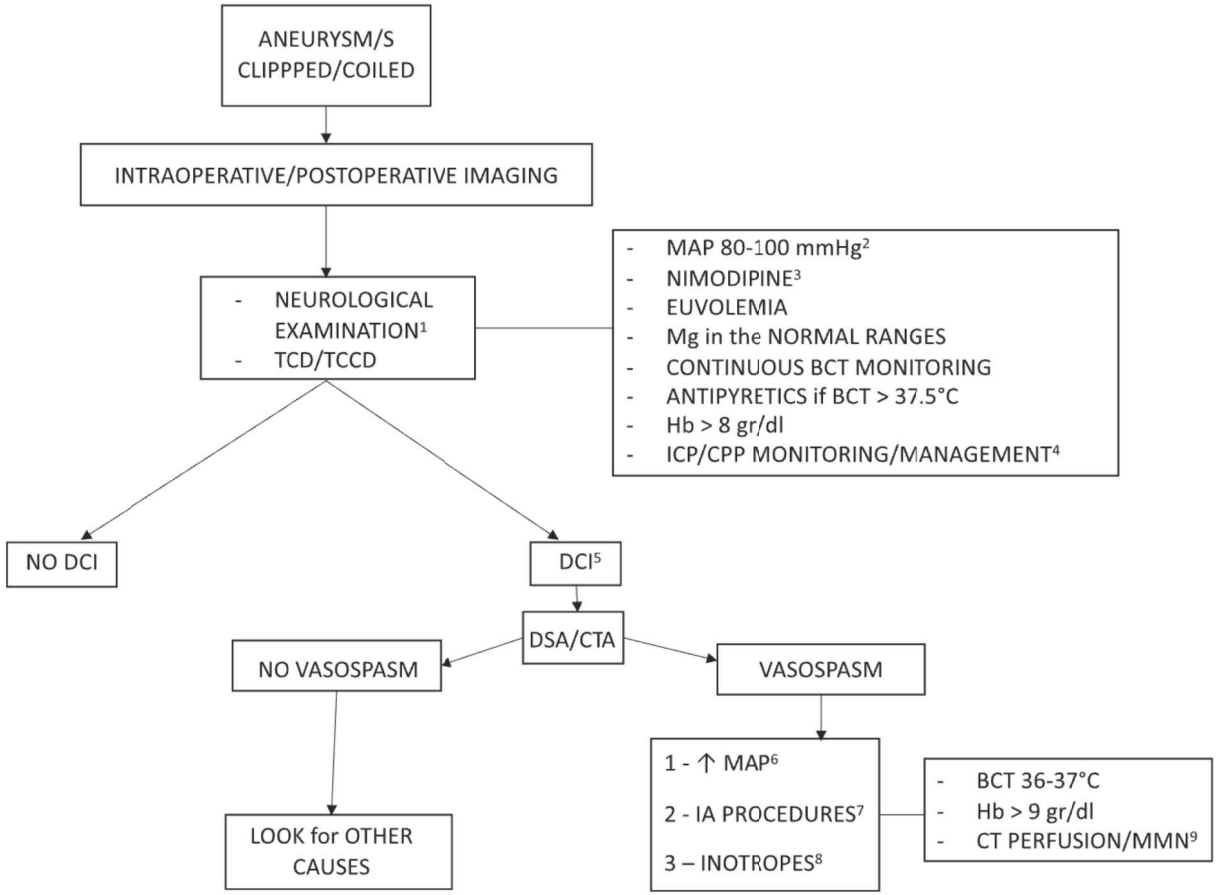
- **AUCUN TRAITEMENT DÉMONTRÉ EFFICACE…**
- Neuromonitoring multimodal pour individualiser thérapie?

- Multiples études en cours
  - Milrinone
  - Anti-inflammatoires
  - Héparine

COR	LOE	Recommendations
2b	B-NR	3. In patients with aSAH and symptomatic vasospasm, elevating systolic BP values may be reasonable to reduce the progression and severity of DCI.[322–325]
2b	B-NR	4. In patients with aSAH and severe vasospasm, use of intra-arterial vasodilator therapy may be reasonable to reverse cerebral vasospasm and reduce the progression and severity of DCI.[326–335]
2b	B-NR	5. In patients with aSAH and severe vasospasm, cerebral angioplasty may be reasonable to reverse cerebral vasospasm and reduce the progression and severity of DCI.[336–344]

