LES ACCIDENTS BAROTRAUMATIQUES

DESIU MED PLG & MED HYP – NOUMEA – 02/2022

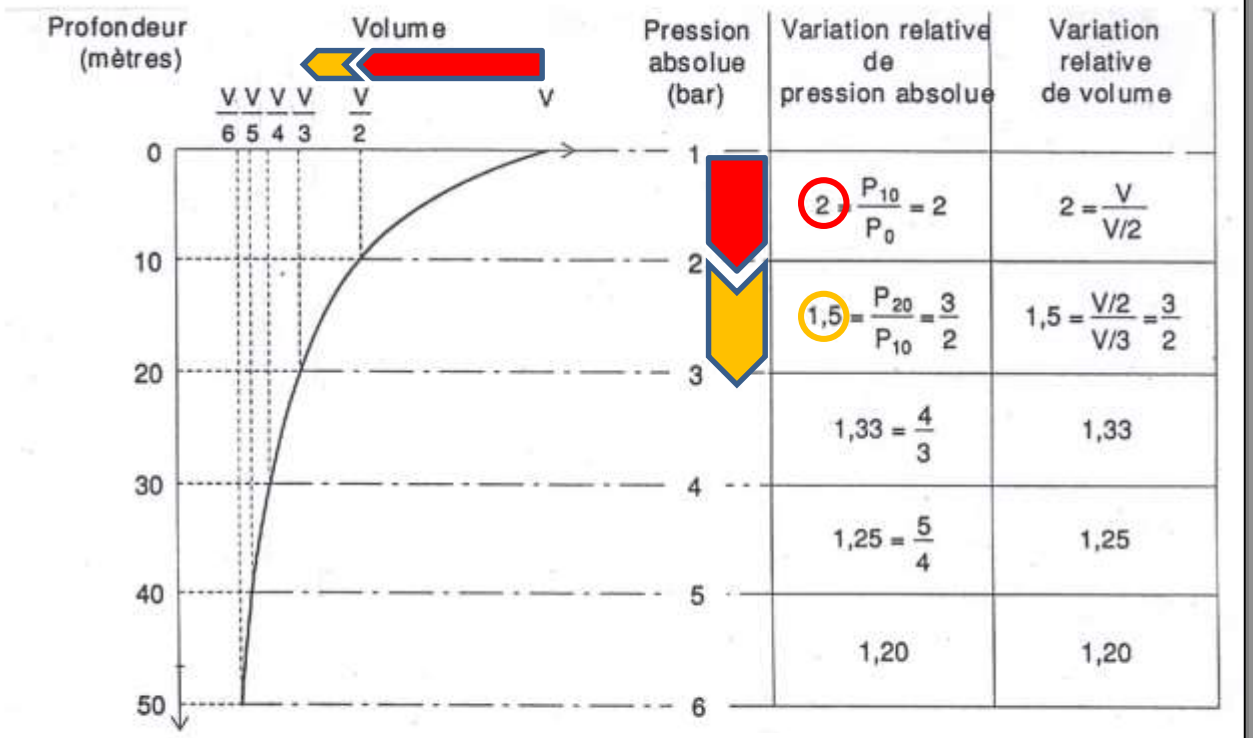
mathieu.coulange@ap-hm.fr

Médecine Hyperbare, Subaquatique et Maritime, Pôle Réanimation Urgences SAMU Hyperbarie, CHU Marseille
Centre de Recherche en Cardio-Vasculaire et en Nutrition, Aix Marseille Université
Institut de Médecine et de Physiologie en Milieu Maritime et en Environnement Extrême - PHYMAREX
Centre National de Plongée, de Secours Nautique & de Survie, ECASC / SDIS04
Société Nationale de Sauvetage en Mer - SNSM

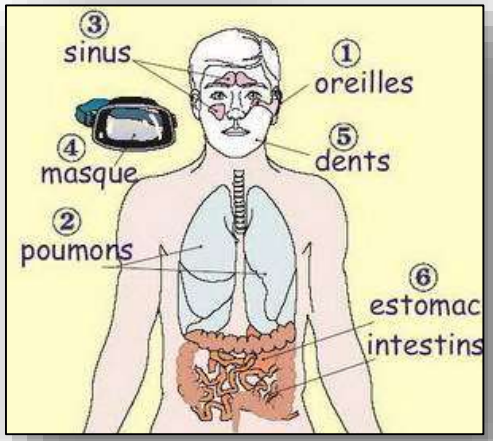
PHYSIOPATHOLOGIE

Loi de Boyle-Mariotte : P x V = constante

*« A température constante, le **volume** d'un gaz est **inversement** proportionnel à la **pression** qu'il subit »*

