Air Medical Transport Course

Altitude Physiology

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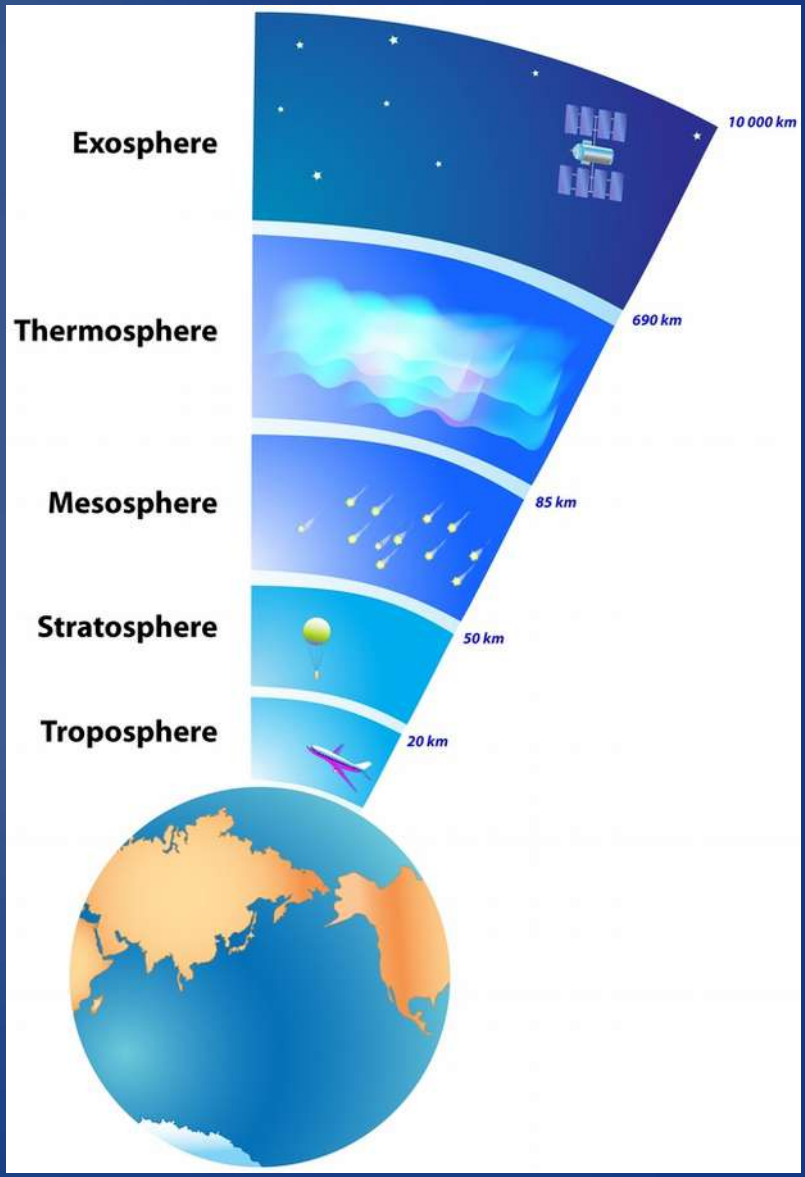
Average Barometric Pressures

Altitude (in 1000 feet)	Barometric Pressure mm Hg	Temperature C°
0	**760 (= 1 bar)**	**+ 15.0**
1	733 (-27)	+ 13.0
2	706 (-27)	+ 11.0
3 (= 915m)	681 (-25)	+ 9.1
4	656 (-25)	+ 7.1
5	632 (-24)	+ 5.1
6	609 (-23)	+ 3.1
7 (=2133m)	586 (-23)	+ 1.1
8	564 (-22)	- 0.9
9	542 (-22)	- 2.8
10 (=3048m)	522 (-20)	- 4.8
18 (=5486m)	**380 (= 0.5 bar)**	**-20.6**
20	349	- 24.6
30	228	- 44.4
34	190 (= 0.25 bar)	- 55.0
48 (=14630m)	95 (= 0.125 bar)	- 55.0



Dalton's Law

- Air sample at sea level:
  - pO_2 = 160 mm Hg = 21%
  - pN_2 = 593 mm Hg = 78%
  - other = 7 mm Hg = 1%
  - 760 mm Hg =100%
- Air sample at 18,000 feet
  - pO_2 = 80 mm Hg = 21%
  - pN_2 = 296 mm Hg = 78%
  - other = 4 mm Hg = 1%
  - 380 mm Hg =100%