Hoh et al. Stroke 2023
Robba et al. Intensive Care Med 2024

DCI / vasospasme – exemple d'algorithme



Picetti et al. J Anesth Analg Crit Care 2022

Prévention / traitement DCI – résumé

Table 1 Prevention and management of delayed cerebral ischemia

Guideline recommendations American Heart Association [30], Neurocritical Care Society [122] & European Stroke Organization [123]	
DCI prevention	
Strong recommendation	Nimodipine (early initiation, enteral) [30, 122, 123]
Moderate recommendation	Maintenance of euvolemia [30, 122, 123]
Insufficient evidence	Calcium channel blockers (other than nicardipine), intravenous or intraventricular [122] or into surgical space [123]
Not recommended	Intravenous nicardipine [122, 123], endothelin receptor antagonist [122], statins [30, 122], magnesium sulphate [30, 122, 123], hypervolemia [122, 123], prophylactic hemodynamic augmentation [30]
Management of DCI	
Weak recommendations	Hemodynamic augmentation if symptomatic vasospasm present [30] Intraarterial vasodilator therapy for severe vasospasm [30] Cerebral angioplasty for severe vasospasm [30]
Insufficient evidence	Hemodynamic augmentation [122, 123]

Hoh et al. Stroke 2023
Robba et al. Intensive Care Med 2024

Augmentation hémodynamique ➔ augmentation DSC?

- 1 seule étude randomisée contrôlée – cessée prématurément
- 41/240 patients prévus, manque de puissance
- HTA (volume + NA) vs contrôle ➔ différence PAM ~ 10 mmHg @ 24h
- Plus d'amélioration clinique dans groupe HTA (57% vs 30%)
- Évolution défavorable (mRS > 3) @ 3 mois IDEM

Table 2. Differences in Change in CBF Values Between the Groups

	On Treatment			Intention to Treat			Crossover Case Excluded		
	No Induced Hypertension (n=13)	Induced Hypertension (n=12)	*P* Value*	No Induced Hypertension (n=12)	Induced Hypertension (n=13)	*P* Value*	No Induced Hypertension (n=12)	Induced Hypertension (n=12)	*P* Value*
Change in overall CBF (median, range)	−8.5 (−42 to 30)	0.1 (−31 to 43)	0.25	−9.7 (−42 to 30)	−1.2 (−31 to 43)	0.25	−9.7 (−42 to 30)	0.1 (−31 to 43)	0.24
Change in lowest CBF (median, range)	1.0 (−23 to 41)	11.2 (−23 to 50)	0.38	1.9 (−23 to 41)	10.3 (−23 to 50)	0.50	1.9 (−23 to 41)	11.2 (−23 to 50)	0.41

HIMALAIA
Gathier et al. Stroke 2015
Gathier et al. Stroke 2018

Augmentation hémodynamique ➔ augmentation DSC?

- 1 seul
- 41/24
- HTA (v @ 24h
- Plus d
- Évolut

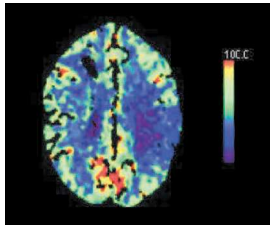
> Our findings do not support the use of induced hypertension to augment overall CBF in aneurysmal subarachnoid hemorrhage patients with DCI. However, a small effect cannot be definitively excluded because a trend was seen in improved CBF in areas with lowest perfusion. This might be of clinical interest, as hypoperfused areas might progress to infarction if not treated. Induced hypertension might thus be beneficial in improving CBF in regions with impaired perfusion. Based on our results, 225 to 250 patients per group would be needed to find a statistically significant difference in change in overall CBF between induced hypertension and no hypertension.