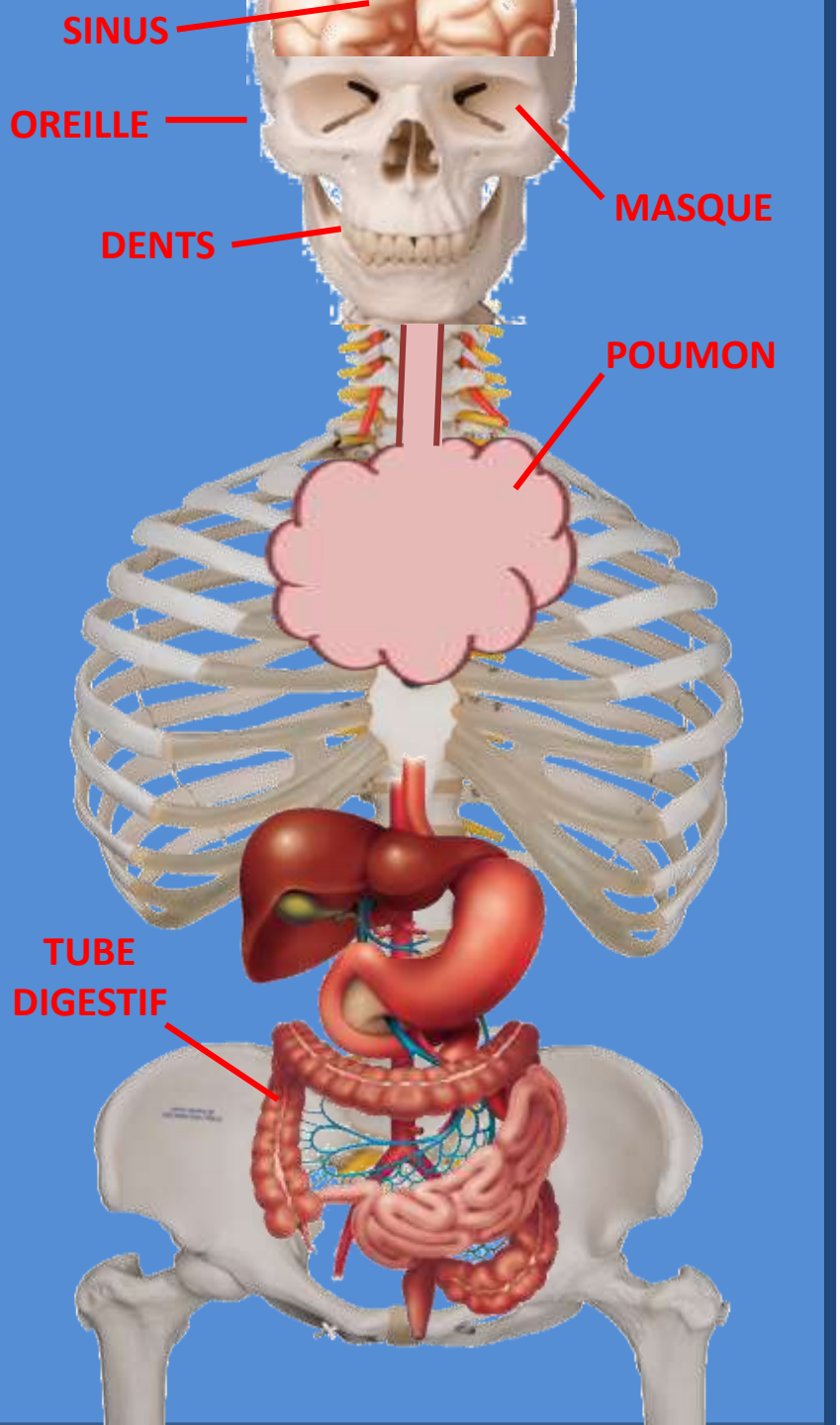


Pression absolue (bar)	Variation relative de pression absolue	Variation relative de volume
1		
2	$2 = \frac{P_{10}}{P_0} = 2$	$2 = \frac{V}{V/2}$
3	$1{,}5 = \frac{P_{20}}{P_{10}} = \frac{3}{2}$	$1{,}5 = \frac{V/2}{V/3} = \frac{3}{2}$
4	$1{,}33 = \frac{4}{3}$	1,33
5	$1{,}25 = \frac{5}{4}$	1,25
6	1,20	1,20



