Luftfartstilsynet
CIVIL AVIATION AUTHORITY - NORWAY

Principles of aeromedical assessment

ECAM, Prague
2018

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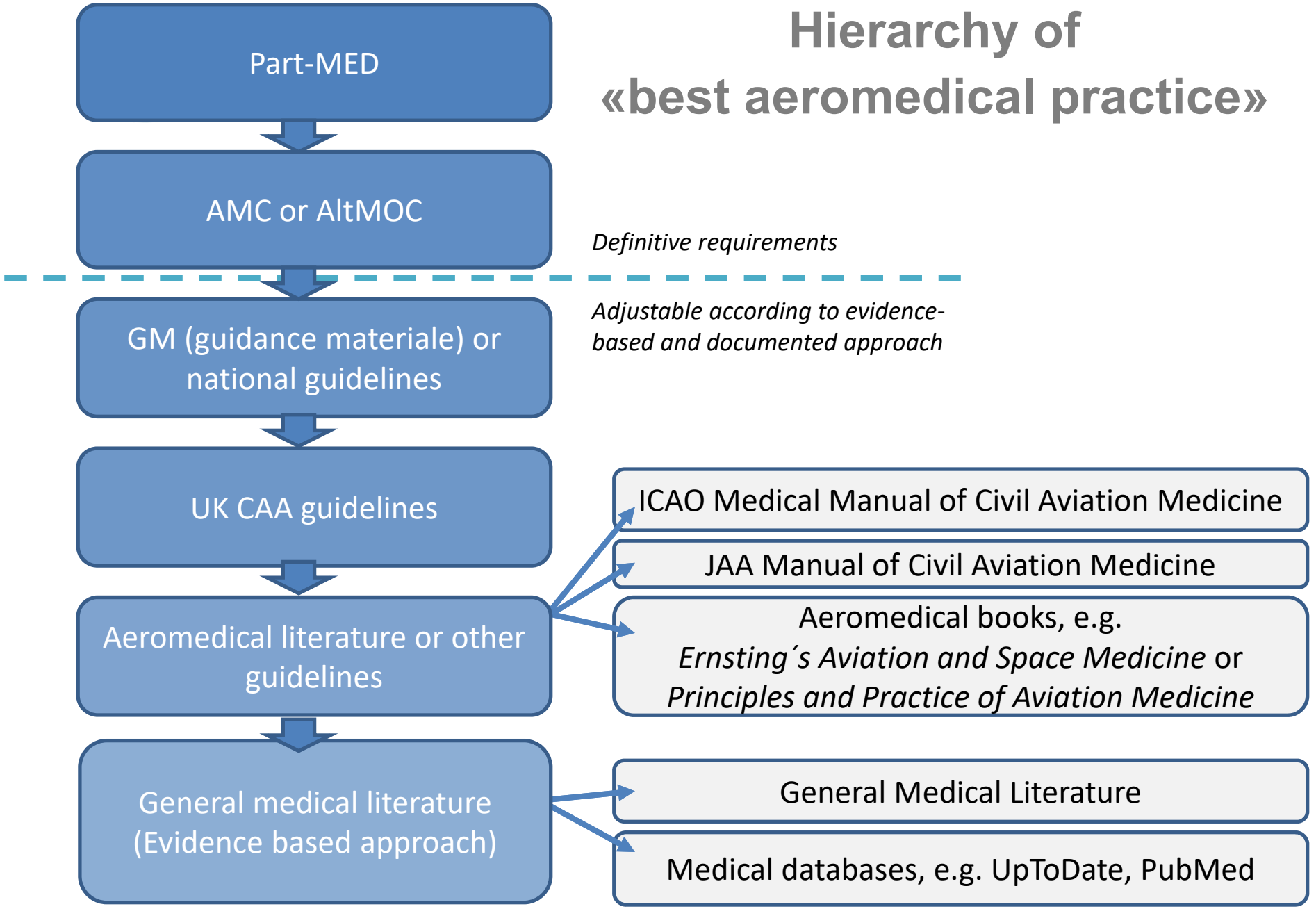
Hierarchy of «best aeromedical practice»



MED.B.005: The assessment shall **always** include…

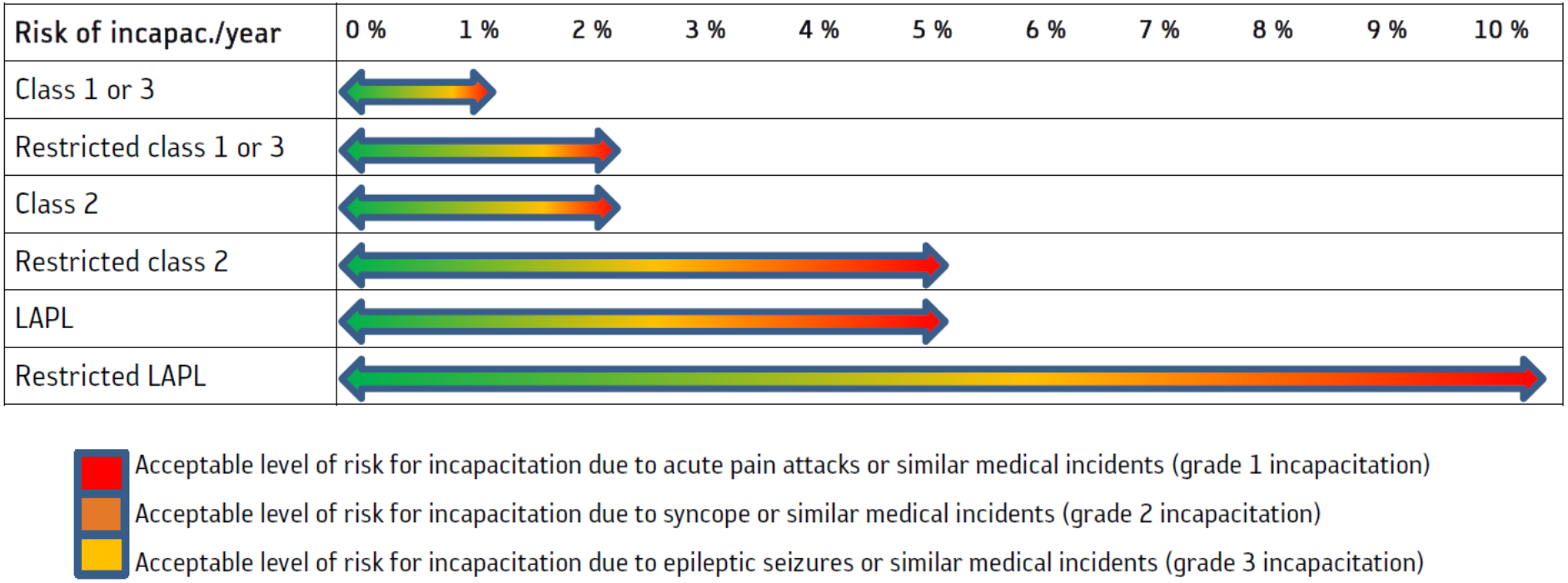
1) …the applicant´s function

- If in doubt, consider medical flight test

2) … the risk of medical incapacitation

- «1% rule»

Acceptable risk of acute incapacitation – national guidelines in Norway



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A handfull of neuro-cases

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Agenda

- A handfull of neuro-cases
  - 1: History of cerebral insult
  - 2: TLoC case A
  - 3: TLoC case B
  - 4: History of neurotrauma
  - 5: PM-NASAH

Case 1: History of cerebral insult

- 45 years old
- Class 1 pilot
- Loss of licence 2 years ago due to a cerebral insult
- Impressive (Wernickes) aphasia in the acute stage, but resolved in a few days (due to regression of edema)
- Presents no symptoms of neurological deficitis today
- MRI caput demonstrated infarction in left parietal region, no other lesions
- Normal findings on R-test, echocardiography, stress-ECG and MR angiography of cerebral and precerebral arteries
    - Diagnose: cryptogenic cerebral insult
- Blood pressure 145/90 mmHg
- Stopped smoking after the cerebral insult

Case 1: History of cerebral insult – Decision?