Dalton's Law

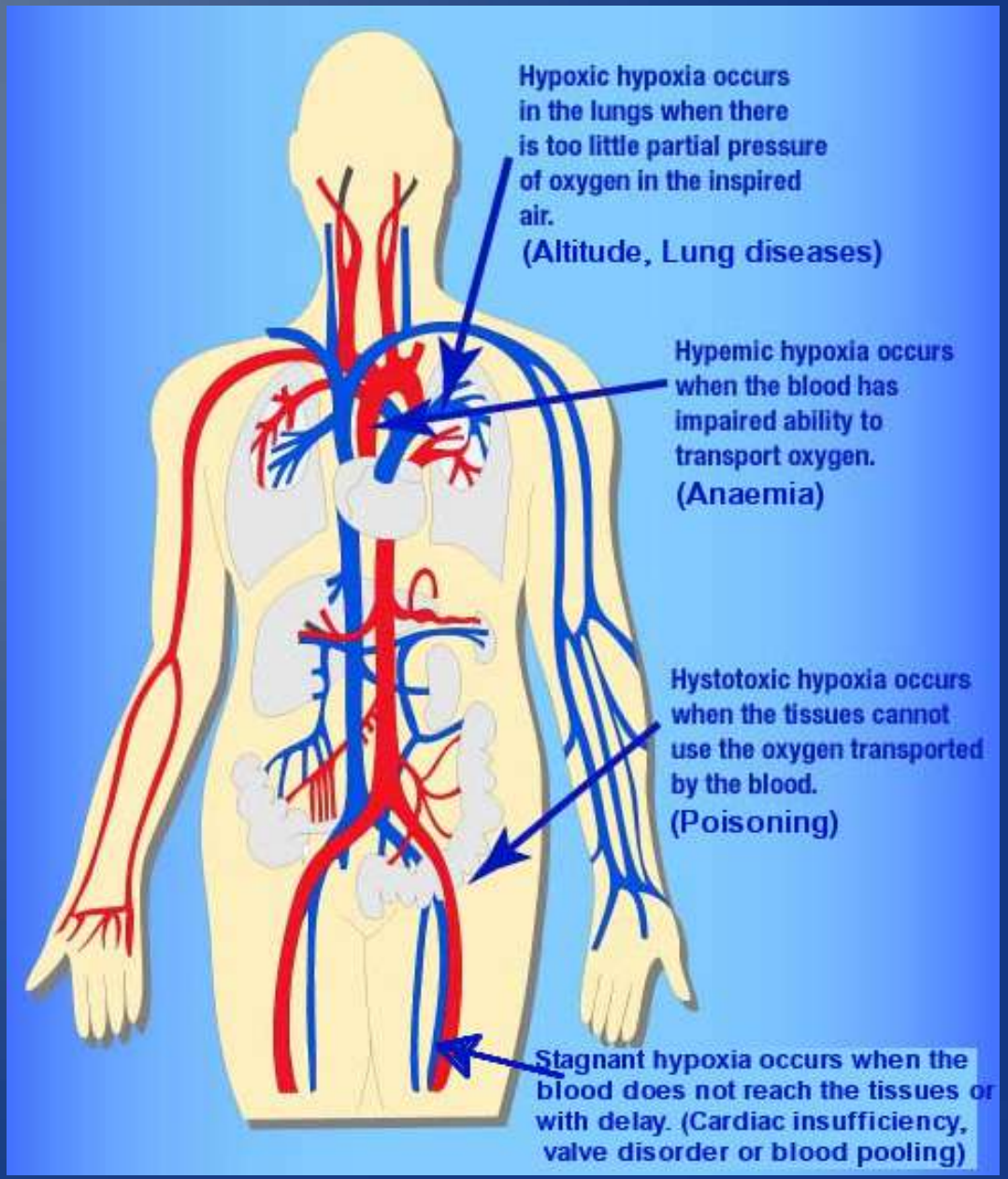
But think of the differences in the body!

Composition and Partial Pressures of Alveolar Air at Sea Level

GAS	Percentage	Pressure (mmHg)
Nitrogen (N2)	74,9 %	569
Oxygen (O2)	13,7 %	104
Water Vapor (H2O)	6,2 %	47
Carbon dioxide (CO2)	5,2%	40
TOTAL	100 %	760

Hypoxia

- A state of oxygen deficiency in the tissues sufficient to impair function.



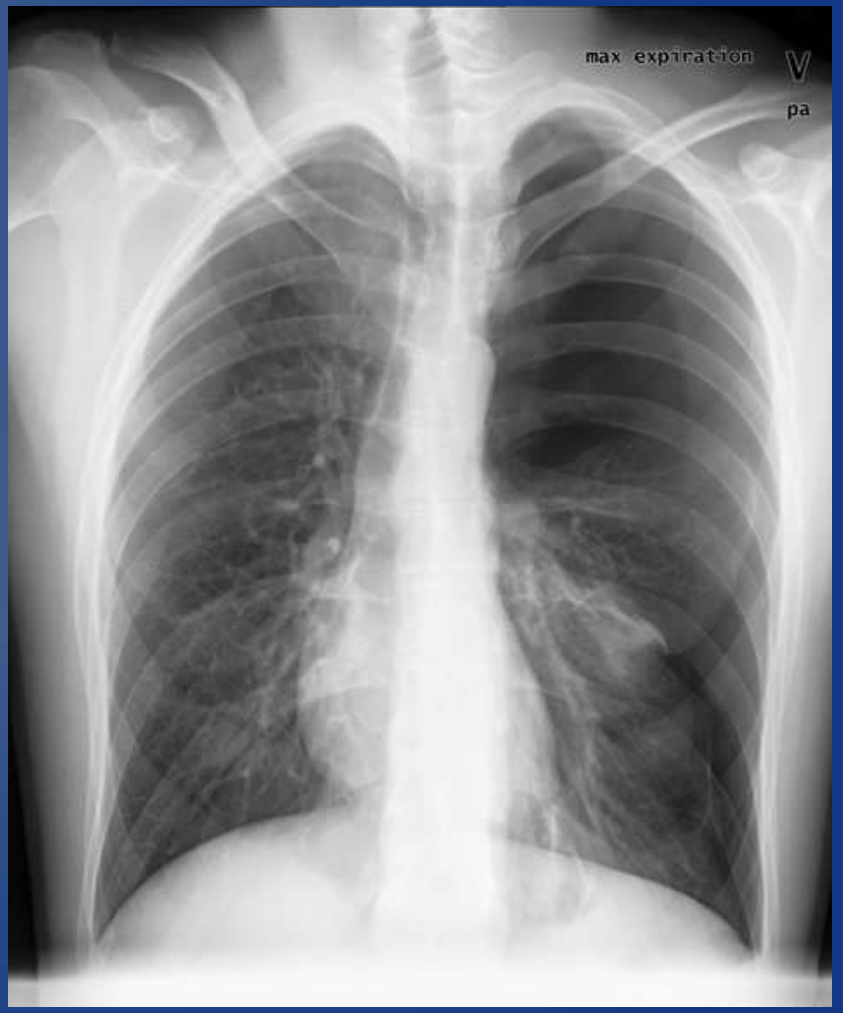
Oxygen Delivery & Adjustment to Altitude

FIO_2	SL	6,000	7,000	8,000	9,000	10,000
0,21	159	128	123	118	113	109
0,30	228	183	176	169	163	157
0,40	**304**	244	235	226	217	209
0,50	380	**304**	293	**282**	271	262
0,60	456	365	352	**339**	325	**314**
0,70	532	426	410	395	379	367
0,80	608	487	469	452	434	419
0,90	684	548	528	492	489	471
1,00	760	609	586	565	542	524

All amounts are pO_2 alv.