± PATHOLOGIE SOUS JACENTE

TABLEAUX CLINIQUES



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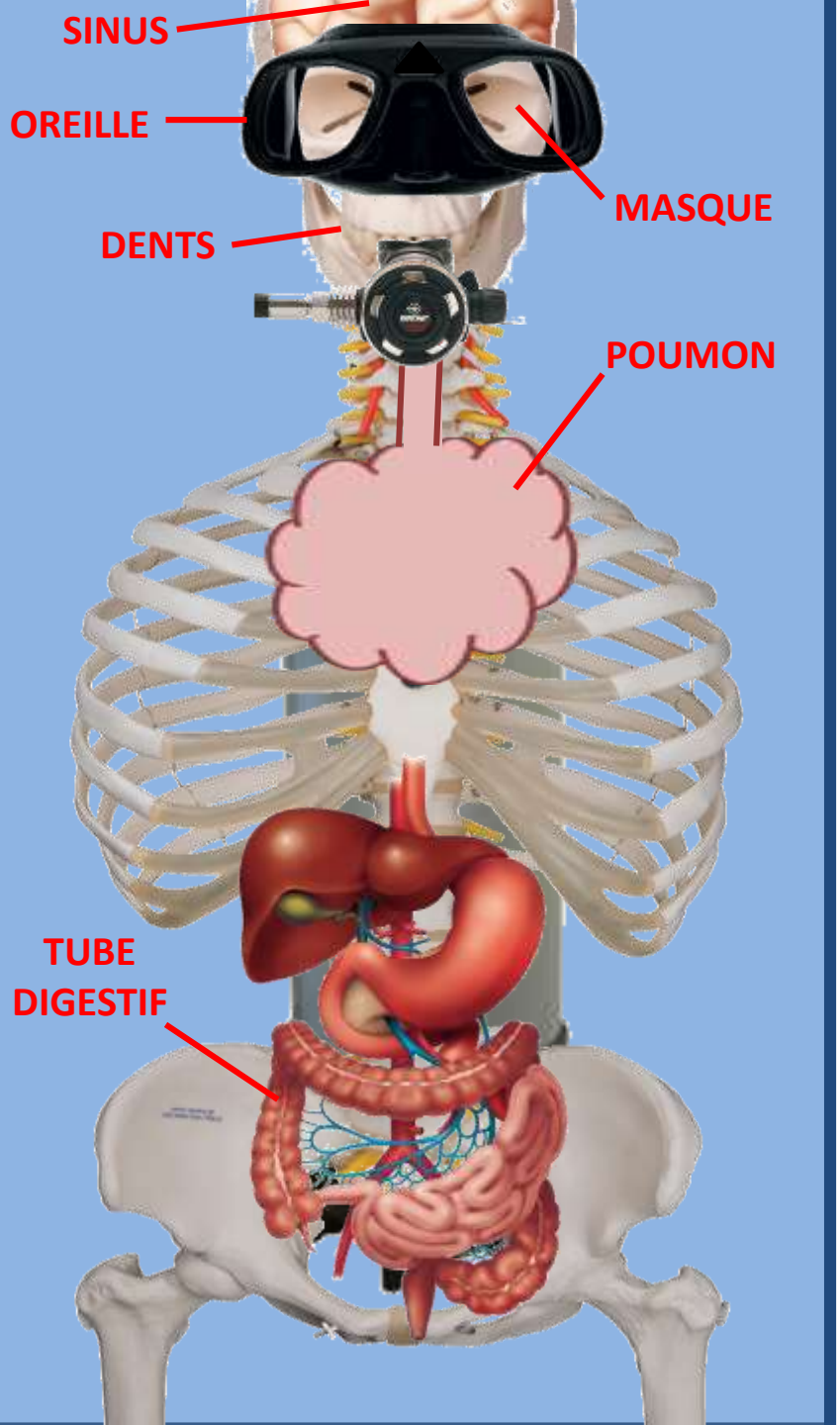
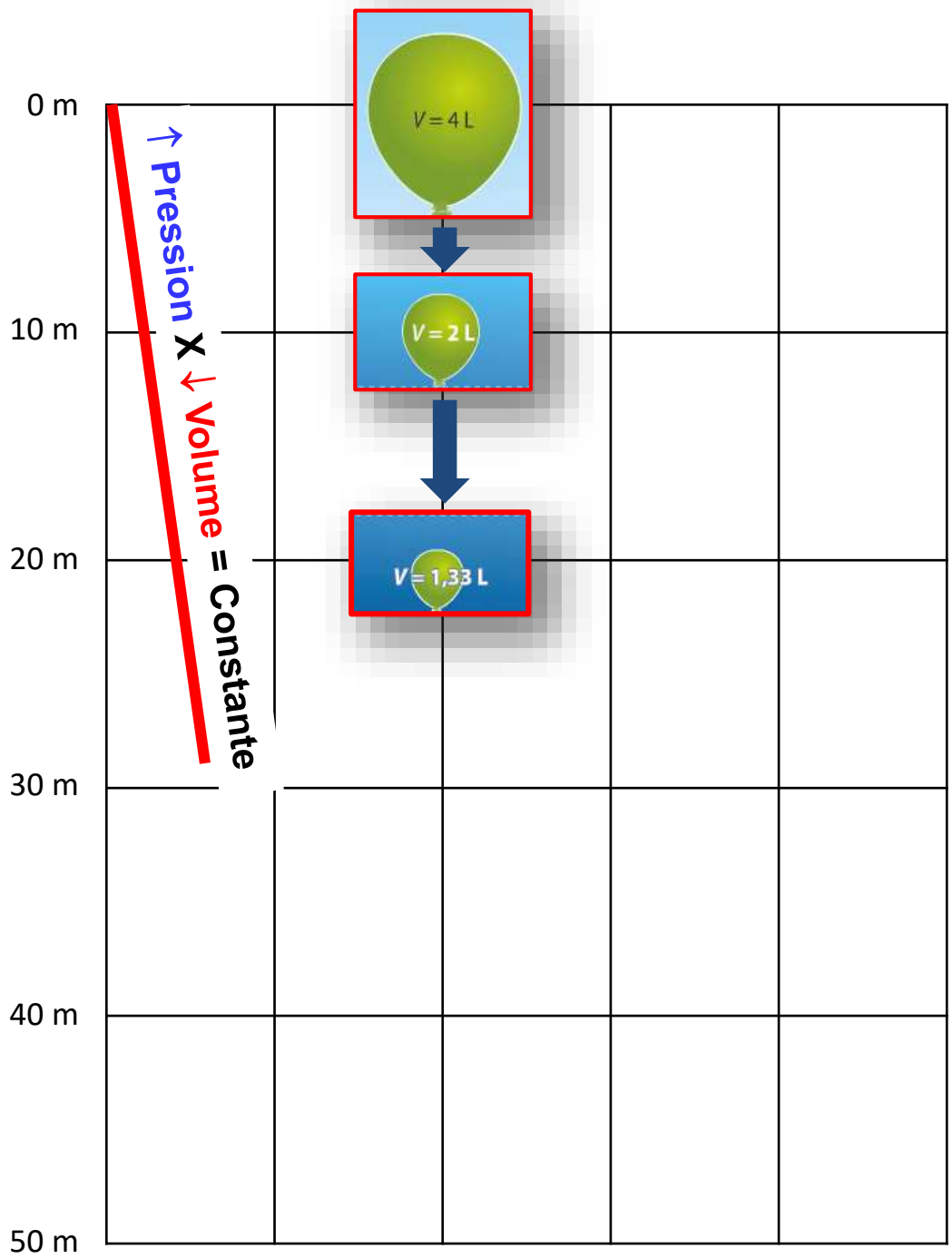
10 m					
20 m					
30 m					
40 m					
50 m					