- 45 years old
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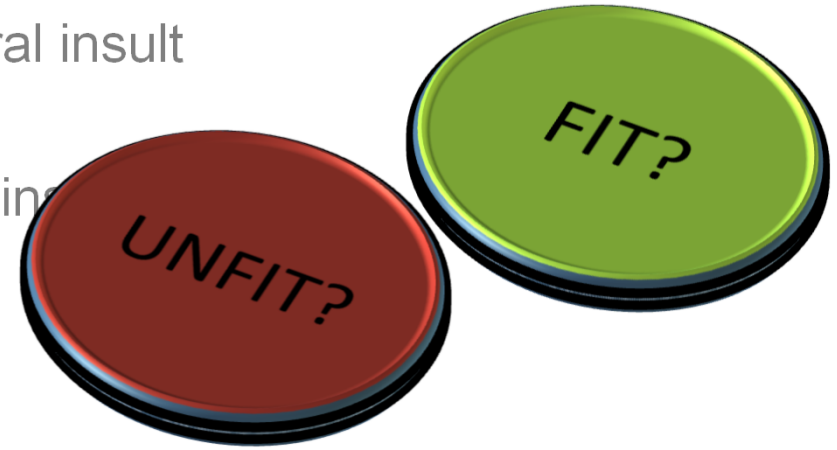


Cryptogenic TIA or ischaemic stroke

- 25-40 % of ischemic strokes are cryptogenic
- No probale cause is found despite a thorough diagnostic evaluation
  - Occult atrial fibrillation? Atrial cardiopathies? PFO? Aortic embolism? Pulmonary shunts? Substenotic atherosclerotic disease?

<u>Aeromedical assessments will depend on the following:</u>

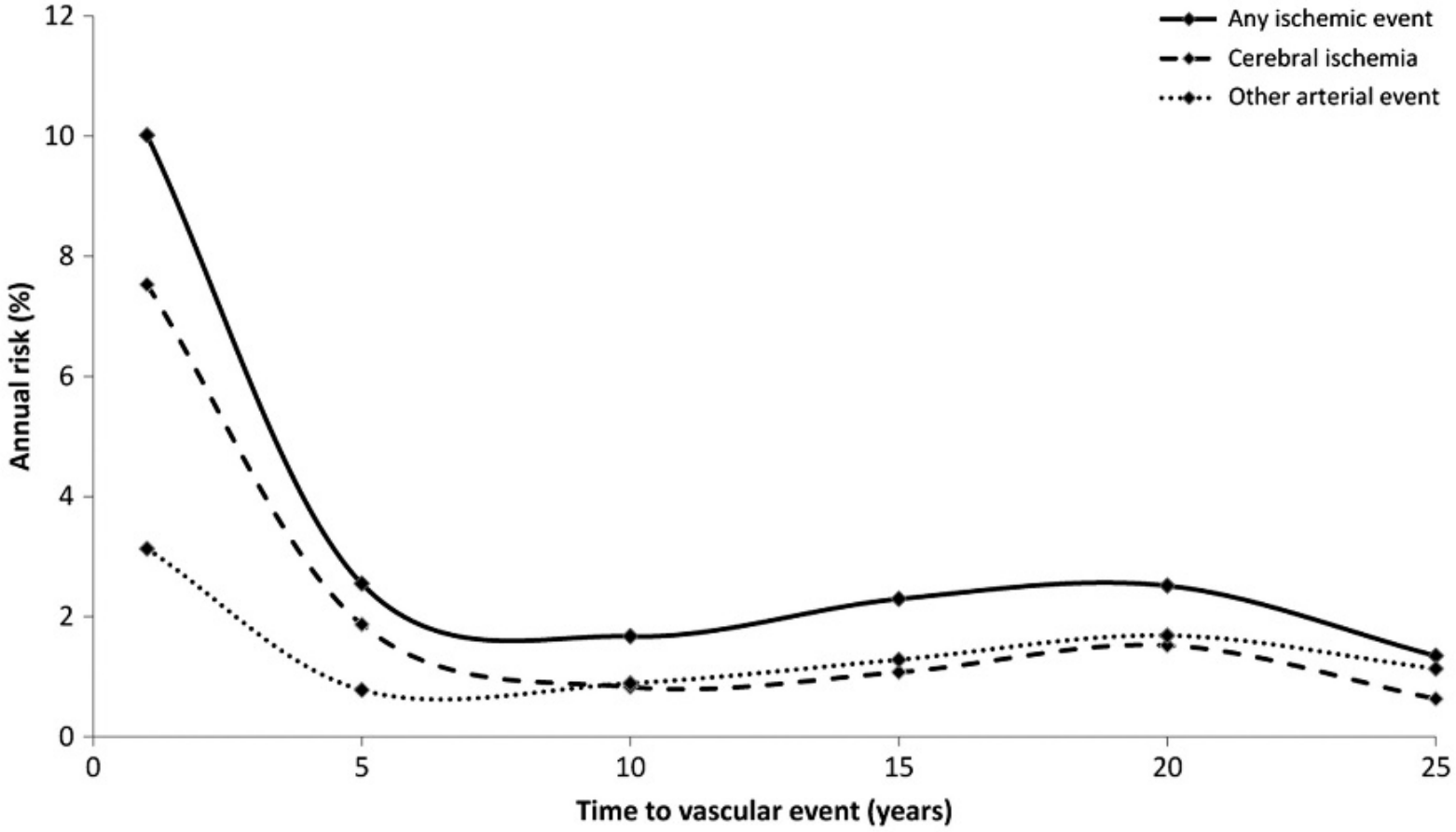
- What is the recurrence risk if the applicant has been screened for risk factors or ethiologies?
  - Selection biases in published studies
  - Limited period of follow-up
- What is the risk of *cardiovascular* events after a history of cerebrovascular event?
- Are there any undetected neurological deficits?

Cryptogenic TIA or ischaemic stroke

- Arntz RM et al. The very long-term risk and predictors of recurrent ischaemic events after a stroke at a young age: the FUTURE study. European Stroke Journal 2016;1(4):337-345
  - Annual risk of cerebral ischemia after 5 years: 1-2 %
  - Annual risk of other arterial event after 5 years: 1-2 %
  - Highest in large artery disease, lowest in undetermined cause

- Li L. et al. Incidence, outcome, risk factors and long-term prognosis of cryptogenic transient ischaemic attack and ischaemic stroke: a population-based study. Lancet Neurol. 2015;14(9):903-913
  - Long-term annual risk of recurrent stroke: 1-2 %
  - Long-term annual risk of acute coronary event: approx. 1 %
  - Recurrence rates in cryptogenic cases are close to those of large artery disease or cardioembolic causes

Arntz RM et al. 2016



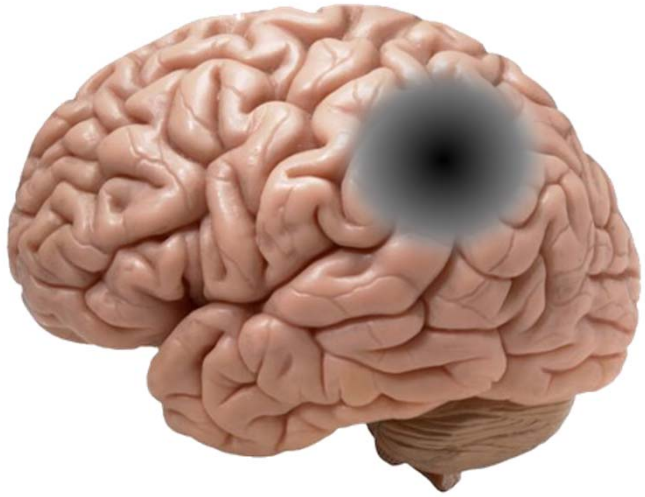
Number at risk

Any ischemic	656	432	259	161	94	53
Cerebral ischemia	656	454	281	186	112	62
Other arterial	656	496	297	189	114	61

Functional neuranatomy – targeted examination

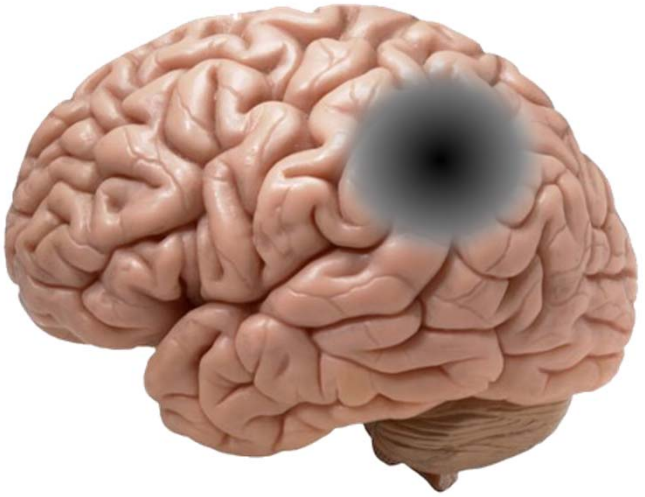
«Presents no symptoms of neurological deficitis today»

Is this sufficient to rule out significant neurological deficits?