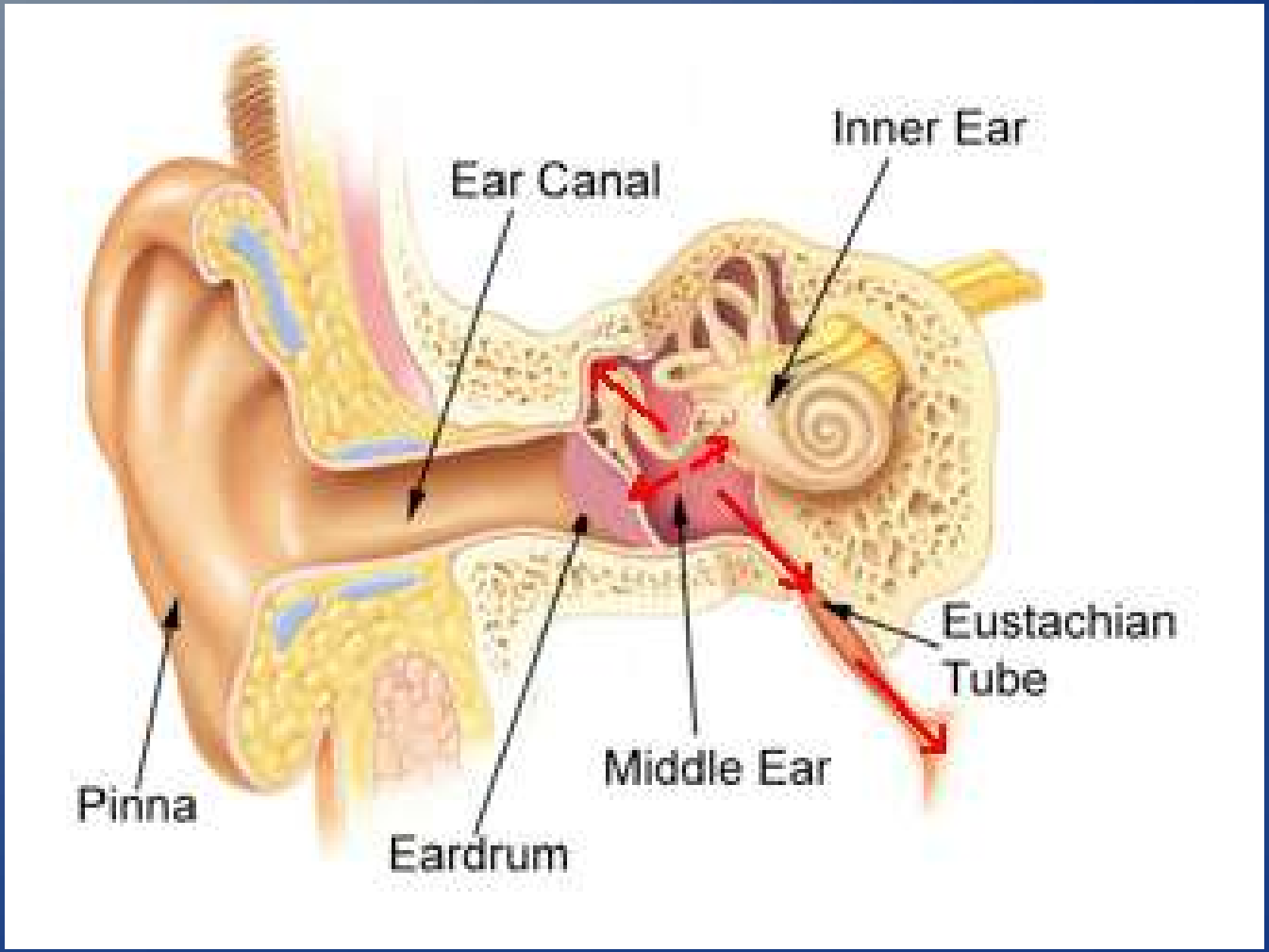
The Respiratory Tract

- Hypoxia
- Bullae
- Pneumothorax
  - Diagnosis and treatment prior to flight
  - Existing pneumothorax left untreated will expand while ambient pressure decreases
  - If the lung tissue continues to be compressed due to trapped gas expansion, intrathoracic pressure will increase
  - Vascular structures within the chest may become compromised
  - Potential tension pneumothorax



The Middle Ear

Ascending



Endotracheal Tubes

Before flight, replace the air in the cuff of the tube for sodium chloride. When not doing so, but instead using a cuff pressure meter you have two risks:

- **<u>Very seldom</u>**, but a decompression at 40000 feet will result in an 800% expansion of air ...

Mechanical Ventilation

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Mechanical Ventilator

Generates a controlled flow of gas into a patient's airways. Oxygen and air are blended according to the prescribed inspired oxygen tension, and delivered to the patient using one of many available modes of ventilation. FiO_2

The central premise of positive pressure ventilation is that gas flows along a pressure gradient between the upper airway and the alveoli. The magnitude, rate and duration of flow are determined by the operator. TV / P_{insp} ,RR

Flow is either volume targeted and pressure variable, or pressure limited and volume variable. VCV / PCV

There are two phases in the respiratory cycle, high lung volume and lower lung volume (inhalation and exhalation). Gas exchange occurs in both phases. $P_{insp} / P_{exsp} > 0$

Protective Lung Ventilation

It has been established that cyclical inflation and deflation may injure lung parenchyma and may worsen outcome.

Large tidal volume ventilation, to “normalize” blood gases has been shown to worsen outcome in lung injury, presumably due to excessive pressure induced stretch injury of the parenchyma.