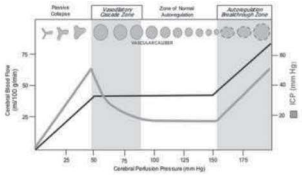
Table 2. Differences in

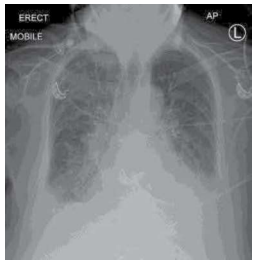
Change in overall CBF (median, range)									
Change in lowest CBF (median, range)	1.0 (−23 to 41)	11.2 (−23 to 50)	0.38	1.9 (−23 to 41)	10.3 (−23 to 50)	0.50	1.9 (−23 to 41)	11.2 (−23 to 50)	0.41

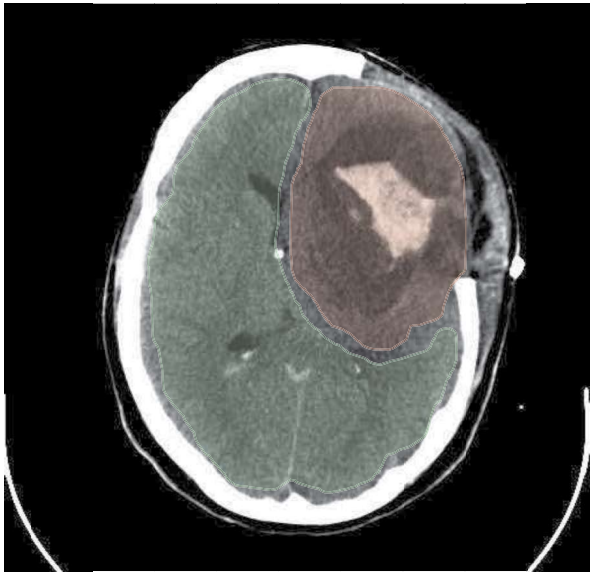
Gathier et al. Stroke 2015
Gathier et al. Stroke 2018

Augmentation hémodynamique ➔ DANGER!





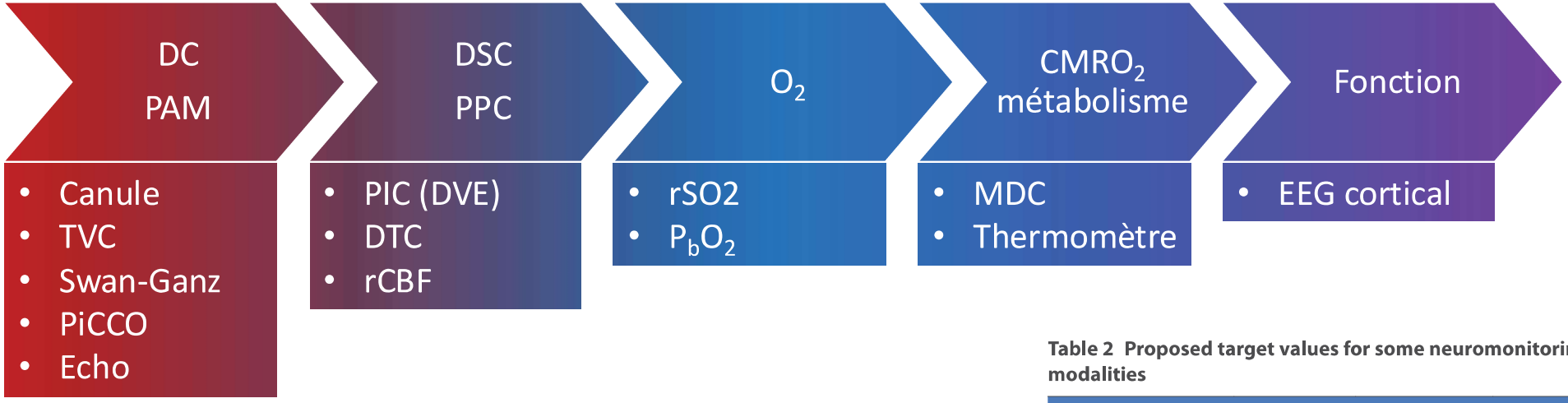




RISQUES

PAM (PPC)

Neuromonitoring multimodal



- Détection de souffrance cérébrale occulte
- Prévention de dommage cérébral secondaire
- Individualisation de thérapie