Functional neuranatomy – targeted examination

- Dysfunction of dominant parietal lobe may in rare cases cause Gerstmanns syndrome:
  - ❑ Dyscalculia
  - ❑ Finger agnosia
  - ❑ Right-left confusion
  - ❑ Agraphia



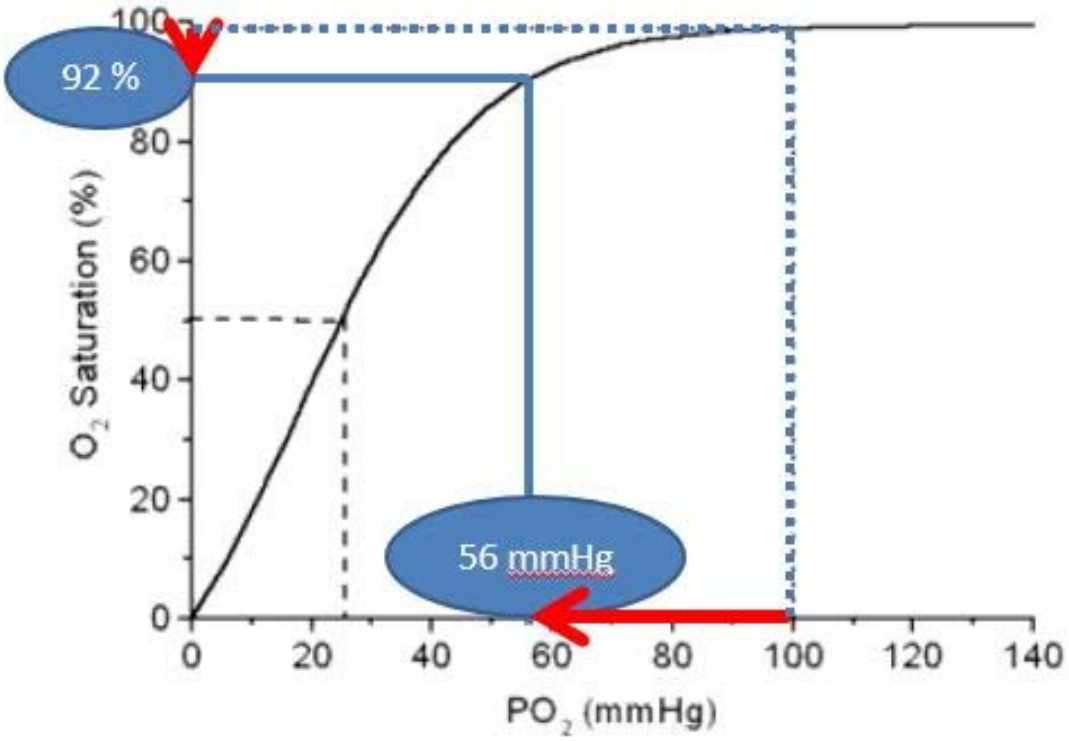
- Other parietal lobe tests:
  - ❑ Position sense
  - ❑ Stereognosia
  - ❑ Graphestesia
  - ❑ Tactile or visual neglect

- Medical flight test
- Neuropsychological assessment

Risk of cerebral ischemia in altitude

- Reduced cerebrocascular reactivity

- Hypobar hypoxia
  - Oxyhemoglobin dissociation curve



→ Elevated risk of cerebral ischemia?

Case 1, aeromedical assessment

- Annual risk of incapacitation (including cerebrovascular or cardiovascular event) > 2 %

- Unfit for class 1 medical certificate

Case 2: Vasovagal syncope / TLoC

- 45 years old male, class 1 pilot
- Faints during blood sampling at the AME office
  - Lightheadedness and nausea
  - Completely recovered in about 30 seconds
  - No other symptoms
- Previous history of 2 similar vasovagal syncopes (2 and 4 years ago)
  - Episode 1: happened during nosebleed
  - Episode 2: happened in the cockpit as the co-pilot talked about a medical visit to his family physician
- Stress-ECG, 24h-ECG, echocardiogram, neurological examination
- Neurologist concluded on a constitutional predisposition to vasovagal syncope
- 6 months observation period has passed

Case 2: Vasovagal syncope / TLoC – Decision?

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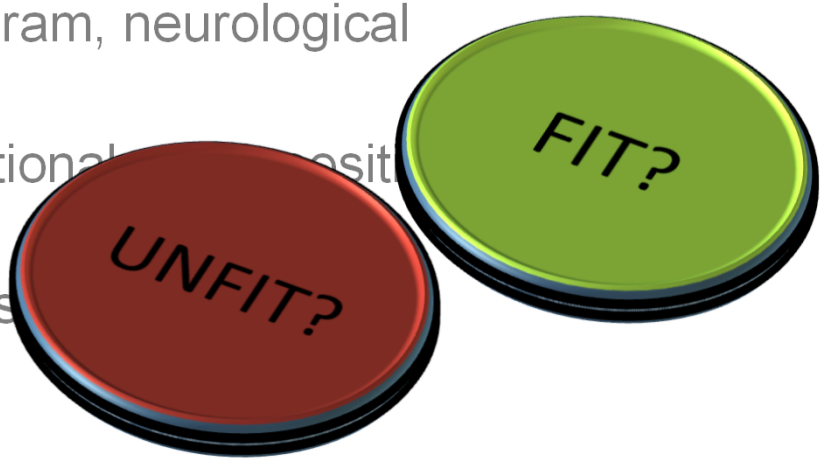

Transient Loss of Counsciousness (TLoC)

Neurological causes

- Epileptic seizure
- Sleep disturbances
- Cerebrovascular disease
- Migraine
- Autonomic dysfunction
- Cataplexy
- Subclavian steal syndrome

Cardiac syncope

- Structural heart disease
- Arrhythmia

Reflex syncope

- Vasovagal syncope
- Situational syncope
- Carotid sinus hypersensitivity

Orthostatic syncope

- Orthostatic syncope
- POTS
- G-induced LoC

Other

- Endocrinological cause
- Psychiatric disorders
- Intoxication

Medical history in TLoC

- **Number, frequency and duration**
- **Onset:** Prodrome or sudden onset?
- **Position:** Standing, sitting, lying or after standing/sitting up?
- **Provocative factors:** Exercise? Urination? Warm and crowded place? Prolonged standing? Emotional stress or fear?
- **Associated symptoms/signs:** Palpitations, nausea, chest pain, fatigue, pallor?
- **Pre-existing medical conditions:** Hypertension, dyslipidaemia, diabetes mellitus, neurologic condition, intoxications?
- **Medication use:** QT prolonging medications? Antihypertensiva?
- **Family history:** Sudden death, drownings, recurrent seizures?

Clinical examinations in TLoC

- Physical examination
- 12-lead ECG, 24h-ECG, stress-ECG
- Echocardiography
- Tilt test?
- Neurological review?