Modern ventilation strategy involves attempting to achieve an adequate minute volume with the lowest possible airway pressure (as this relates to the degree of alveolar distension). The pressure that we are interested in minimizing is at the level of the alveolus, the plateau pressure.

$$Vt = 6 – 8\ ml/kg$$

Classification of Ventilation

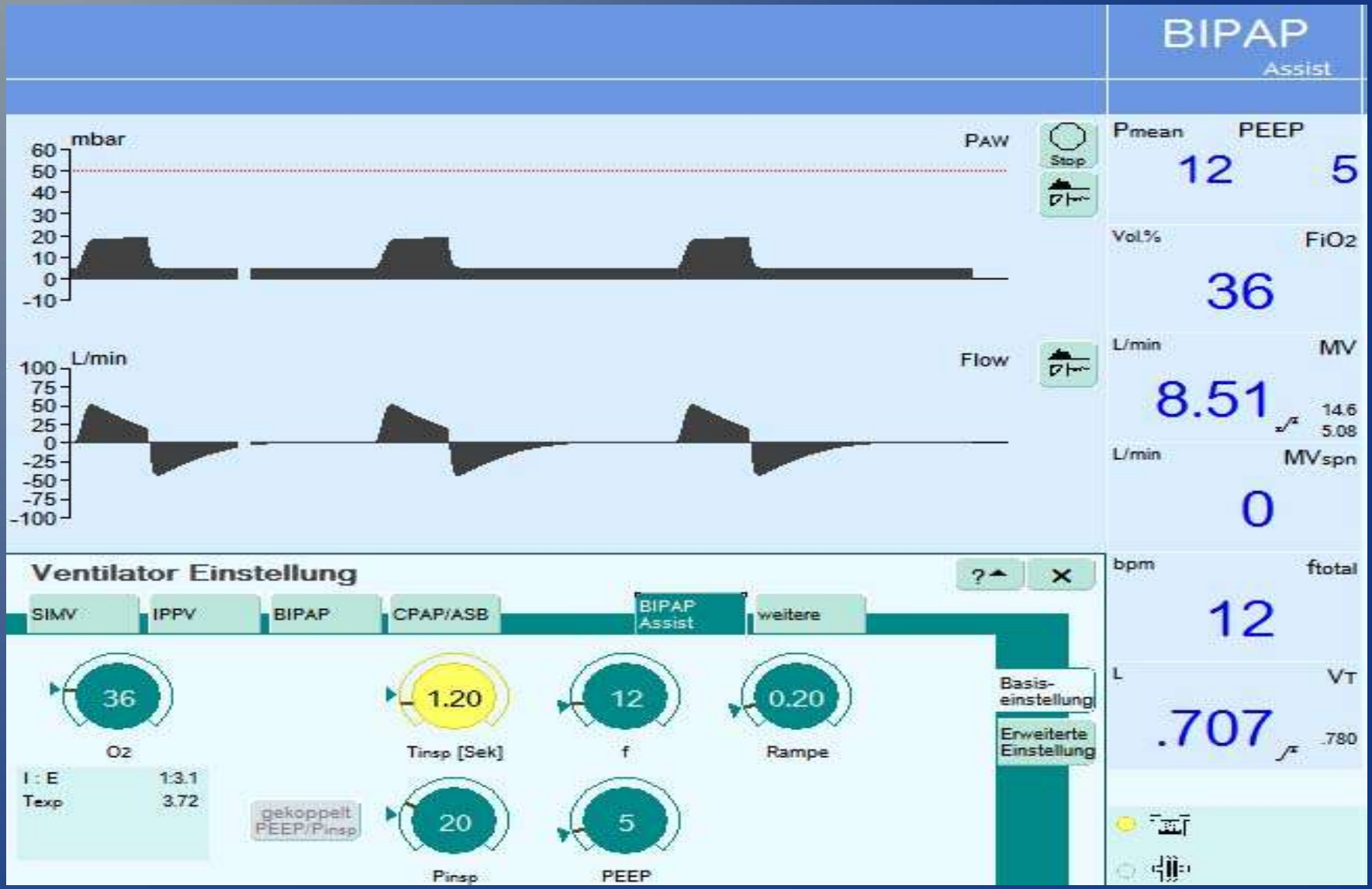
- Control
- Cycling
- Trigger
- Breath
- Flow Pattern
- Mode

Mode: Biphasic Positive Airway Pressure (Bilevel, BIPAP, DuoPAP)

Bilevel ventilation (bilevel CPAP) or BIPAP, is ARPV with spontaneous breathing. A sophisticated valve has been developed which allows the patient to breath spontaneously at either CPAP/PEEP levels, and partial assistance (pressure support or automatic tube compensation) can be introduced to assist the spontaneous breaths. This mode appears to be extremely well tolerated, and heavy sedation is not required (it is in APRV and IRV).

Any intensive care patient can be managed on this mode of ventilation. Bilevel can be used as conventional pressure controlled ventilation, or as Airway Pressure Release Ventilation.

BIPAP cont.


BIPAP
Assist
mbar
60
50
40
30
20
10
0
-10
PAW
Stop
Pmean
PEEP
12
5
Vol%
FiO2
36
L/min
100
75
50
25
0
-25
-50
-75
-100
Flow
L/min
MV
8.51
14.6
5.08
L/min
MVspn
0
Ventilator Einstellung
SIMV
IPPV
BIPAP
CPAP/ASB
BIPAP Assist
weitere
bpm
ftotal
12
36
O2
1.20
Tinsp [Sek]
12
f
0.20
Rampe
Basis-einstellung
Erweiterte Einstellung
L
VT
.707
.780
I : E
1:3.1
Texp
3.72
gekoppelt PEEP/Pinsp
20
Pinsp
5
PEEP

Mode: Adaptive Support Ventilation (ASV)

A dual control mode that uses pressure ventilation (both PC and PSV) to maintain a set volume target (V_E) using the least required settings for minimal WOB depending on the patient's condition and effort.

It automatically adapts to patient demand by increasing or decreasing support, depending on the patient's elastic and resistive loads.

ASV cont.

The clinician enters the patient's IBW, which allows the ventilator's algorithm to choose a required VE. The ventilator then delivers 100 mL/min/kg.

