Aeromedical concern

Sinus Pathology

- ANNEX IV [PART-MED] SUBPART A GENERAL REQUIREMENTS
- MED.B.080 Otorhino-laryngology

(a) Applicants shall not possess any abnormality of the function of ..., nose, sinuses ..., or any active pathological condition, congenital or acquired, acute or chronic, or any sequelae of surgery or trauma which is likely to interfere with the safe exercise of the privileges of the applicable licence(s).
(d) Applicants for a Class 1 medical certificate with:

... (4) **significant restriction of the nasal passages**;
(5) **sinus dysfunction**;

... shall undergo further medical examination and assessment to establish that the condition does not interfere with the safe exercise of the privileges of the licence held.
Aeromedical concern
Sinus Pathology

<table>
<thead>
<tr>
<th>Clinical examination</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>(404) Head, face, neck, scalp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(405) Buccal cavity, teeth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(406) Pharynx</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(407) Nasal passages and naso-pharynx (incl. anterior rhinoscopy)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(408) Vestibular system incl. Romberg test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(409) Speech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(410) Sinuses</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>(411) Ext acoustic meati, tympanic membranes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(412) Pneumatic otoscopy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(413) Impedance tympanometry including Valsalva manoeuvre (initial only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Aeromedical concern
Sinus Pathology

Annex to ED Decision 2012/006/R

SUBPART MED - SPECIFIC REQUIREMENTS RELATING TO AERO-MEDICAL CERTIFICATION

INSTRUCTIONS FOR COMPLETION OF THE MEDICAL EXAMINATION REPORT FORMS

Shaded areas do not require completion for the medical examination report form for the LAPL.

210 NOSE, SINUSES – To include appearance and any evidence of nasal obstruction or sinus tenderness on palpation.
Nose – Sinuses: Physiology

Concept NOSES

We need 2 noses and 120 cm$^2$ of pseudo stratified columnar ciliated epithelium for conditioning of ± 12000 litre of air / d / 6cm nose
Concept Nose

- **WARMING** (from -5°C → 34°C)

- **HUMIDIFICATION:** (from 0% → 90%), production of 0.5L H₂O/d

- **FILTRATION** Aerosols (95%), Particles (>15 µm: 95%)

... SMELL, IMMUNODEFENCE, PRESSURE CONTROL
- slitlike structures to maximalise the contact between air and mucosa (↑ risk of obstruction)

- Elimination of mucus is crucial. It has to be drained and vaporised in time, also at the level of the sinuses.
Concept Nose
AIRWAY = HEALTH

Obstruction
Oedema
mucosal Irritation
Stasis
Ventilation and drainage is crucial, also at the level of the sinuses: ➔ key role OMC
Recessus frontalis
Infundibulum maxillare

Slitlike architecture
Ostia 1 – 5mm

Ethmoid
Sphenoid
Sinusitis: Symptomatology

- Chronic "Cold" (≈ vasomotor rhinitis, atopic or not)
- Nasal congestion, blockage → waking up dry mouth - throat
- Night-time coughing,
- Facial pain, headache, facial 'fullness' worsening when bending over, aching teeth, irritated / sore troat
- General malaise, respiratory dysfunction (astma)
- Discharge,
- Halithosis,
- Hyp- / anosmia (→ polyps?),
- Dizziness,
- Unless complications occur, → no symptoms required
- fever is not a feature
Sinusitis : Clinical Signs

- Anatomic deviations nose: piramid, septum, conchae, obstruction...
Sinusitis: Clinical Signs

• Mucosal aberrance: hypertrophy, polyps,
• Anterior / posterior discharge / crustation
• Chronic sinusitis is more inflammatory than infectious: All is possible, nothing has to...
• Allergic manifestations
Sinusitis: Clinical Signs

- Rhinoscopy:
Sinusitis : Clinical Signs

- Allergic manifestations
- Mucosal aberrance: hypertrophy, polyps,
- Anterior / posterior discharge
Sinusitis: additional exams

- Nasal endoscopy (conchae, septum, meati...)
- **Standard**: CT sinusses 2/3 planes.
  - Shows what, where, why.
- MRI: no bony details,
- RX sinus: no functional answers
- Blood analysis (atopy?) ?
Sinusitis: additional exams

In case of doubt: CT sinuses

EMPIC: obliges ENT to fill in / declare uncertain data!
Barosinusitis - Aerosinusitis
Barosinusitis is characterized by mucosal inflammation in one or more of the paranasal sinuses. Inflammation is caused by a pressure gradient, almost always negative, between the sinus cavity and the surrounding ambient environment.