Vasovagal syncope – recurrence risk

- Recurrent vasovagal syncope (Fenton 2000):
  - 28 % year 1
  - 10 % year 2
  - 11 % year 3
- Uncertain diagnosis and > 40 years (Brignole 2009)
  - 15.4 % year 1
  - 4.2 % year 2
  - 8.5 % year 3
- Retrospective studies indicate 2-4 x **increased** likelihood of motor vehicle crash in history of syncope (UpToDate)
  - Challenged by findings in a prospective study (Vern H.T. et al. 2015)

Vasovagal syncope – recurrence risk

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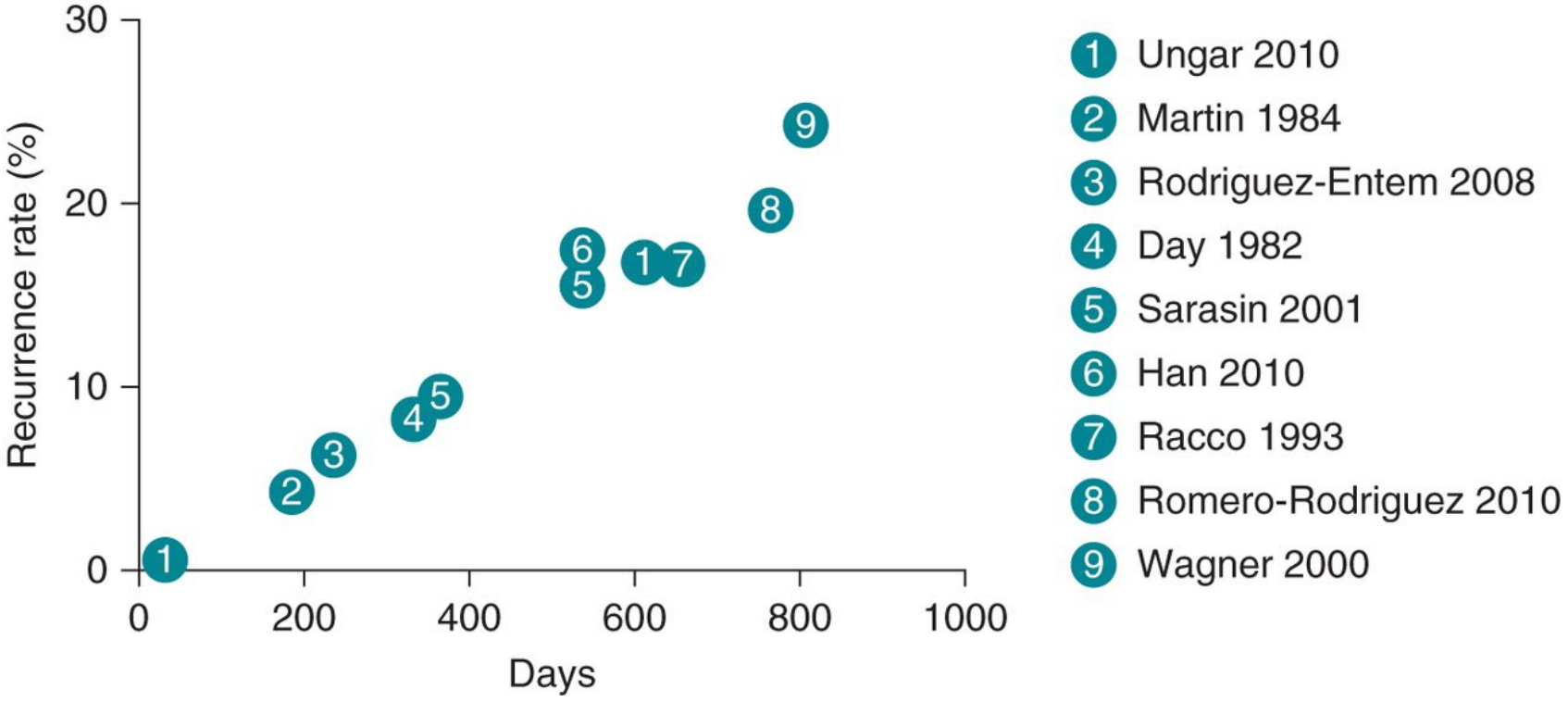
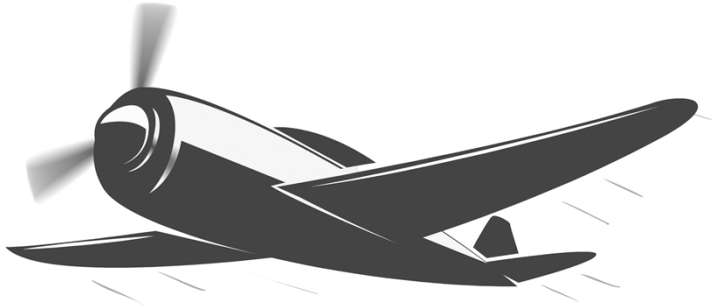
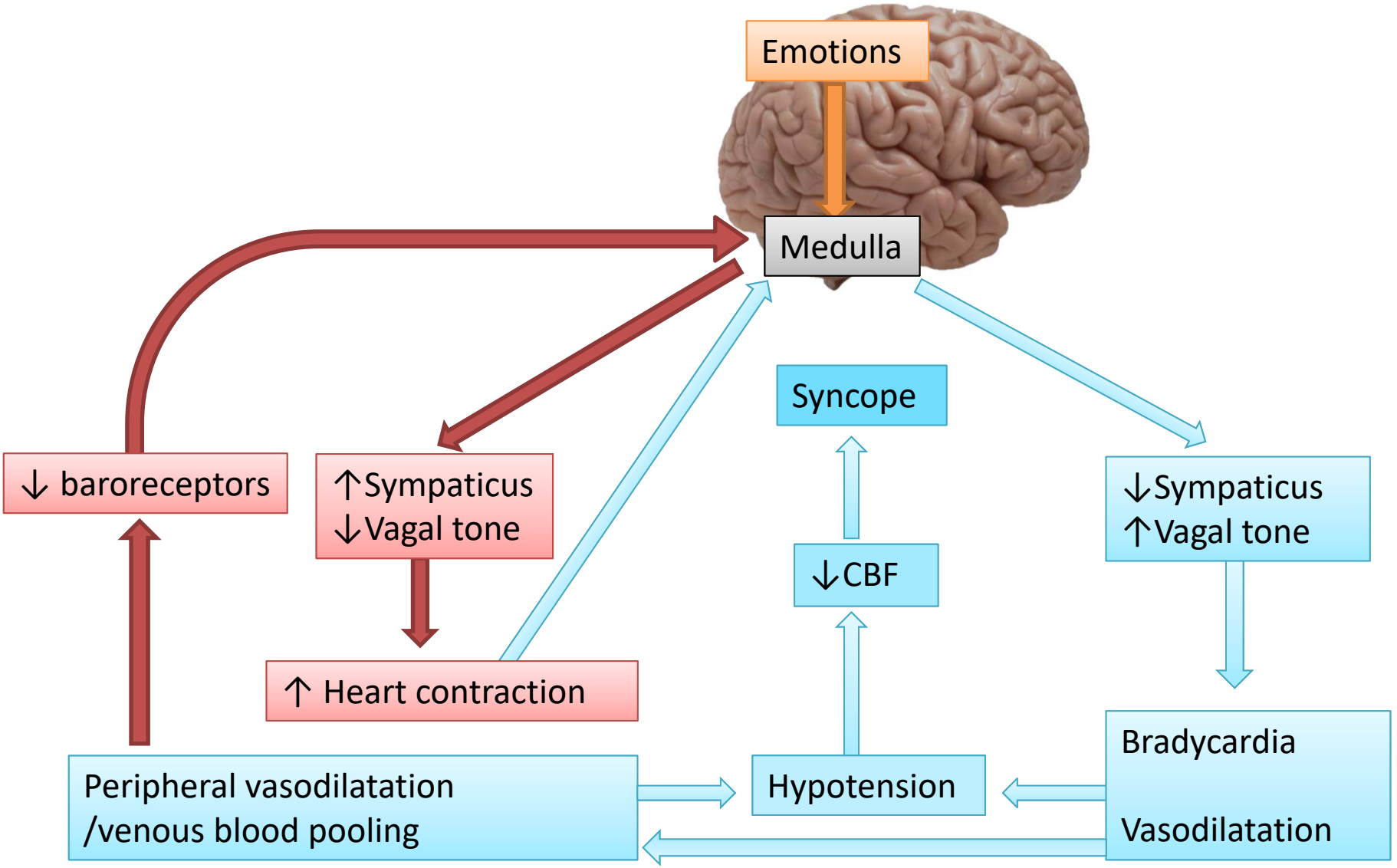


Syncope risk in pilots

- A benign syncope may still be hazardous while flying!
- How is the risk of syncope affected by hypobaric environment or G-forces during flying?