SINUS
OREILLE
MASQUE
DENTS
POUMON
TUBE
DIGESTIF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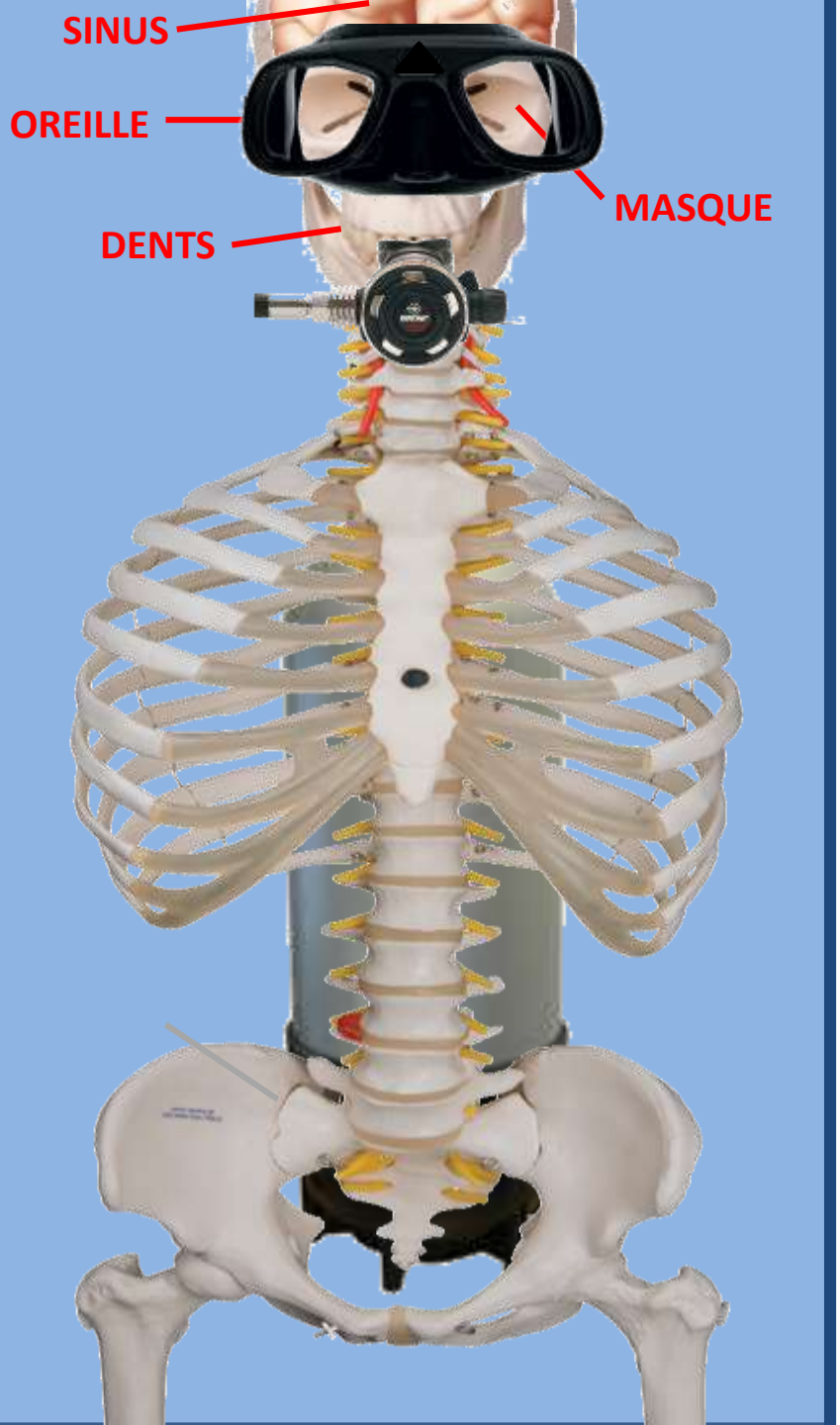
↑ Pression X ↓ Volume = Constante