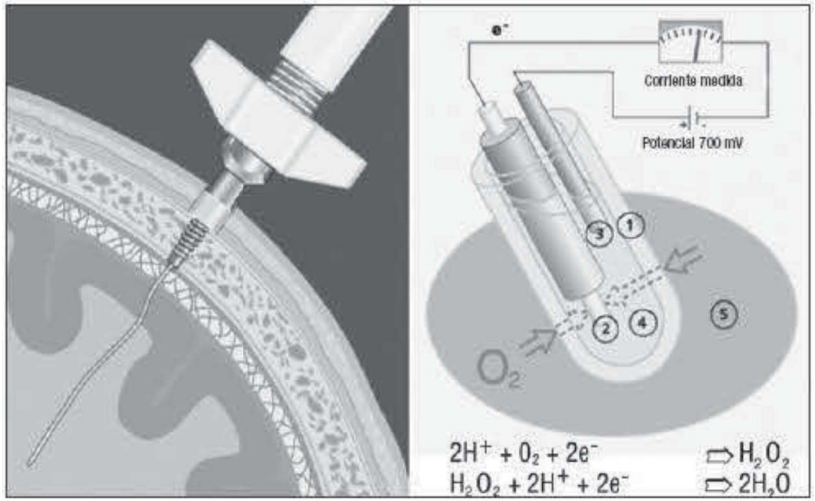
Table 2 Proposed target values for some neuromonitoring modalities

	Normal	Desirable	Critical
ICP	~10 mmHg	<18–22 mmHg	>25 mmHg
CPP	50–60 mmHg	60- (80) mmHg	<50 mmHg
$PbtO_2$	~30 mmHg	20–25 mmHg	<15 mmHg
Lactate/Pyruvate Ratio	<25	<25	>40
Brain Glucose	>1 mmol/l	>0.8 mmol/l	<0.5 mmol/l
Brain temperature	~36.5 °C	36.5–37 °C	>37.5 °C

Meyfroidt et al. Intensive Care Med 2022

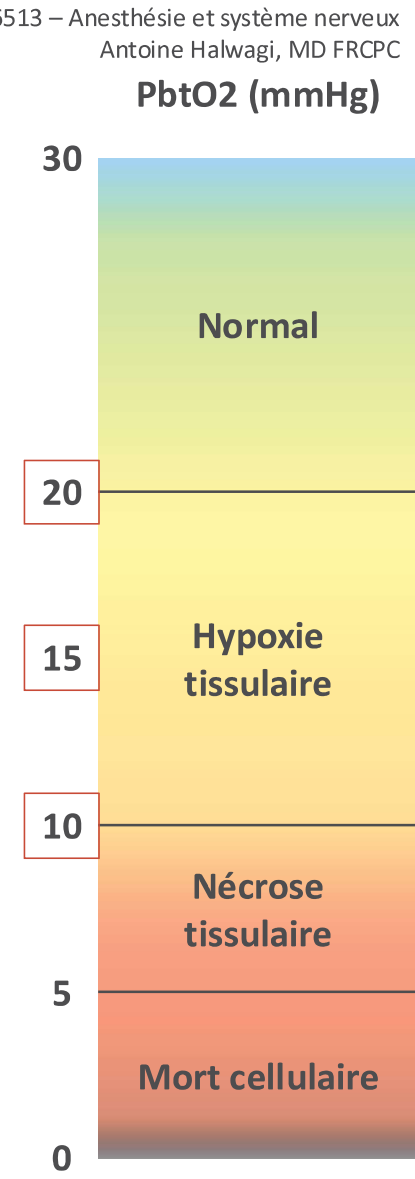
Neuromonitoring avancé: P_bO_2

- Électrode polarographique de Clark ➔ pression tissulaire partielle O_2
  - Diffusion O2 à travers membrane ➔ dépolarisation ➔ courant électrique
  - Mesure pression partielle O2 dans volume de qq mm^3



Déterminants de $P_{bt}O_2$

- Livraison O2 = contenu O2 x débit
  - DSC (DC, PPC)
  - SaO2
  - Hb
  - PaO2
- Consommation O2 = métabolisme
  - CMRO2 – état d'éveil, agitation, convulsions, frissons
  - T°
- Diffusion tissulaire O2
  - Œdème interstitiel
  - Dysfonction microvasculaire