Pathogenesis



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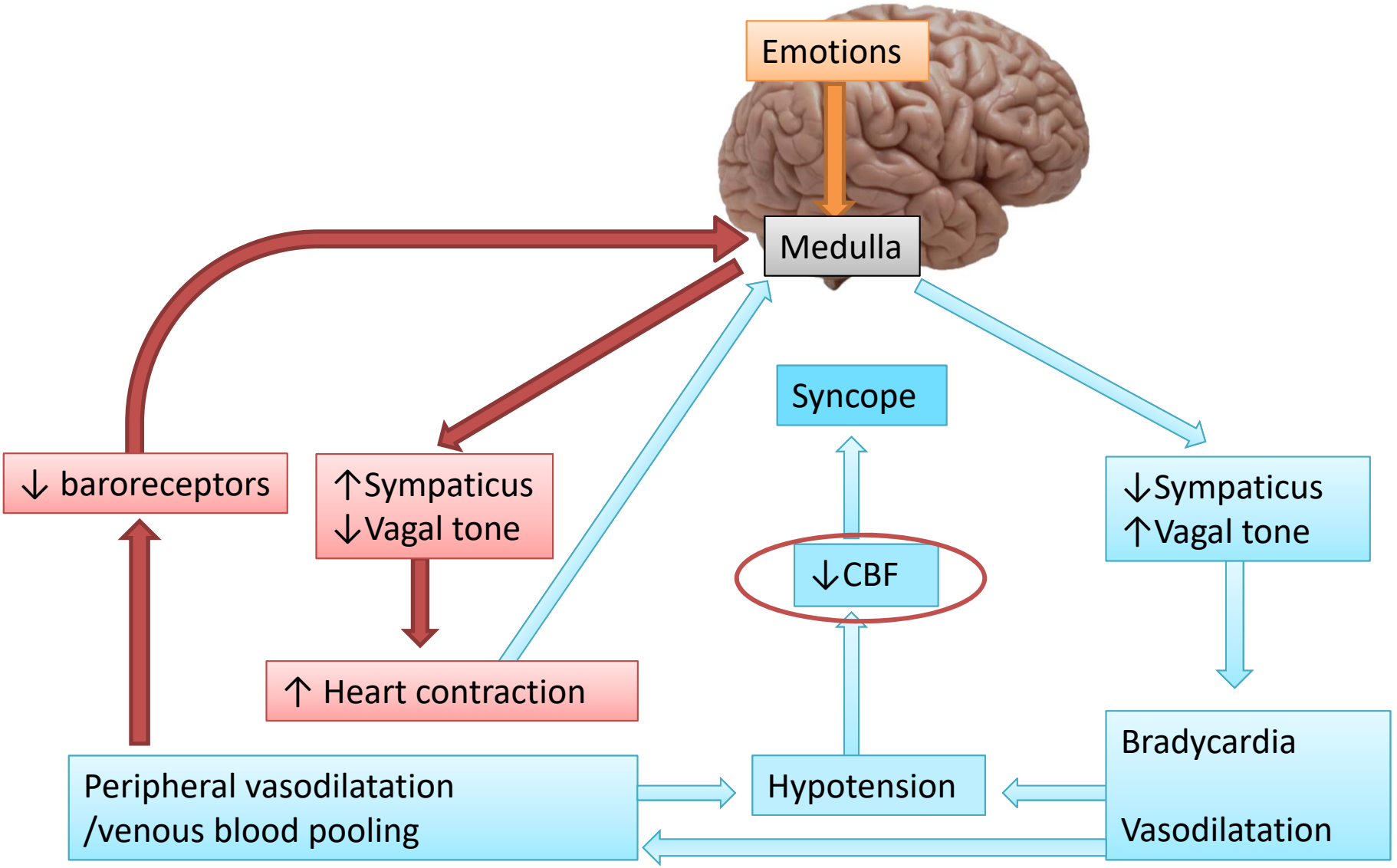
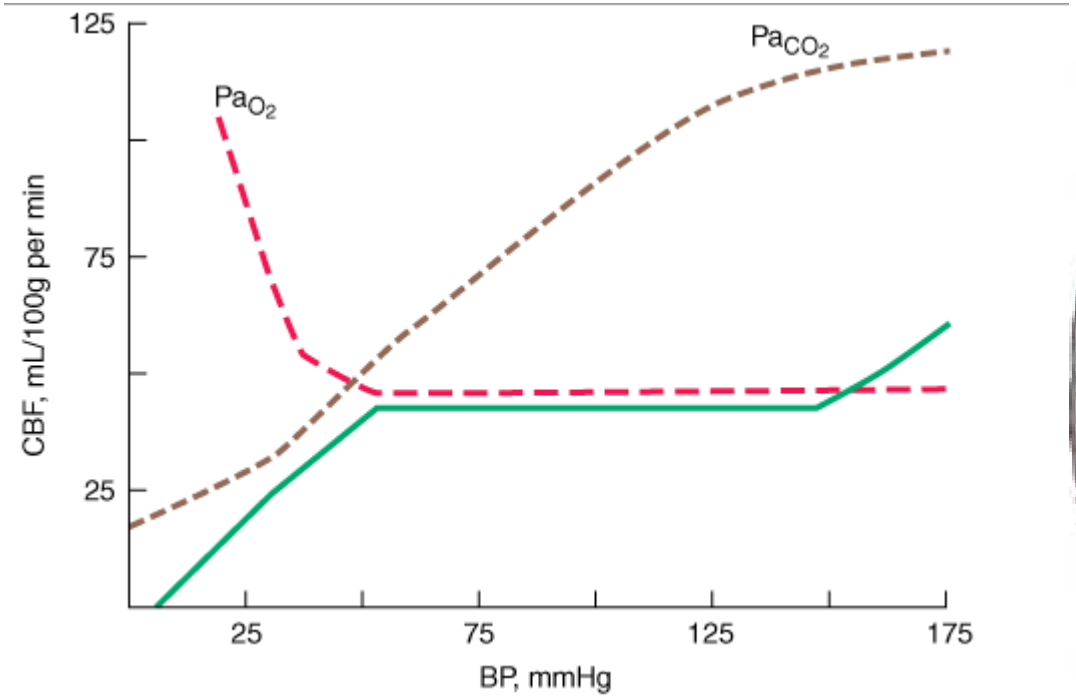
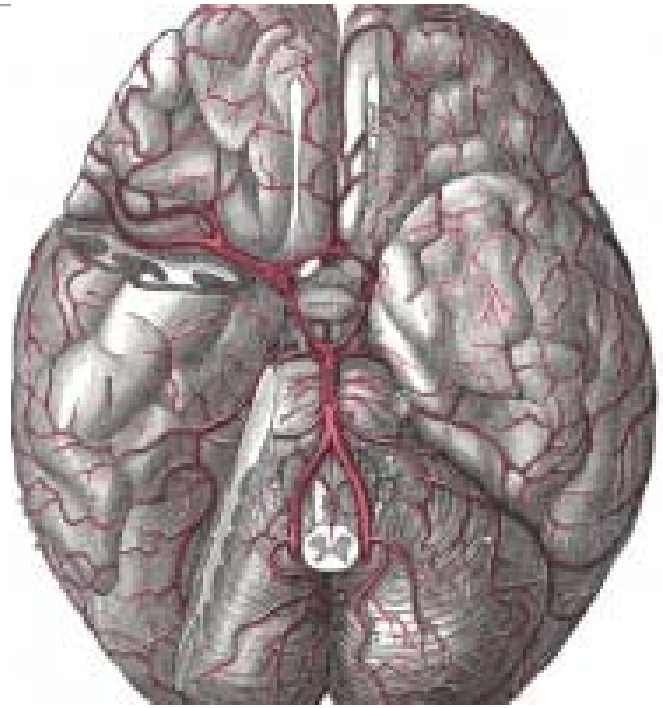


Cerebral bloodflow and autoregulation

- CBF = CPP/CVR
  - approx.50ml/100g/min (20 in white matter, 70 in grey matter)

- Autoregulation
  - vasodilatation in hypoxia or ↓CPP
  - vasoconstriction in hypocapnia or ↑CPP



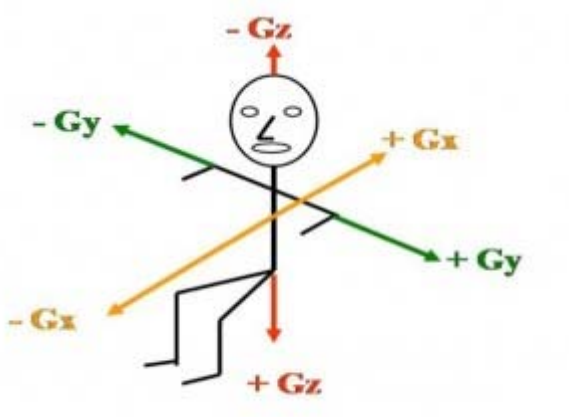


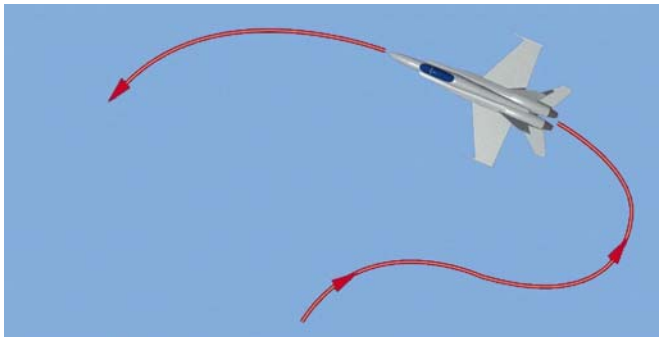
Hypobaric hypoxia

- ↓atmospheric pressure => hypoxia + hypocapnia
  - Different from normobaric hypoxia with normal or elevated pCO2
  - Hypoxia => cerebral vasodilatation
  - Hypocapnia => cerebral vasoconstriction (makes the brain more sensitive to hypoxia)