- A severe attack can cause acute incapacitation
- Subtle barotrauma is distracting and incapacitating
Ju-87
15000 ft (390mmHg)
Pull-out at
1500 ft (720mmHg)

>480 ft/sec
330 mmHg / < 30 sec
Dysbarisme

Volume × Pressure = Constant

Constant T° etc...

Boyle - Mariotte
Dysbarism

- Barotitis
- Barodontalgie
- Barosinusitis

- Abdominal ...
- Evacuation trauma patients

- severity
  - ++
  - +++
  - +++

ask others

Dr. Paul Van Der Veken ENT
Sinus Barotrauma

- Smith en Furry (72) found on a series of more than 250,000 airmen 1% barosinusitis, corresponding with ± 5% of the barotitis incidence (Campbell ’44).
- Mostly frontal sinuses involved, 2nd maxillary
- Descent barosinusitis (“squeeze”) = 2x ascent barosinusitis (“reverse squeeze”)
Pathophysiology of acute barotrauma

Plane take off

- cockpit pressure (and pressure on body) drops
- relative pressure in sinus grows
Further Ascent:

**OBSTRUCTIVE variant**

“reverse squeeze” : PAIN DURING ASCENT

→ Mostly intrasinuspathology
→ Pain caused by pressure mucosa against periost
Pathophysiology of acute barotrauma

Further Ascent:

**OBSTRUCTIVE variant**

“reverse squeeze” : PAIN DURING ASCENT

- Mostly intrasinuspathology
- Pain caused by pressure mucosa against periost
- Pressurised air may dissect surrounding tissues
- subcutaneous / orbital / cerebral emphysema
- pneumocephalus, blindness, trigeminal dysfunct

- Cave barodontalgia
Pathophysiology of acute barotrauma

Further Ascent:

NON- (SEMI-) OBSTRUCTIVE "squeeze"

→ lower pressure on body
→ less pressure in blood vessels
→ less mucosal swelling (around ostium)
→ air escapes out of sinus (one way valve)

Dr. Paul Van Der Veken ENT
Pathophysiology of acute barotrauma

Cruise
- ostium still closed
- oxygen absorbed in blood vessels (Graham’s law**)
- pressure in sinus goes further down
Pathophysiology of acute barotrauma

Descent
- cockpit pressure (and pressure on body) rises
- relative pressure in sinus goes further down;
- aerosinusitis may build up from -35 mmHg (Max)
  -66 mmHg (Fron)

- relative surpressure in bloodvessels
  - vasodilatation → pain
  - exsudation (-100 to -150 mmHg)

- stripping and collapse of mucosa near ostium
  leads to total closure
  (-260 to -300 mmHg)
- submucosal bleeding can cause permanent thickening of mucosal lining.
The greatest density change occurs between sea level and 5,000 feet; therefore, the problems associated with pressure and density change must be considered even in pressurized aircraft...

But medical requirements have to be met, especially to be able to cope with urgencies...
Physiology of Flight

commercial flt : landing at 300ft/min

<table>
<thead>
<tr>
<th>Altitude: from</th>
<th>To</th>
<th>Δ mmHg</th>
<th>mmHg/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000 ft</td>
<td>5000 ft</td>
<td>23</td>
<td>0.115</td>
</tr>
<tr>
<td>4000 ft</td>
<td>3000 ft</td>
<td>25</td>
<td>0.128</td>
</tr>
<tr>
<td>2000 ft</td>
<td>1000 ft</td>
<td>26</td>
<td>0.132</td>
</tr>
<tr>
<td>1000 ft</td>
<td>0000 ft</td>
<td>27</td>
<td>0.136</td>
</tr>
</tbody>
</table>

Sudden decompression: most airliners allow
- max alt 25000ft for 2 min
- descent 5000ft/min to 10000ft

3 min to 10000ft = 523-282= 241mmHg/180sec
= 1,34mmHg/s

<table>
<thead>
<tr>
<th>Altitude: from</th>
<th>To</th>
<th>Δ mmHg</th>
<th>mmHg/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>25000 ft</td>
<td>20000 ft</td>
<td>67</td>
<td>1.1</td>
</tr>
<tr>
<td>20000 ft</td>
<td>15000 ft</td>
<td>80</td>
<td>1.3</td>
</tr>
<tr>
<td>15000 ft</td>
<td>10000 ft</td>
<td>94</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Dr. Paul Van Der Veken ENT
Physiology of Flight

Baropain: -35 to -66 mmHg
Exsudation: -100 to -150 mmHg

Maximal difference in commercial flt is 200 mmHg

Sudden decompression: most airliners allow
- max alt 25000ft \(\Delta\) from 7000ft = \(\Delta304\) mmHg
## Physiology of Flight