Monitoring de l'oxygénation cérébrale

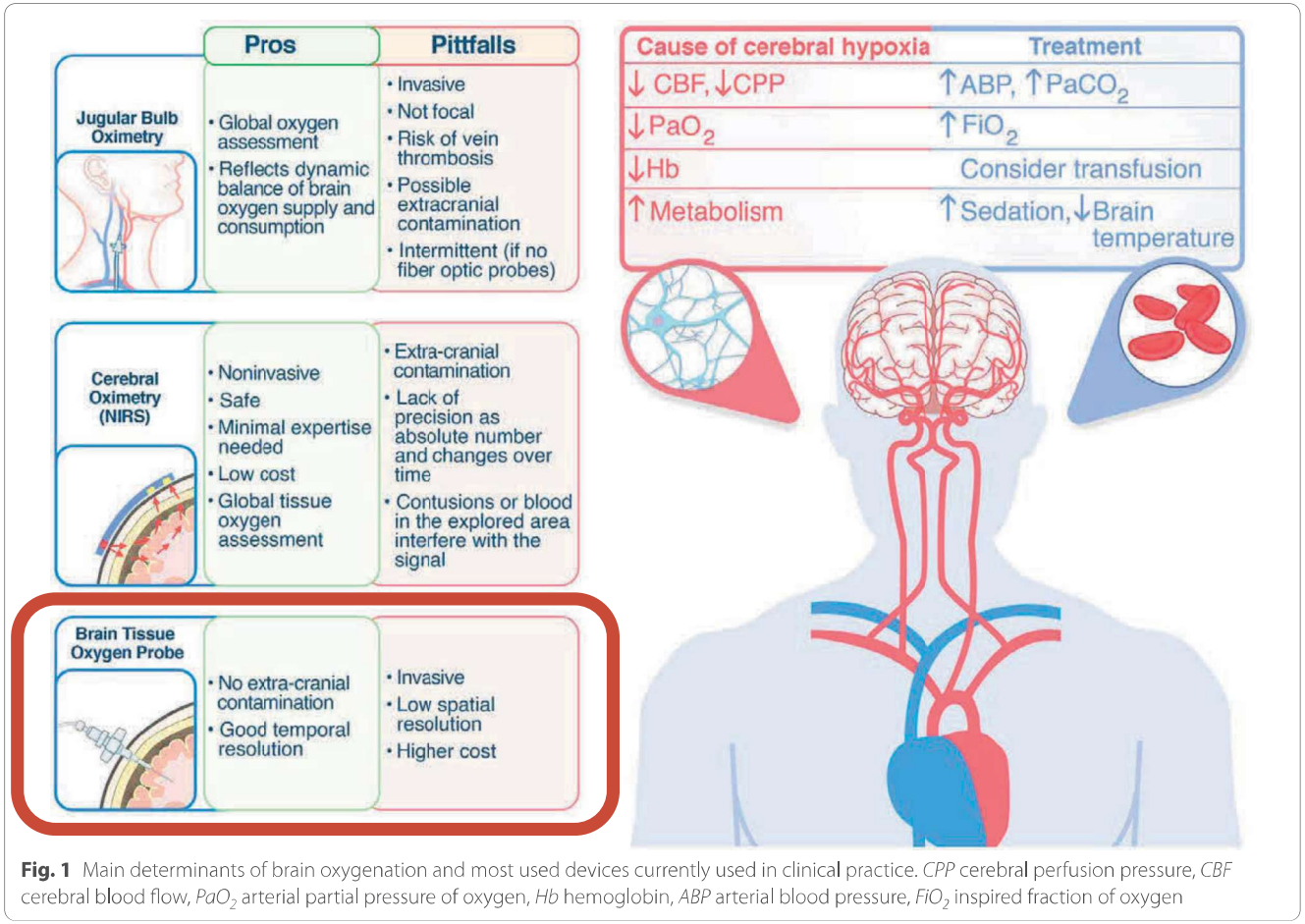
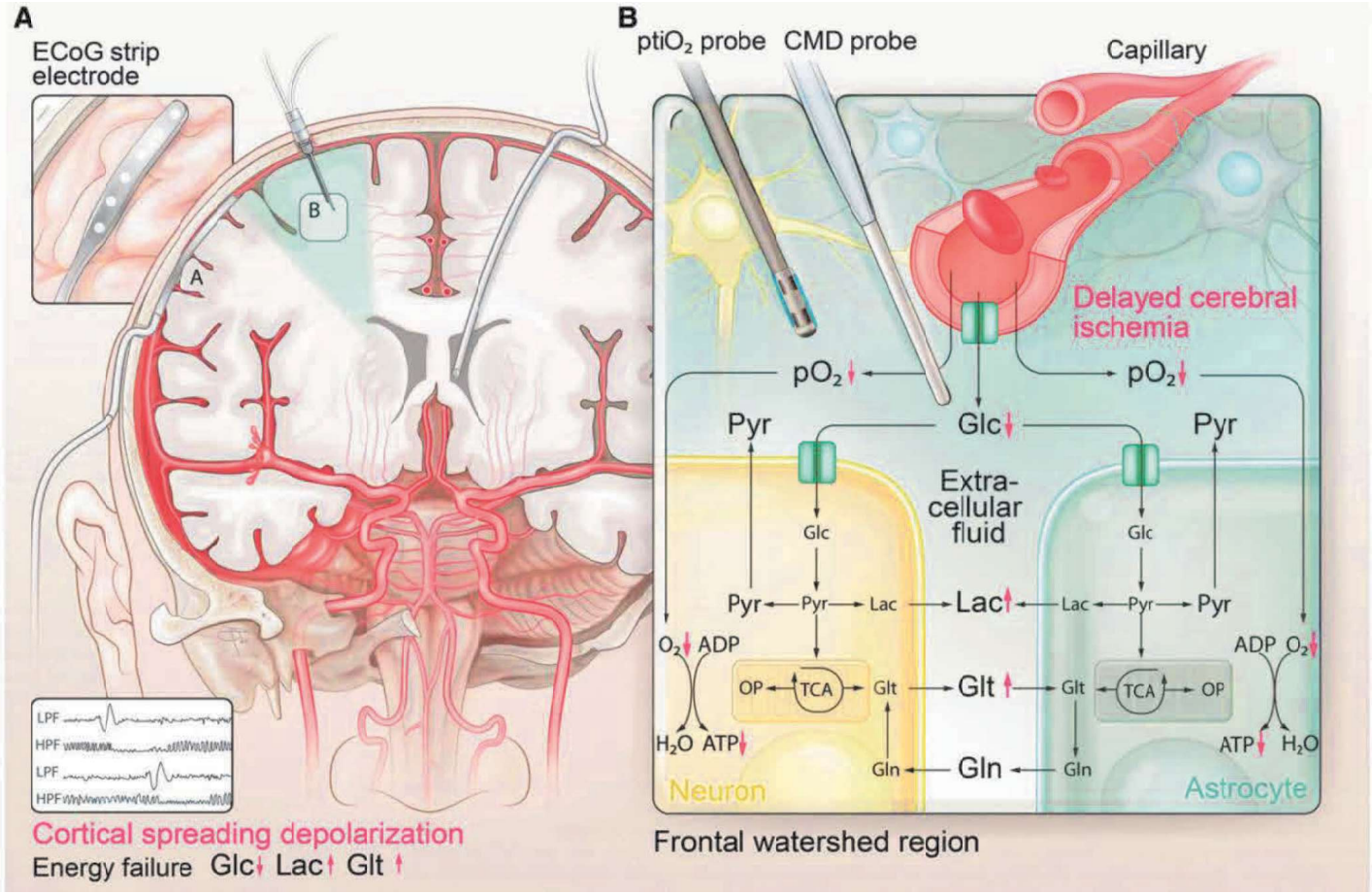