- The clinical effect of hypobaric hypoxia depends on several factors:
  - E.g. ascent speed, duration, physical activity level, temperature, comorbidity, medications, stimulantia,

Gz-induced LoC





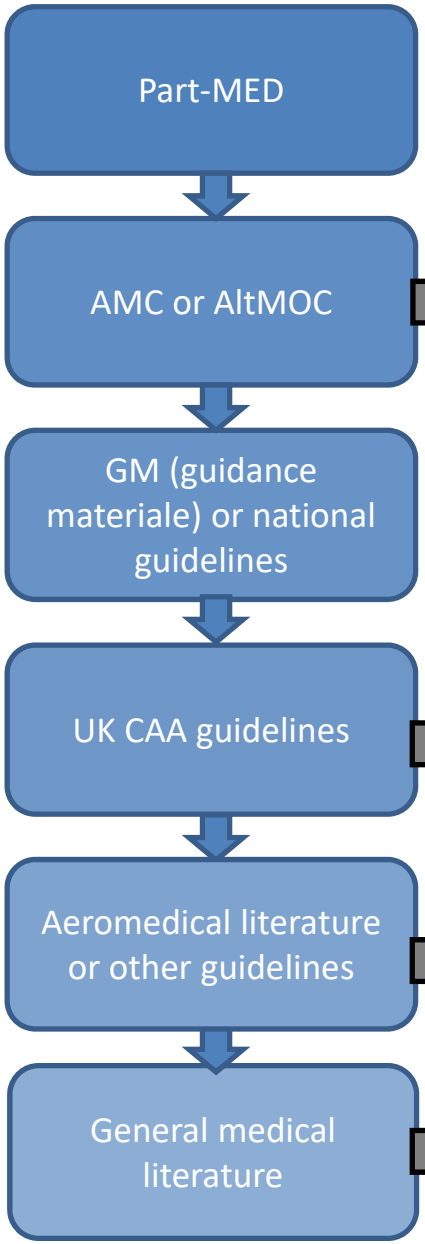
+Gz:

- Stagnation hypoxia
- ↓CPP, ↓cognition and visual function, grey-out, black-out, G-LOC with or without myoclonus

-Gz:

- Push-pull effect: ↓threshold for subsequent +Gz LoC due to ↓HR and cerebral vasoconstriction
- Red-out.

Regulations and guidelines on recurrent vasovagal syncope



- **AMC1 MED.B.010(i)** – ambigous requirement
  - **Single episode:** fit, OML?
  - **Recurrent:** grounded 6 months, OML 5+/- yrs

- **UK CAA guidelines**
  - **Single episode**: 3-6 months, OML 6-12 months
  - **Recurrent:** grounded 6mo.-3+yrs, OML 5-10+ yrs

- **Ernsting´s 5th ed.**:
  - **Single episode:** grounded 6 months, OML for 5 years
  - **Recurrent:** unfit!

- **Evidence based approach to 1 %-rule:**
  - **Single episode:** grounded for xxxx years?
  - **Recurrent:** unfit!

Case 2, aeromedical assessment

- Controversial
  - AMC to Part-MED: fit with OML
  - UK CAA guidelines: fit with OML
  - Ernsting´s: unfit
  - Percentage rule: unfit
- The regulatory requirements trump general guidelines or the percentage rule
- 6 months observation period has passed and supplementary medical examinations are satisfactory

- AMC1 MED.B.010(i): restricted (OML) class 1 medical certificate may be issued

Case 3: Underreported syncopes

- 49 year old female, commercial pilot for the last 20 years. Never been ill, never used any medications. Very fit.
- During revalidation of a medical class 1 the applicant explains that she was operated upon 5 months ago due to a non-perforated appendicitis.
- No other remarks in the application or on the somatic examination.
- AME obtains the medical discharge summary. It appears here that the applicant had 2 episodes of syncope last year (18 and 12 months ago). She underwent a comprehensive cardiological and neurological investigation with normal findings. The syncopes were therefore interpreted as likely vasovagal syncopes.
- According to the medical report the syncopes occurred suddenly in a sitting position, but the applicant explains that both occured gradually when sitting up. No new episodes.

Case 3: Underreported syncopes – Decision?

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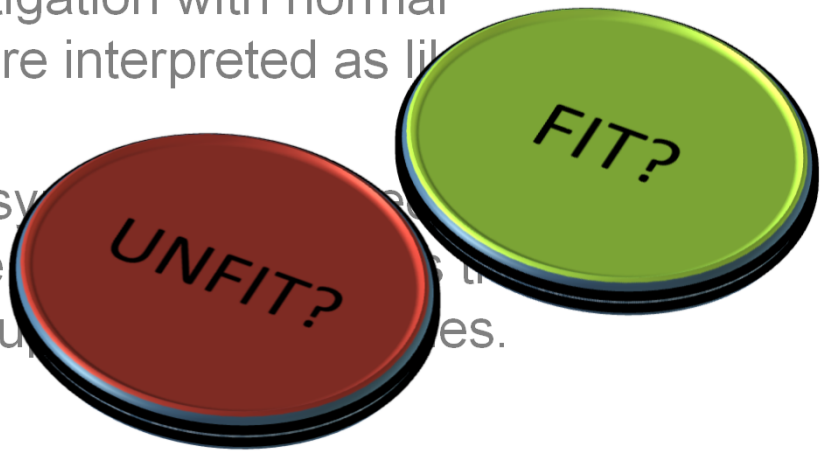
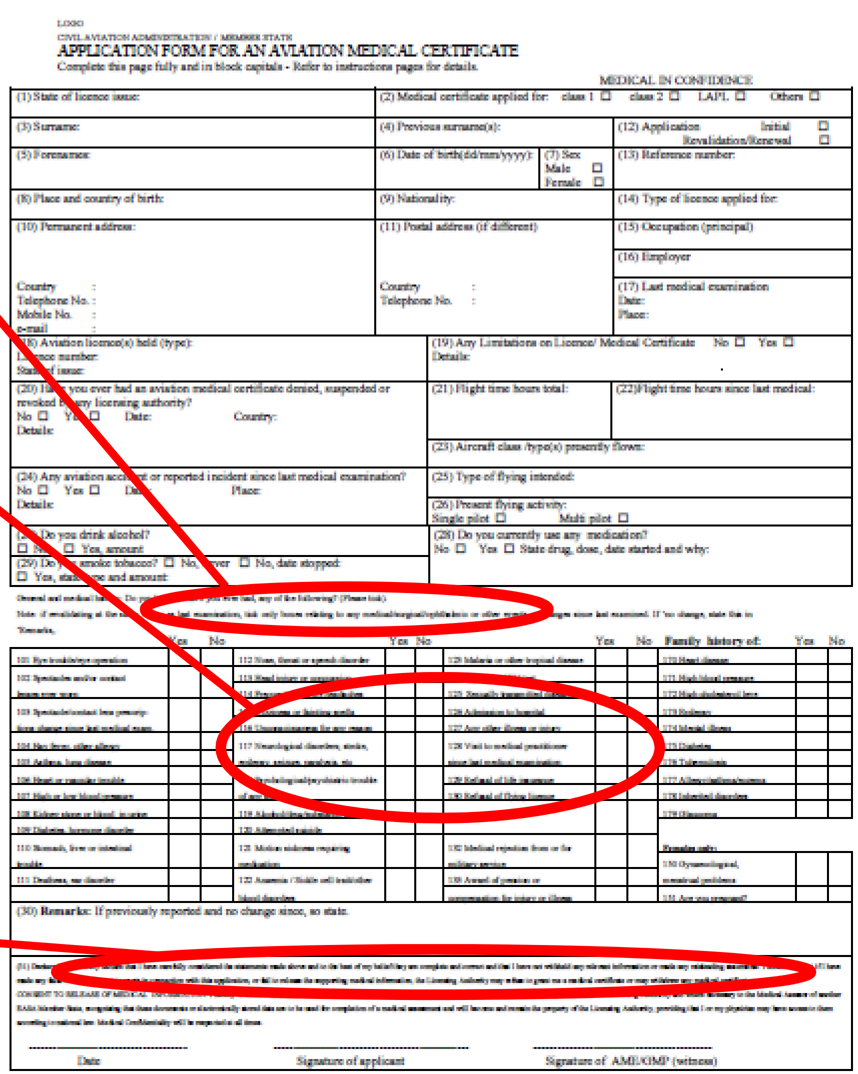


Case 3: Underreported syncopes

- «Do you have, or **have you *ever* had**, any of the following?»