Landing at 300ft/min  →  200sec for 1000ft

<table>
<thead>
<tr>
<th></th>
<th>Alt Fl</th>
<th>6000 → 5000ft</th>
<th>4000 → 3000ft</th>
<th>2000 → 1000ft</th>
<th>1000 → 00ft</th>
<th>300ft → 00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ mmHg/200s</td>
<td>23</td>
<td>25.6</td>
<td>26.3</td>
<td>27.1</td>
<td>27.3 (8.2/60s)</td>
<td></td>
</tr>
<tr>
<td>mmHg/sec</td>
<td>0.115</td>
<td>0.128</td>
<td>0.132</td>
<td>0.136</td>
<td>0.137</td>
<td></td>
</tr>
<tr>
<td>mmHg/min</td>
<td>6.90</td>
<td>7.68</td>
<td>7.89</td>
<td>8.13</td>
<td>8.20</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>F-16 (500kn vertical dive)</th>
<th>400 → 240</th>
<th>Δ Cockpit alt 8500</th>
<th>500 → 240</th>
<th>Δ Cockpit alt 13500</th>
<th>Ju-87</th>
<th>Glider max</th>
<th>Free Fall: fl 350→250→150</th>
<th>1.8 → 2.45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ft/sec</td>
<td></td>
<td>447</td>
<td>435</td>
<td>480</td>
<td>10</td>
<td>167</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mmHg/sec</td>
<td></td>
<td>10.2</td>
<td>8</td>
<td>11</td>
<td>0.265</td>
<td>1.8</td>
<td>2.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heli autorotation**

<table>
<thead>
<tr>
<th></th>
<th>Ft/sec</th>
<th>30 (2000→0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mmHg/sec</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>
# Physiology of Flight

<table>
<thead>
<tr>
<th>Type</th>
<th>Cabin Alt</th>
<th>mmHg</th>
<th>ΔHg Gnd</th>
<th>Ascent ft/sec</th>
<th>Descent ft/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comm airliner A-320-321 Sudden decom</td>
<td>6-8000</td>
<td>560</td>
<td>200</td>
<td>8.3</td>
<td>Max desc 12.5=750ft/mi n</td>
</tr>
<tr>
<td></td>
<td>6-8000</td>
<td>560</td>
<td>200</td>
<td>8.3</td>
<td>Max desc 12.5=750ft/mi n</td>
</tr>
<tr>
<td></td>
<td>25000&lt;2mi n</td>
<td>282</td>
<td>478</td>
<td>8.3</td>
<td>Max desc 12.5=750ft/mi n</td>
</tr>
<tr>
<td>Glider BE – FR Mountain/wave Namibia</td>
<td>≤7000</td>
<td>590</td>
<td>170</td>
<td>40 (winch)</td>
<td>2 - ≤10</td>
</tr>
<tr>
<td></td>
<td>26000</td>
<td>260</td>
<td>500</td>
<td>40 (winch)</td>
<td>2 - ≤10</td>
</tr>
<tr>
<td></td>
<td>10-16000</td>
<td>420</td>
<td>340</td>
<td>40 (winch)</td>
<td>2 - ≤10</td>
</tr>
<tr>
<td>Helicopter</td>
<td>&lt;10000</td>
<td>490</td>
<td>270</td>
<td>4-8</td>
<td>4-8</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>732</td>
<td>28</td>
<td>4-8</td>
<td>4-8</td>
</tr>
<tr>
<td>Mil F-16</td>
<td>21500</td>
<td>300</td>
<td>460</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Para free Fall</td>
<td>30000</td>
<td>226</td>
<td>500</td>
<td>270</td>
<td>270</td>
</tr>
</tbody>
</table>
Symptoms Barotrauma

• Weissman defined three grades of sinus barotraumas according to symptomatology.

• Grade I → mild transient sinus discomfort no changes on X-ray.
• Grade II → severe pain for \( \leq 24 \) h some mucosal thickening on X-ray.
• Grade III → severe pain for \( > 24 \) h severe mucosal thickening opacification epistaxis or subsequent sinusitis may be observed.
Sinus Barotrauma:
Acute

→ single event, conservative treatment

→ mostly URI, allergy

→ resolve flying when symptoms disappear
Sinus Barotrauma: Recurrent

- Recurrent attacks
- Chronic obstruction ostia (inflammation, anatomy, polyps, neoplasm...)
- ΔΔ by CT sinuses, endoscopy, CAP, skin prick..
- **conservative** treatment: importance of corticosteroids
- **surgical** treatment: FESS
Complications barotrauma:

- Rare, but orbital cellulitis, abcess, hematoma, subcutaneous emphysema are possible.
- Repeated attacks of acute barosinusitis can cause permanent damage of the paranasal sinus mucosa, which leads to recurrent barosinusitis. This condition results from hematoma formation and fibrosis and chronic mucosal thickening, which can further impede adequate sinus ventilation.
Barodontalgia

- **Class Pathology Features**
  - I  Irreversible pulpitis
    Sharp transient (momentary) pain on ascent
  - II Reversible pulpitis
    Dull throbbing pain on ascent
  - III Necrotic pulp
    Dull throbbing pain on descent
  - IV Periapical pathology
    Severe persistent pain (on ascent / descent)
Therapie barotrauma: Medication

- **Prevention**: do not fly with URI, nasal obstruction.