A series of test breaths measures the system compliance, resistance and auto-PEEP

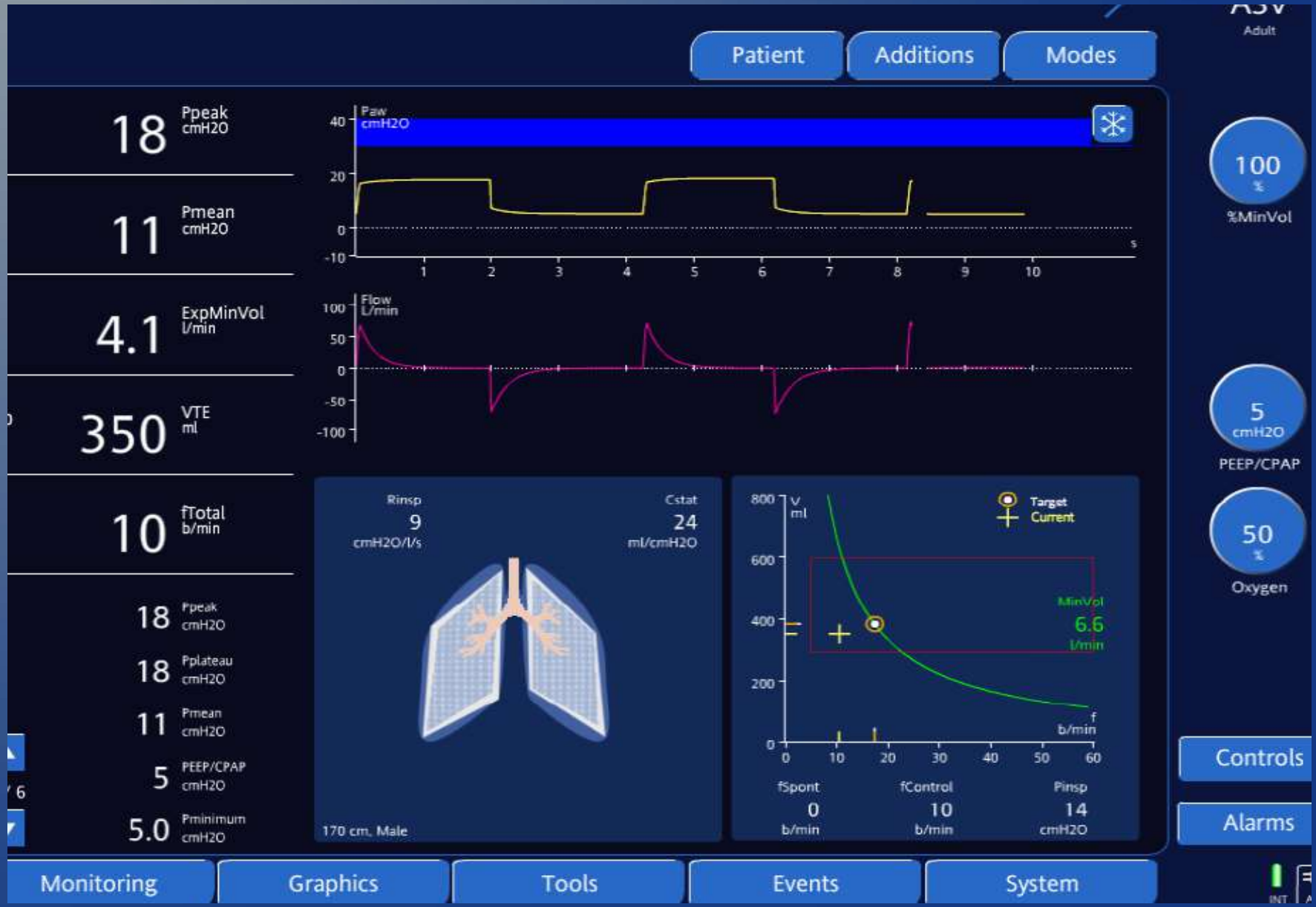
If no spontaneous effort occurs, the ventilator determines the appropriate respiratory rate, VT, and pressure limit delivered for the mandatory breaths

I:E ratio and TI of the mandatory breaths are continually being "optimized" by the ventilator to prevent auto-PEEP

If the patient begins having spontaneous breaths, the number of mandatory breaths decrease and the ventilator switches to PS at the same pressure level

Pressure limits for both mandatory and spontaneous breaths are always being automatically adjusted to meet the VE target

ASV cont.


ASV
Adult
Patient
Additions
Modes
18
Ppeak
cmH2O
11
Pmean
cmH2O
4.1
ExpMinVol
l/min
350
VTE
ml
10
fTotal
b/min
Paw
cmH2O
Flow
L/min
s
100
%MinVol
5
cmH2O
PEEP/CPAP
50
Oxygen
Rinsp
9
cmH2O/l/s
Cstat
24
ml/cmH2O
170 cm, Male
V
ml
Target
Current
MinVol
6.6
l/min
f
b/min
fSpont
0
b/min
fControl
10
b/min
Pinsp
14
cmH2O
18
Ppeak
cmH2O
18
Pplateau
cmH2O
11
Pmean
cmH2O
5
PEEP/CPAP
cmH2O
5.0
Pminimum
cmH2O
Controls
Alarms
Monitoring
Graphics
Tools
Events
System