- «Dizziness or fainting spells»
- «Admission to hospital»
- «Any other illness or injury»

- «..if I have made any false or misleading statements (…) **or fail to release** the supporting medical information, the Licensing Authority **may refuse** to grant me a medical certificate (…)»


LOGO
CIVIL AVIATION ADMINISTRATION / MEMBER STATE
APPLICATION FORM FOR AN AVIATION MEDICAL CERTIFICATE
Complete this page fully and in block capitals - Refer to instructions pages for details.
MEDICAL IN CONFIDENCE
(1) State of licence issue:
(2) Medical certificate applied for: class 1 class 2 LAPL Others
(3) Surname:
(4) Previous surname(s):
(12) Application Initial Revalidation/Renewal
(5) Forenames:
(6) Date of birth(dd/mm/yyyy):
(7) Sex Male Female
(13) Reference number:
(8) Place and country of birth:
(9) Nationality:
(14) Type of licence applied for:
(10) Permanent address:
(11) Postal address (if different)
(15) Occupation (principal)
(16) Employer
Country :
Telephone No. :
Mobile No. :
e-mail
(17) Last medical examination
Date:
Place:
(19) Any Limitations on Licence/ Medical Certificate No Yes
Details:
(21) Flight time hours total:
(22)Flight time hours since last medical:
(23) Aircraft class /type(s) presently flown:
(25) Type of flying intended:
(26) Present flying activity: Single pilot Multi pilot
(28) Do you currently use any medication? No Yes State drug, dose, date started and why:
(30) Remarks: If previously reported and no change since, so state.
Date
Signature of applicant
Signature of AME/GMP (witness)

MED.A.025 Obligations of AeMC, AME, GMP and OHMP

(a) When conducting medical examinations and/or assessments, AeMC, AME, GMP and OHMP shall:

(1) ensure that communication with the person can be established without language barriers;

(2) make the person aware of the consequences of providing incomplete, inaccurate or false statements on their medical history.

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- **Lack of reporting may be the largest risk associated with a history of syncope.**

- **Do we trust the applicant or the discharging doctor regarding sudden onset of syncope?**

  AMC1 MED.B.010(i)(5): Applicants who experienced loss of consciousness *without significant warning* should be assessed as unfit

Case 4, history of neurotrauma

- Moderate head injury (bicycle accident) 1 year ago
  - LoC 30 minutes, followed by GCS 12 and gradually improved to GCS 15 same day
  - 3 cm long, linear skull base fracture in the frontal bone
  - No cerebral contusion or intracranial hematoma on CT/MR
- No seizures during 1 year of observation
- No neurological sequela
- During last month: moderate headache, intermittent salty taste, nasal itching and moderate nasal discharge. Previous history of allergic rhinitis/hay fever. Pollen season.
- Medication: Statins due to familial hypercolesterolemia. No side effects.
- No other known diseases.
- Applies for a renewal of class 2 medical certificate

Case 4, history of neurotrauma – Decision?

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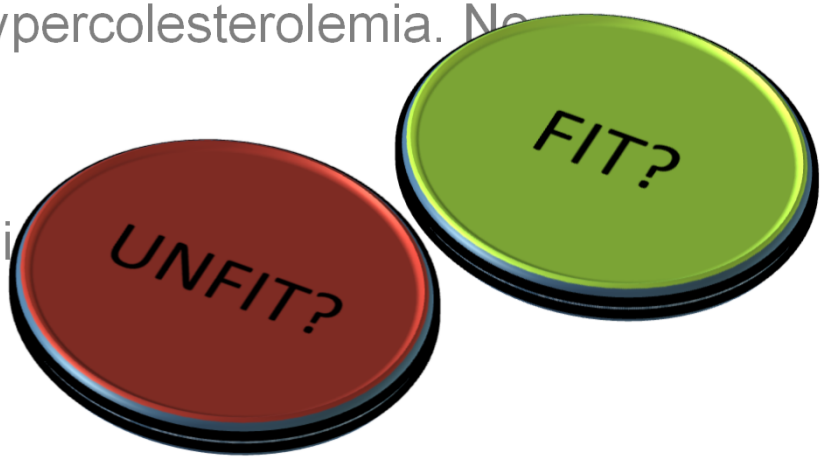
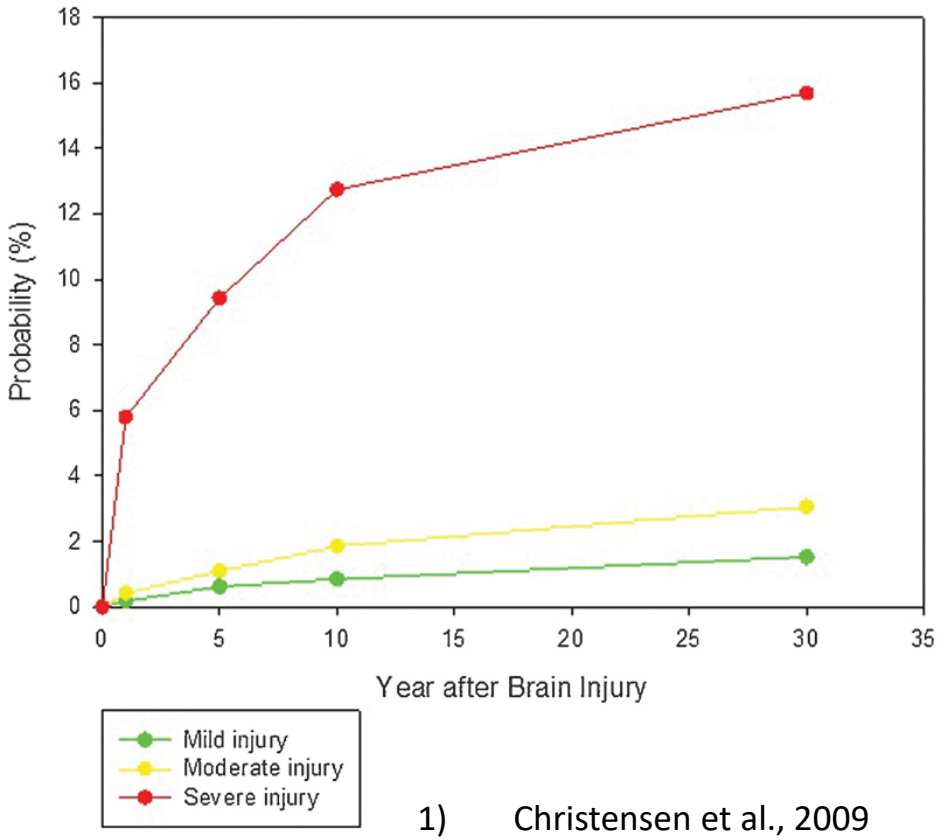


Posttraumatic epilepsy

- Cumulative risk of epilepsy
  - Mild TBI: 2,1 – 4,4 % (2,3)
  - Moderate TBI: 4,2 – 7,6 % (2,3)
  - Severe TBI: 13,6 - 16,7 % (2,3)

- Relative Risk factors (1,5)
  - Skull fracture: RR 2,0
  - Posttraum. amnesia RR 1,3
  - LoC RR 1,6
  - Focal neurology RR 1,4
  - Midline shift RR 1,5
  - Brain contusion RR 2,4
    - *N.B. temporal/frontal cortical injury or irritation by glial scar*
  - SDH RR 2,0
  - ICH RR 2,7

Cumulative probability of unprovoked seizure (4)



1) Christensen et al., 2009
2) Annegers et al., 2008
3) Ferguson et al., 2010
4) Christensen, 2015
5) Xu T et al., 2017

Posttraumatic epilepsy

- Long-term annual risk of epilepsy in moderate TBI after 1 year without history of seizure

Table 1.3: Residual risk (%) after years of seizure-free interval after different initial risk levels (from Jennett, 1995(a) using data from Jennett, 1975)

Initial risk (%)	Years after injury									
	1	2	3	4	5	6	7	8	9	10
6	3	2	1.5	1						
10	5	3	2.5	2	1.5	1				
15	7	5	4	3	2.5	2	1			
20	10	7	5	4.5	3.5	3	2	1.5	1	
25	13	9	7	6	5	4	2.5	2	1.5	1
30	16	12	9	7.5	6	5	3	3	2	1
35	19	14	11	9	7.5	6	4	3.5	2.5	1.5
40	23	17	13	11	9	7	5	4.5	3	2
45	27	20	16	14	11	9	6	5	4	2
50	31	24	19	16	13	11	7	6.5	5	3
55	35	28	22	19	16	13	9	8	6	3.5
60	40	32	26	22	18	15	11	10	7	4

Department for Transport. Systematic review of the Probability of Future Seizures after an Initial Seizure or Other Event Creating an Increased Future Risk. 2010 Warwick, UK.