Fig. 1 Main determinants of brain oxygenation and most used devices currently used in clinical practice. *CPP* cerebral perfusion pressure, *CBF* cerebral blood flow, *PaO_2* arterial partial pressure of oxygen, *Hb* hemoglobin, *ABP* arterial blood pressure, *FiO_2* inspired fraction of oxygen

- **PIC ↑ PbtO2 ↓**
  traiter PIC
- **PIC ↑ PbtO2 ↑**
  hyperémie, ≠ AR
- **PIC ↓ PbtO2 ↓**
  optimiser DC, PPC, CMRO2, Hb, PaO2
- **PIC ↓ PbtO2 ↑**
  (diminuer PPC?)

Robba et al. Intensive Care Med 2022

Neuromonitoring multimodal en HSA



Veldeman et al. Stroke 2021

Conclusion

- Considérations en HSA varient en fonction:

- Sévérité du saignement
- Sécurisation de l'anévrisme
- Présence d'hydrocéphalie ou d'HTIC
  - Mécanisme d'HTIC
- Présence ou période à risque d'ischémie cérébrale retardée
- Étendue d'atteinte extra-cérébrale

En somme…

- Considérations à ajuster en fonction de pathologie et évolution
- Pas de « recette neuro »
- HTIC n’est pas invariablement présente
- Littérature en évolution
- Individualisation de thérapie
- Impact de pathologies extracrâniennes sur bien-être cérébral