Transport Hygiene

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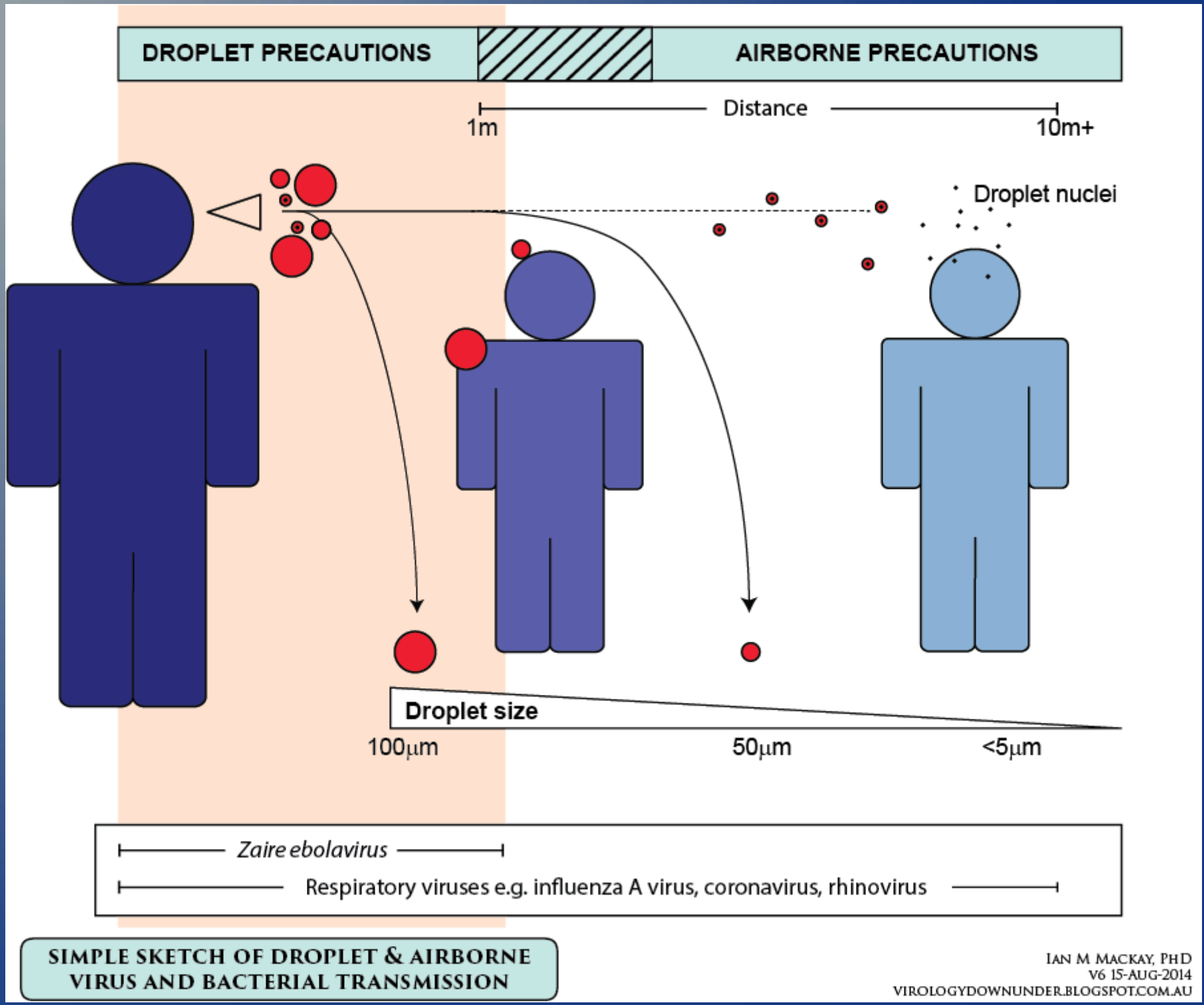
Transmission of Microorganisms

- Airborne Route
- Droplet Transmission
- Direct/Indirect Contact
- Fecal/Oral Route
- Vectorborne Transmission (mosquitoes, etc.)



SIMPLE SKETCH OF DROPLET & AIRBORNE VIRUS AND BACTERIAL TRANSMISSION

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V6 15-AUG-2014
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Patient Risk Categories

- Category A

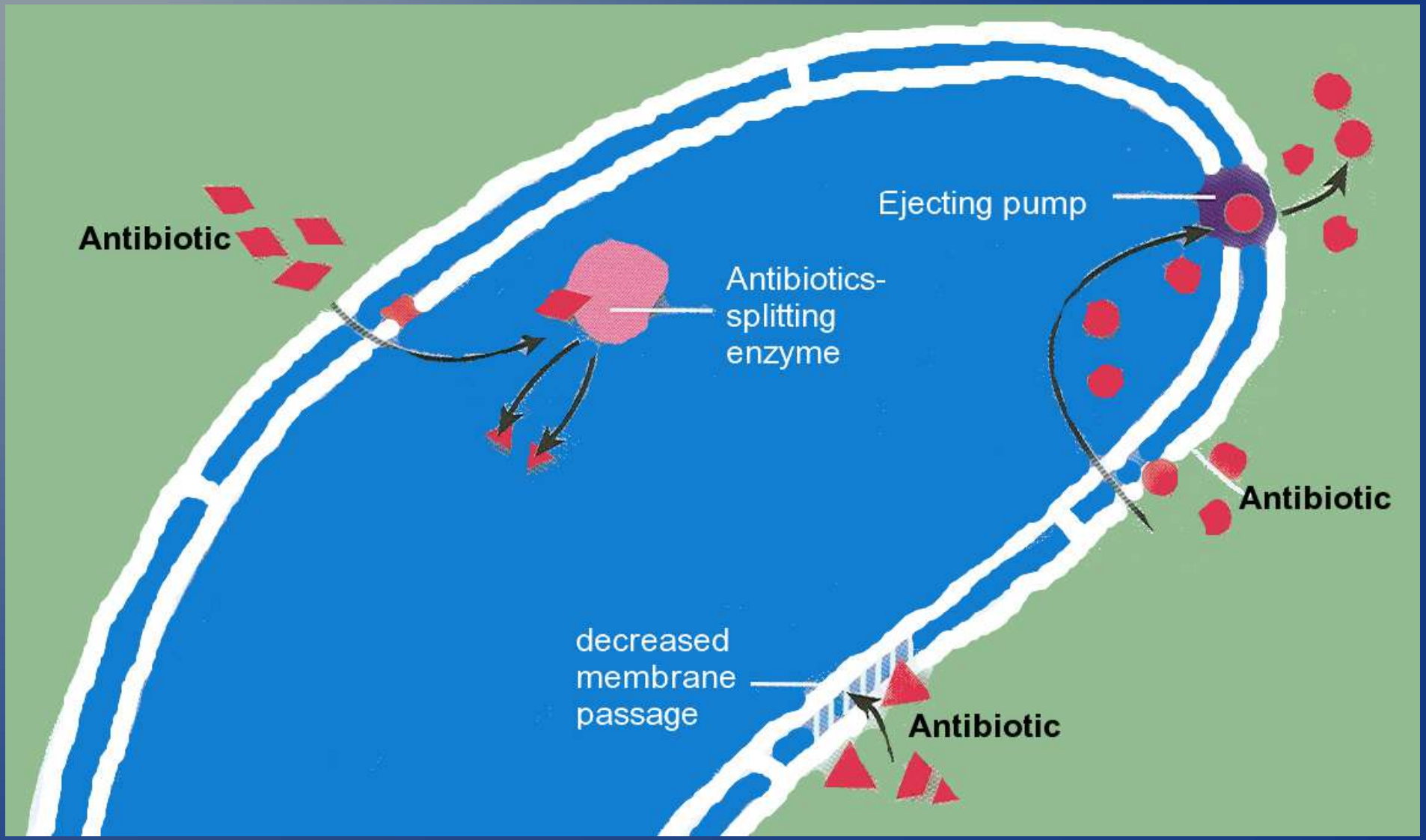
  Patients without a suspicion of an infection
- Category B