V = 4 L
V = 2 L
V = 1,33 L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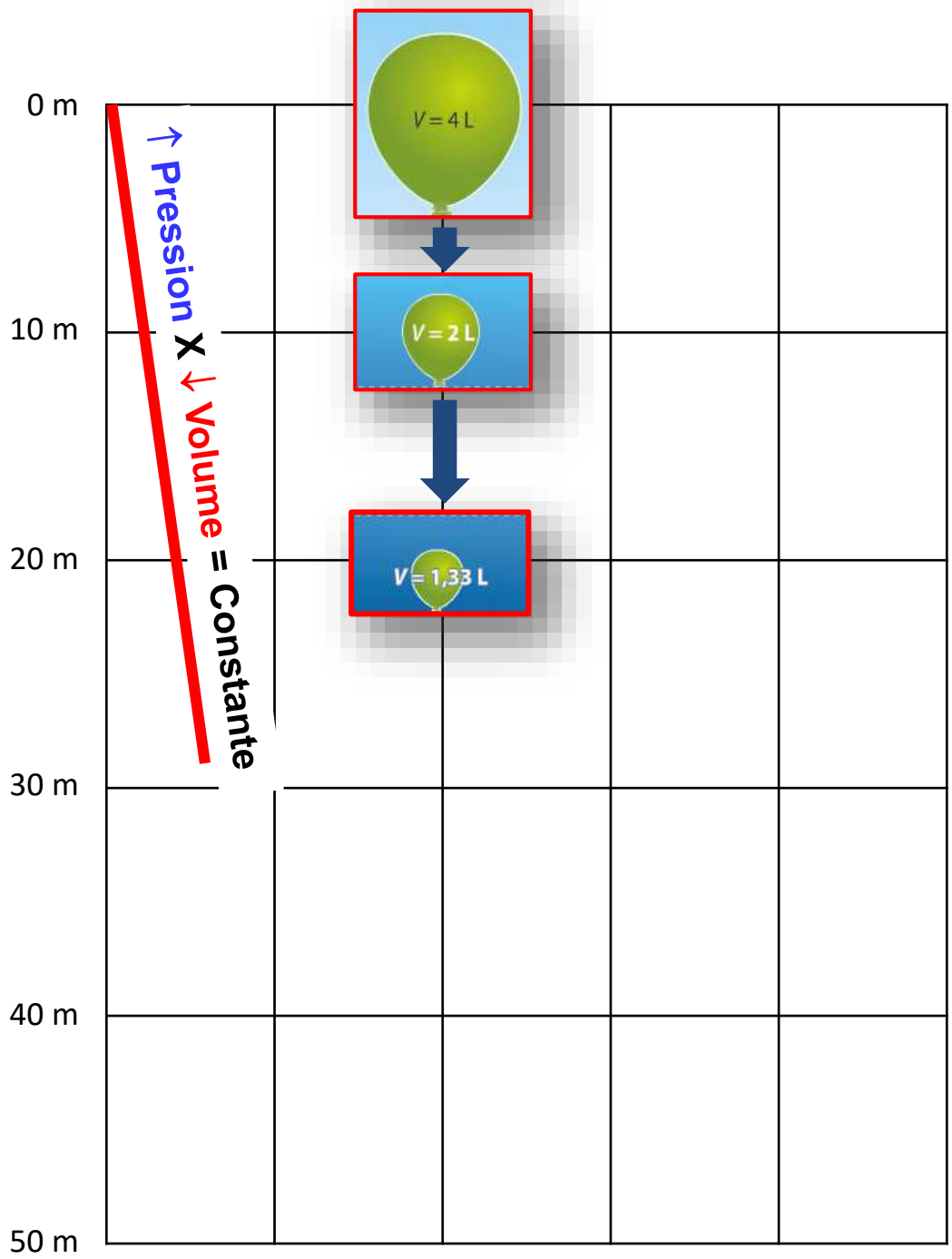