Posttraumatic epilepsy

- Long-term annual risk of epilepsy in moderate TBI after 1 year without history of seizure

Epi-risk < 2-3 %

Table 1.3: Residual risk (%) after years of ...izure-free interval after different initial risk levels (from Jennett, 1995/... using data from Jennett, 1975)

Initial risk (%)	Years after injury									
	1		3	4	5	6	7	8	9	10
<6	<3	2	1.5	1						
10	5	3	2.5	2	1.5	1				
15	7	5	4	3	2.5	2	1			
20	10	7	5	4.5	3.5	3	2	1.5	1	
25	13	9	7	6	5	4	2.5	2	1.5	1
30	16	12	9	7.5	6	5	3	3	2	1
35	19	14	11	9	7.5	6	4	3.5	2.5	1.5
40	23	17	13	11	9	7	5	4.5	3	2
45	27	20	16	14	11	9	6	5	4	2
50	31	24	19	16	13	11	7	6.5	5	3
55	35	28	22	19	16	13	9	8	6	3.5
60	40	32	26	22	18	15	11	10	7	4

Department for Transport. Systematic review of the Probability of Future Seizures after an Initial Seizure or Other Event Creating an Increased Future Risk. 2010 Warwick, UK.

Posttraumatic epilepsy

- UK CAA guidelines
  - Moderate head injury after 1 year of observation:
    - Unrestricted class 2 medical if full recovery without symptoms
    - CT/MRI is mandatory before recertification

Moderate	• Initial GCS 9-12 • LOC 30 mins to 24 hours • PTA 30 mins to 24 hours • Linear Skull fracture	Class 1, 3 Unfit 6 months after full recovery without symptoms Then Class 1 OML for 2 years, Class 3 unrestricted Class 2 Unfit for 3 months after full recovery without symptoms Then OSL for further 3 months LAPL Unfit for 3 months after full recovery without symptoms	Medical report from attending specialist including investigations. CT/MRI mandatory before recertification Class 1& 3 applicants must be referred to CAA for decision AND AME clinical assessment after full recovery without symptoms

Traumatic CSF leak

- 1-3 % of closed TBI
- May be delayed
- Lab tests: beta trace protein and beta 2 transferrin
- High resolution CT, CT cisternography, MRI
- Flying is contraindicated
  - Possibility of backflow and microbial contamination
  - Risk of pneumocephalus

Pneumocephalus

Case 4, aeromedical assessment

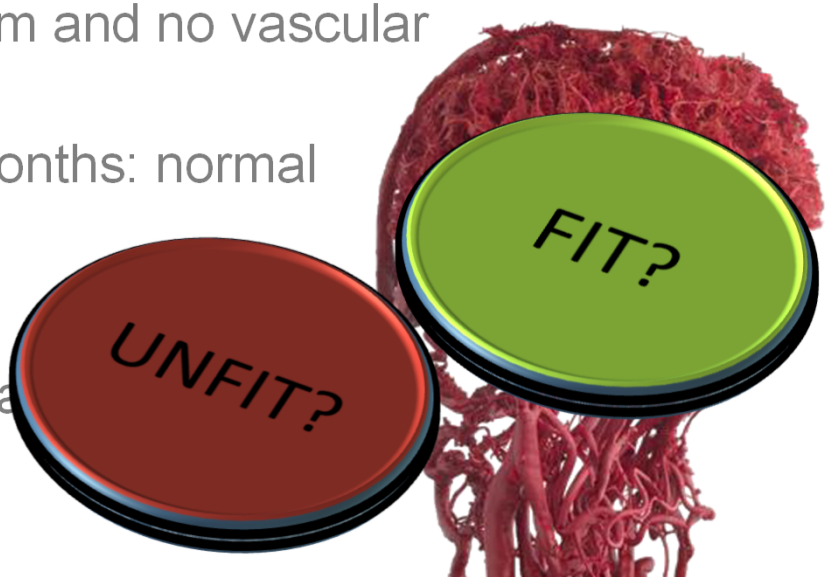
- Possible CSF leakage
- Refer for further examinations

Case 5, Perimesencephalic nonaneurysmal subarachnoid hemorrhage (PM-NASAH)

- Commercial pilot
- Male, 46 yr
- Sudden onset of intense headache during an evening exercise
- Nausea and vomiting,
- No LoC
- CT caput done after 12 hours revealed perimesencephal subarachnoid bleeding (prepontine and in suprasellar cistern)
- 3D-DSA demonstrated no vasospasm and no vascular malformations
- Repeated CT angiography after 3 months: normal
- 7 months of observation has passed
- No symptoms the last 4 months
- Applies for renewal of class 1 medical certificate

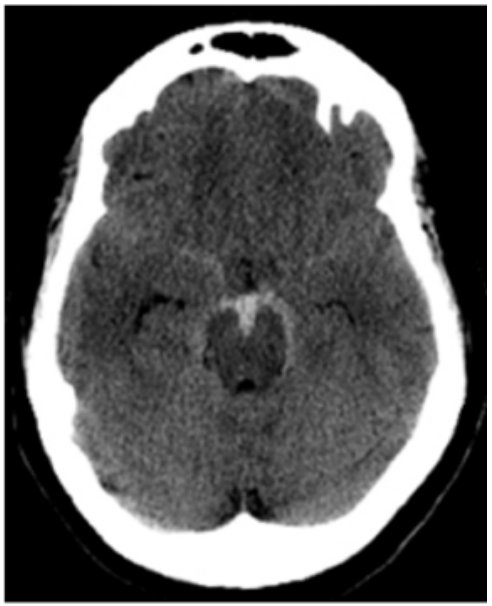
Case 5, Perimesencephalic nonaneurysmal subarachnoid hemorrhage (PM-NASAH) – Decision?

- Commercial pilot
- Male, 46 yr
- Sudden onset of intense headache during an evening exercise
- Nausea and vomiting,
- No LoC
- CT caput done after 12 hours revealed perimesencephal subarachnoid bleeding (prepontine and in suprasellar cistern)
- 3D-DSA demonstrated no vasospasm and no vascular malformations
- Repeated CT angiography after 3 months: normal
- 7 months of observation has passed
- No symptoms the last 4 months
- Applies for renewal of class 1 medica



Case 5, PM-NASAH

- **PM-NASAH**
  - “Benign” history
  - Characteristic findings on CT caput
  - Negative cerebral angiography
  - Repeated imaging? DSA?
  - Risk of re-bleeding
    - Approx. 4 % in 6 months
    - After first year: annual risk of < 0,5 %



- **Aneurysmal subarachnoid hemorrhage**
  - Most patients are unfit for flying
  - In certain cases a restricted medical certificate may be issued after >1 year of observation (depending on localization and treatment modality)

Case 5, aeromedical assesment

- History and CT findings are typical for PM-NASAH
- Negative 3D DSA + negative repeated CT angiography
- Annual risk of acute incapacitation
  - after 7 months of observation period: < 2 %
  - After 12 months of observation period: < 1%
- Decision: fit wih OML restriction
- OML restriction may be removed when 12 months have passed

Questions?

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Remember: Scores are calculated based on the *speed* of a correct answer. They start at 1000 Kahoots, and then count down to 500 (at zero seconds)

The time limit has been set to 90 seconds.