  Patients with an infection that is usually not transmitted by normal contact (closed TBC, Hepatitis B without a wound, HIV)
- Category C-1

  Patients with a contagious infection (open TBC, meningococcal Meningitis, Diphtheria, Typhus, Cholera)
- Category C-2

  Suspicion (enough) of a high contagious life-threatening infection (Lassa, Ebola, SARS)
- Category D

  Patients that are endangered to get infected (reduced immune response or extended burns)


Antibiotic
Antibiotics-
splitting
enzyme
Ejecting pump
Antibiotic
decreased
membrane
passage
Antibiotic

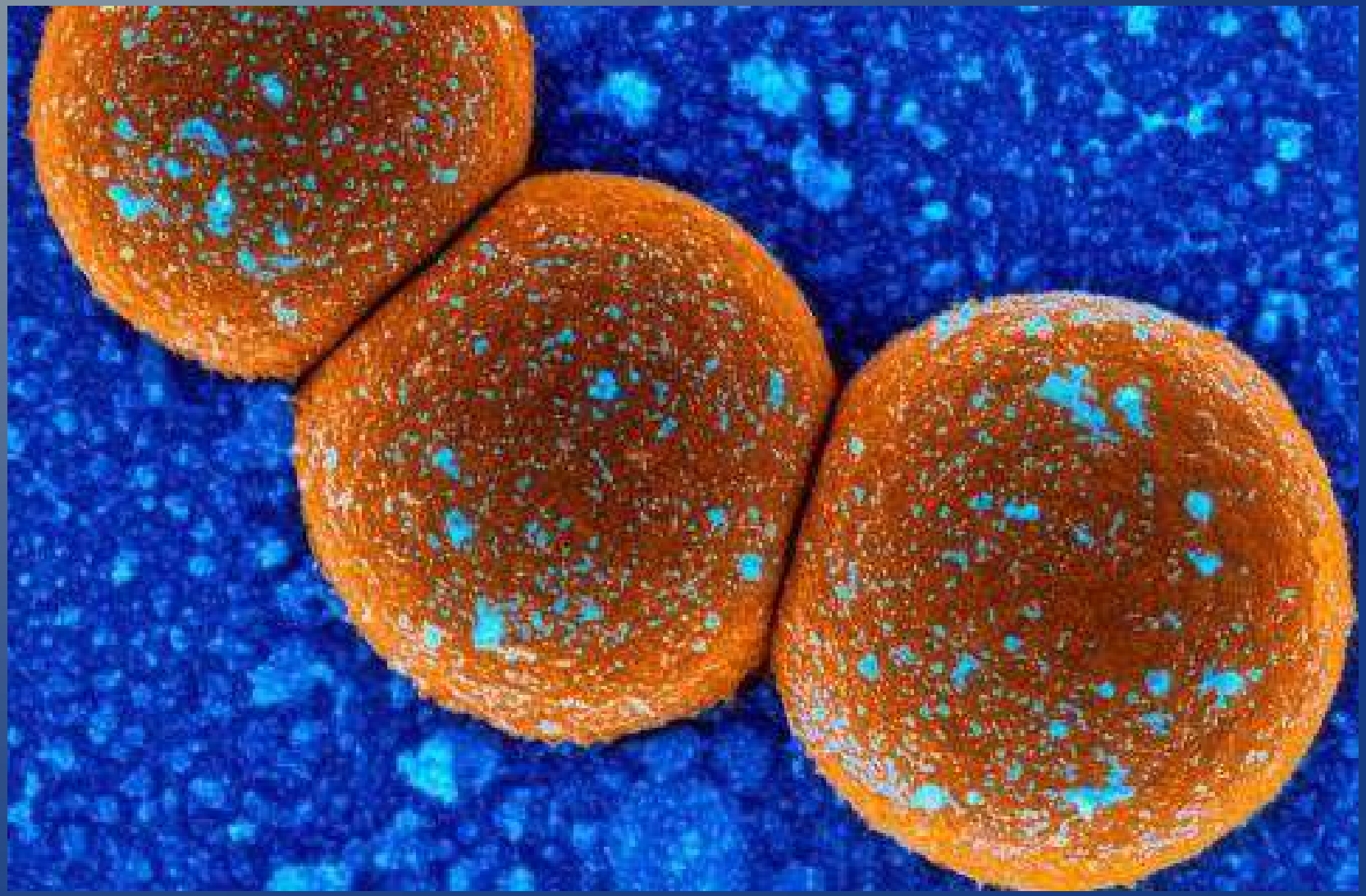
Transmission Risk

	MRSA Risk of Contact			TBC Risk of Contact			ESBL Risk of Contact			CD Risk of Contact			EHEC Risk of Contact			VRE Risk of Contact		
	low	middle	high	low	middle	high	low	middle	high	low	middle	high	low	middle	high	low	middle	high
Coughing			X			X		X		X			X			X		
open endobronchial suctioning			X			X		X		X			X			X		
closed endobronchial suctioning		X			X				X	X			X			X		
mechanical ventilation without HME filter			X			X		X		X			X			X		
mechanical ventilation with HME filter	X			X				X		X			X			X		
Emesis																		
Stool	X			X					X			X			X			X
Urine		X			X			X		X				X			X	
Catheterisation	X				X			X		X			X				X	
peripheral venous line	X			X			X			X			X			X		
central venous line	X			X			X			X			X			X		
non invasive blood pressure control		X		X			X			X			X			X		
temperature control (ear/tympanic)	X			X			X			X			X			X		
blood glucose control	X			X			X			X			X			X		
ECG		X		X				X		X			X			X		
changing linen on the stretcher			X	X					X		X			X			X	