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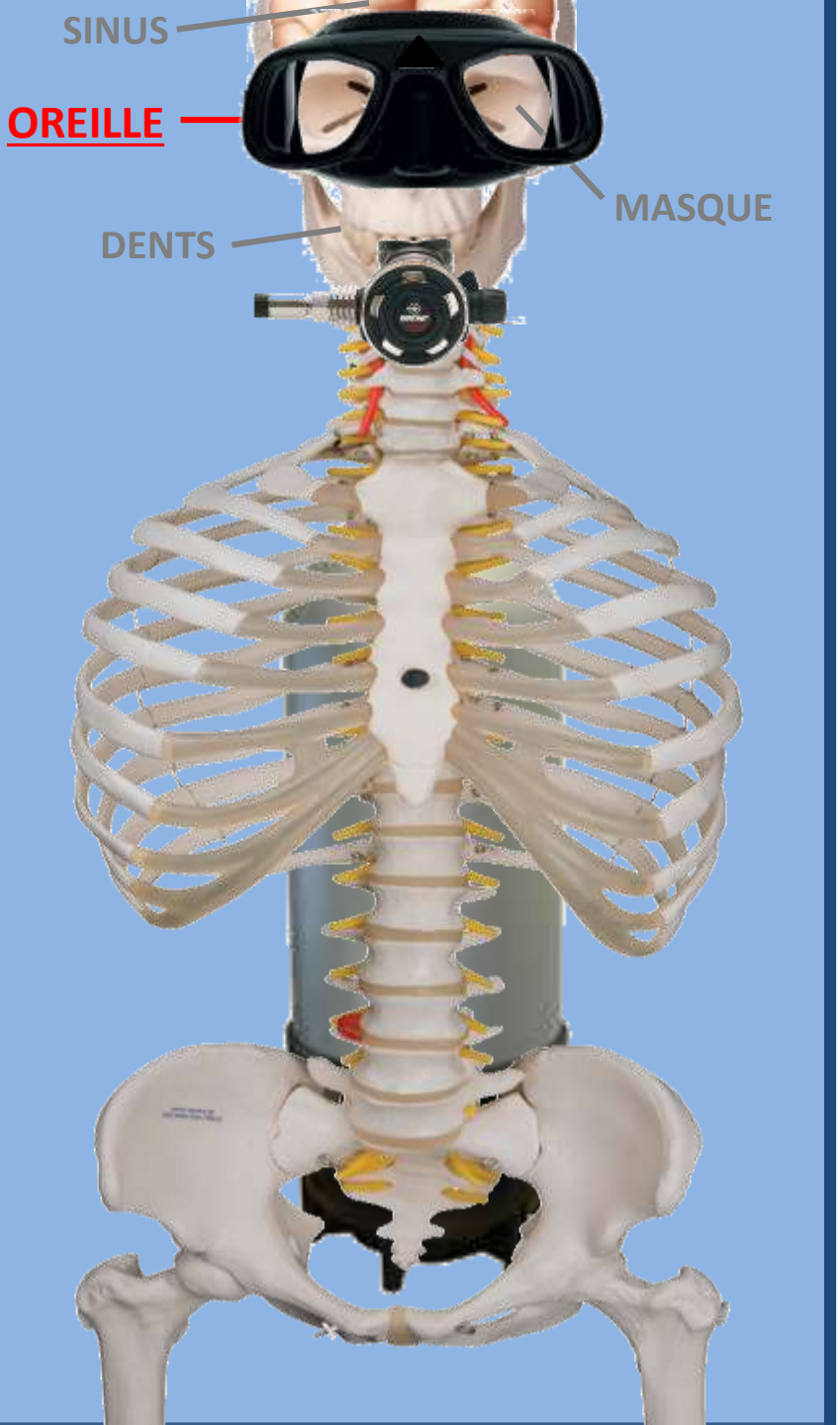
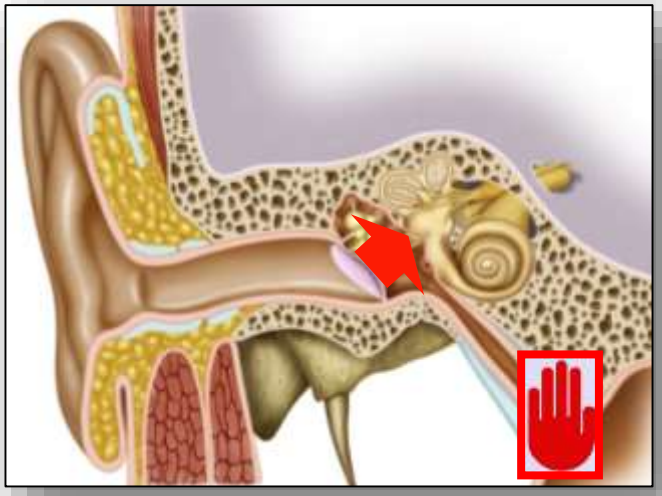
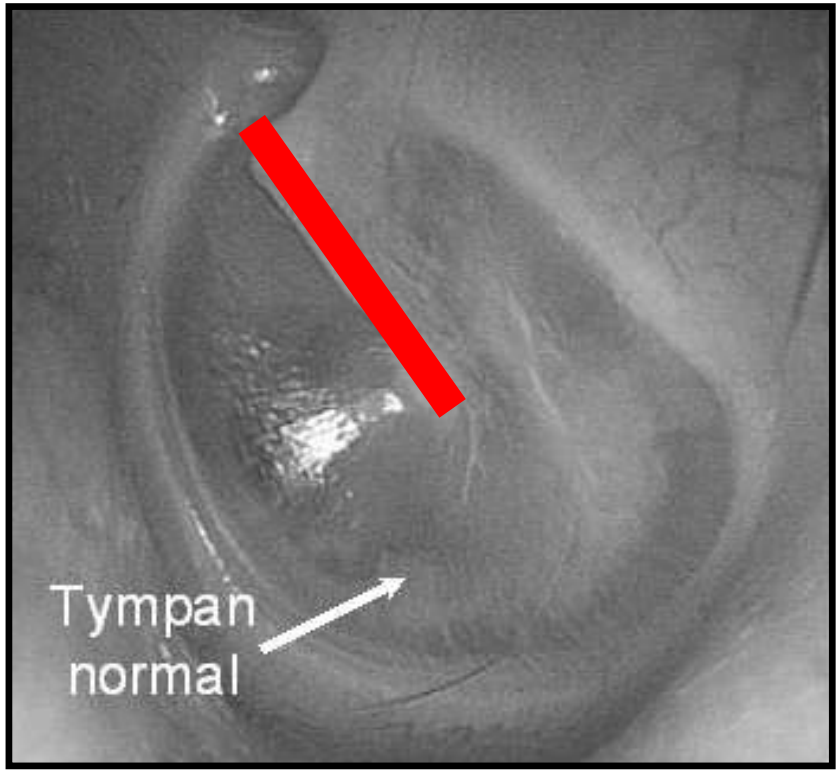