- **Premedication** before flight:
  - Decongestion:
    - Topical: oxy- / xylometazoline, Dexa-Rhinospray
    - Per oral: pseudoeofedrine (Aerinaze), Fenylefrine (R AR)
      Antihistaminics if maintenance treatment

- **In flight**: if possible: regain higher flight level.

- **Prevention secundairy infection**: antibiotics: doxycycline, amoxicillin, macrolidne, quinolones..

- **Combination with corticoids**: combat inflammation!

- **Pain control**: paracetamol, ibuprofen, somtimes narcotic analgetica. Never aspirine.
Therapie barotrauma: Surgical

- In urgency: eventually sinus punctation (considered obsolete)
- **FESS**: success ratio before FESS hardly 50%, now up to 100% (...).
- Every intervention is individually tailored
- Failure: scar formation on frontal recess, maxillary of sphenoidal ostium:
  - for flying personnel: intervention a minima.
  - Option “balloon sinoplasty”....
- polyposis nasi: high rates of relapse
- Postoperatively 3 - 6 weeks grounding, aftercare!!
  pressure chamber test.
Therapie barotrauma: Surgical

Caldwell-Luc

FESS
CHRONIC SINUSITIS

- Moeilijker te behandelen zijn de sinusgerelateerde pathologieën, soms subtiele anatomische afwijkingen die aanleiding geven tot chronische sinusitis die tot obstructie van de sinusostia leiden. Vaak een grotere therapeutische uitdaging,
- Geneest zelden spontaan noch medicamenteus
- Hebben vaak reeds een ingreep ondergaan zonder lange termijnresultaat
- Psychologische implicaties bij leerling piloten
- In het verleden was de behandeling ervan moeilijk tot onvoldoende, maar de introductie van CTscan en de Hopkins starre endoscoop leidden begin jaren 80 tot Messerklinger de FESS techniek introduceerde. Hierbij wordt met minimaal invasieve technieken de ventilatie van de sinus hersteld ter hoogte van de natuurlijke drainageplaats van de sinus, uitgaand van de stelling dat
  - → als de ventilatie correct gebeurt, en
  - → als het mucociliair transport herstelt,
  - → geneest de sinuspathologie.

Dr. Paul Van Der Veken ENT
Hiervoor wordt rekening gehouden met de natuurlijke banen van mucociliair transport, dat sinusaal slijm richting ostium duwt, en eens in de neus, richting nasofarynx (30’).

De frontale, maxillaire en voorste ethmoëdale sinussen draineren in de middelste neusgang, ter hoogte van het OMC, het osteomeataal complex.

Het osteomeataal complex is een spleetje in de middelste neusgang, afgelijnd door de processus uncinatus, de bulla ethmoëdalis, het ethmoëdaal infundibulum en ethmoëdale infraorbitale cellen (Haller).

Indien in deze belangrijke sleutelzone het de drainage beperkt wordt, leidt dit dus tot slijmstase → verhoogde bacteriële load → inflammatie → verstopping → ... infectie

Belang van de anatomie van deze zone, maar tevens beïnvloed door mucosale zwelling:

URI, allergieën, irritantia (tabak), poliepen, chronische sinusitis.
Postoperative aptitude decision making

• Three months [99] to two years [100] takes “wound healing”, if the duration is measured as time interval from injury (e.g. during surgery) to accomplishment of the optimal and final functional result. Especially in adults [101], the regenerated tissue shows less serous glands [97] with increased number of excretory ducts [102]. Subepithelial stroma of the regenerated tissue is thicker and the number of vessels is increased [103]. Only slightly more than half of all patients show a normal mucociliary clearance 18 months after sinus surgery.
CONCLUSION

- Diagnosis (chronic) sinusitis is not evident. CT sinuses is crucial
- EMPIC?
- Chronic sinusitis increases the risk of barosinusitis, but also of barotitis, and influences wellbeing during flight
- Barosinusitis is rather rare, but not without danger.

Dr. Paul Van Der Veken
ENT Brussels Aviation Medical