Persistance of Germs on Surfaces

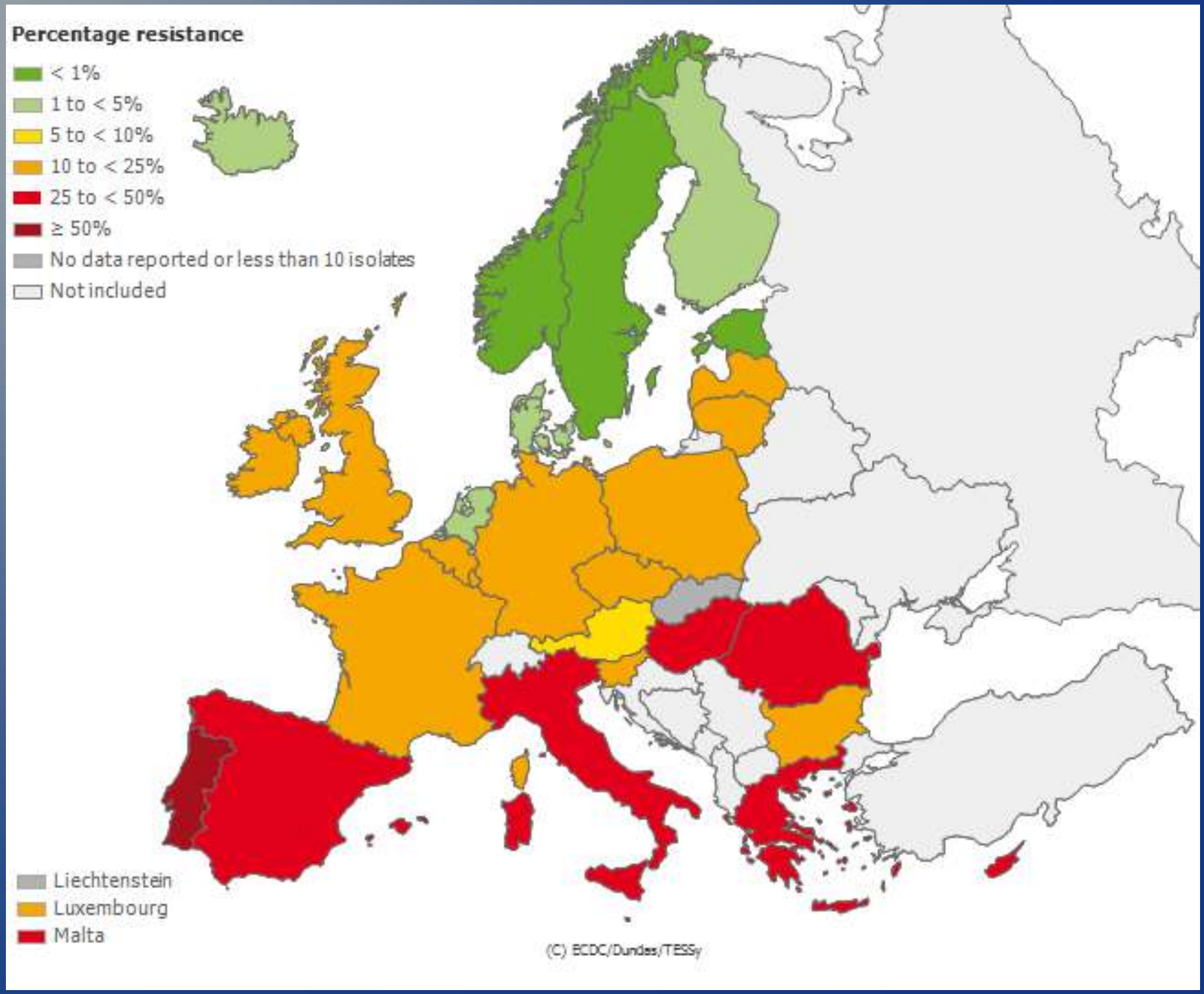
BACTERIA	Klebsiella	> 30 months
	Pseudomonas aeroginosa	> 16 months
	Escherischia Coli	> 16 months
	Staphylococcus aureus (MRSA)	7 days to 7 months
	Corynebacterium dyphtheriae	7 days to 6 months
	Enterococcus species (VRE, VSE)	5 days to 4 months
	Mycobacterium tuberculosis	1 day to 4 months
	Salmonella typhy	6 to 28 days
	Streptococcus pneumoniae	up to 20 days
	Campylobacter jejuni	up to 6 days
FUNGAL SPORES	Torulopsis glabrata	up to 5 months
	Candida albicans	up to 4 months
	Candida parapsilosis	14 days
VIRUS	Adenovirus	up to 3 months
	Vaccinia Virus	up to 5 months
	Herpes Simplex Virus type 1 & 2	up to 2 months
	Hepatitis A Virus	up to 2 months
	Hepatitis B Virus	more than 7 days
	Human Immunodeficiency Virus	more than 7 days
	Papovavirus	7 days
	Noro Virus	up to 7 days
	Corona Virus (SARS, MERS-CoV)	up to 4 days
	Influenza Virus	up to 2 days

Methicilline Resistant Staphylococcus Aureus (MRSA)



Predisposing Factors

- High age
- Patients with a stroke
- Male gender
- Previous infection with MRG
- Long hospital stays
- Chronic skin lesions
- Nursing homes
- Working on a farm
- Diabetes mellitus
- Recent surgery
- Hemodialysis
- Immunosuppression
- Prolonged antibiotic therapy
- Implants
- Intensive Care Therapy
- Closer contacts to MRSA positive persons


Percentage resistance
< 1%
1 to < 5%
5 to < 10%
10 to < 25%
25 to < 50%
≥ 50%
No data reported or less than 10 isolates
Not included
Liechtenstein
Luxembourg
Malta
(C) ECDC/Dundas/TESSy

Typhoid Fever