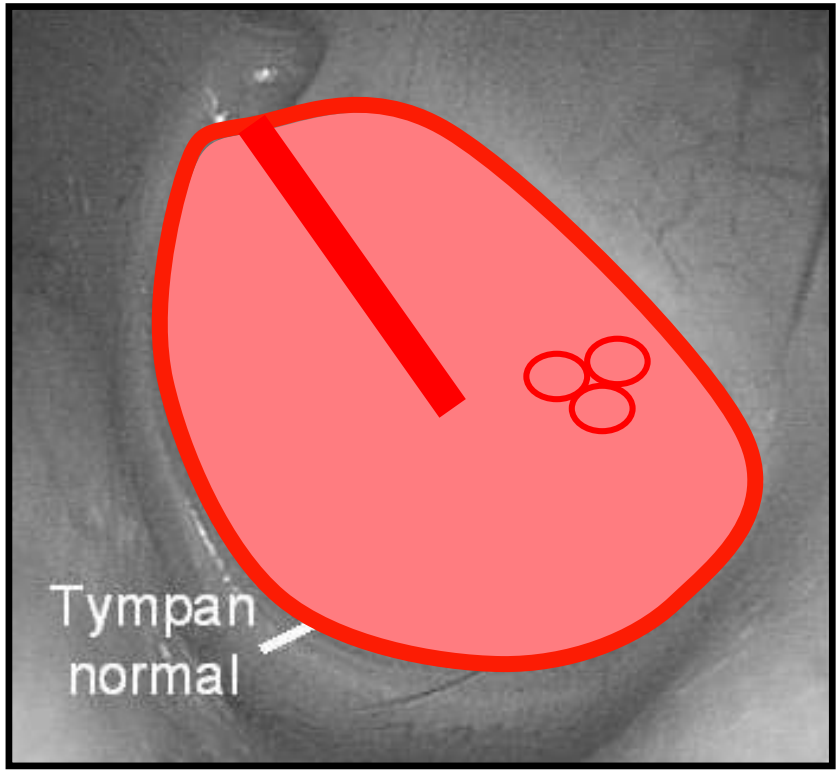
OTITE BAROTRAUMATIQUE

OTITE MOYENNE BAROTRAUMATIQUE



<u>Stade I</u> : hyperhémie du manche marteau

5 stades otoscopiques de Haines et Harris

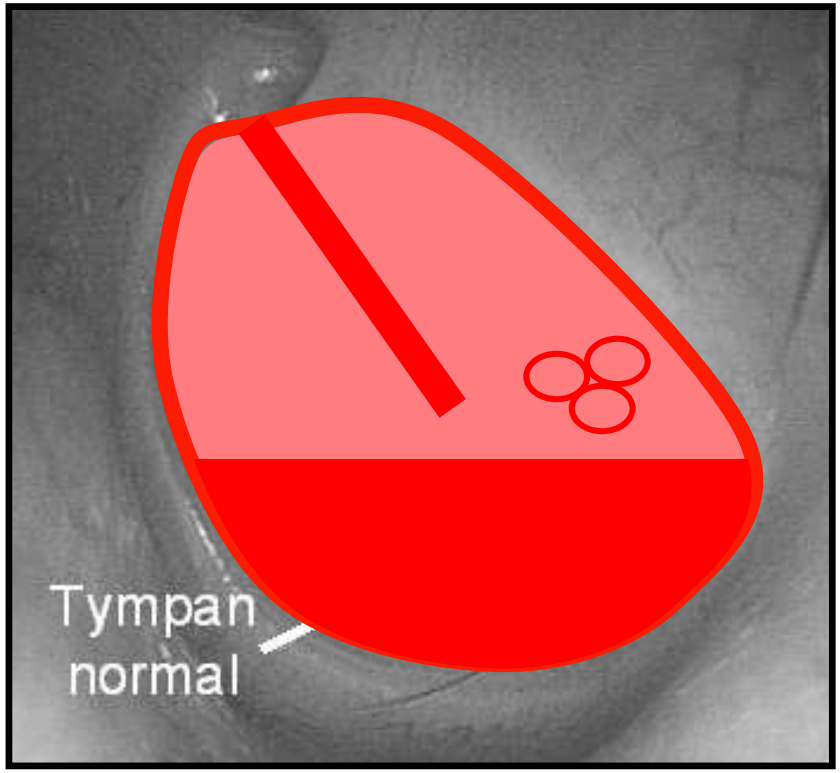


Stade I : hyperhémie du manche marteau

Stade II : hyperhémie diffuse
Stade III : bombement du tympan, bulles rétrotympaniques

CIT 3J + +

5 stades otoscopiques de Haines et Harris



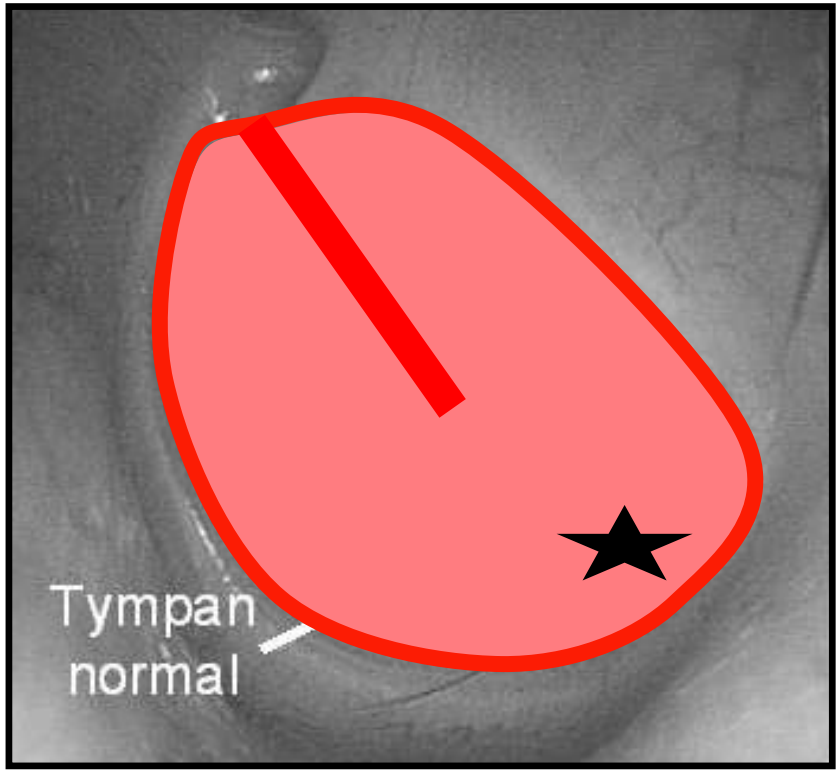
Stade I : hyperhémie du manche marteau

Stade II : hyperhémie diffuse
Stade III : bombement du tympan, bulles rétrotympaniques

Stade IV : hématome rétrotympanique

CIT 7J + **±**

5 stades otoscopiques de Haines et Harris



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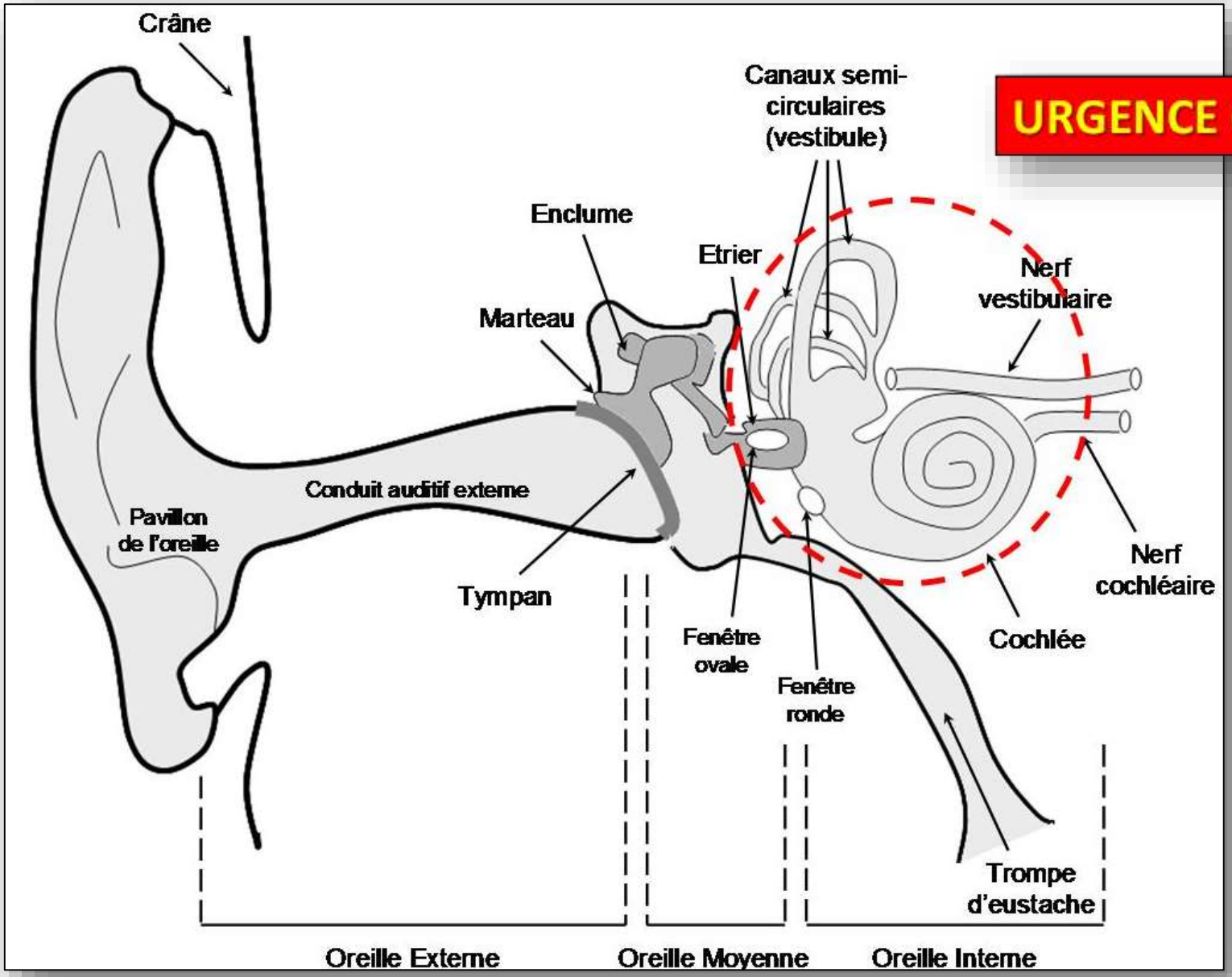
Stade II : hyperhémie diffuse
Stade III : bombement du tympan, bulles rétrotympaniques

Stade IV : hématome rétrotympanique

Stade V : perforation tympanique

5 stades otoscopiques de Haines et Harris

BAROTRAUMATISME DE L'OREILLE INTERNE

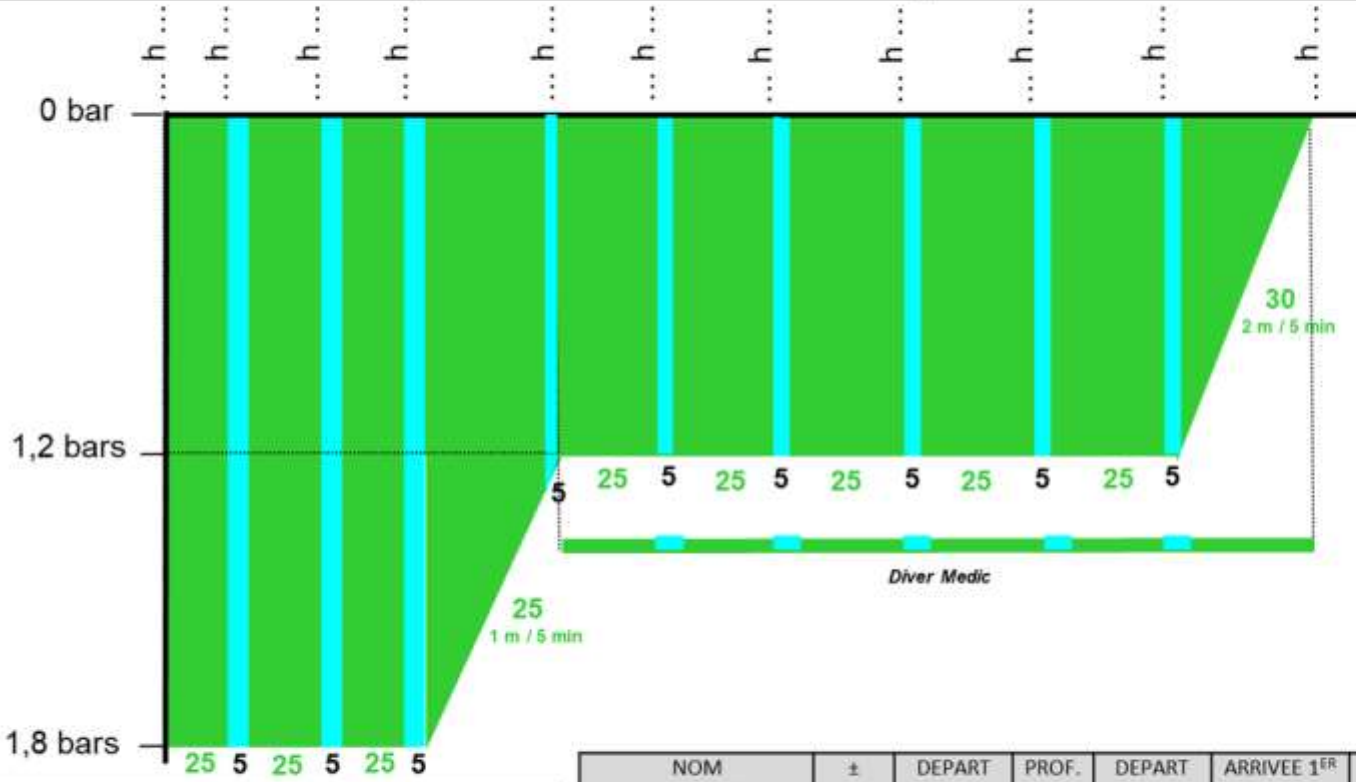


AVIS ORL DANS LES 24H

PHYMAREX ©

TABLE D'URGENCE N°2 - OXY / 1,8 bar / 300 min

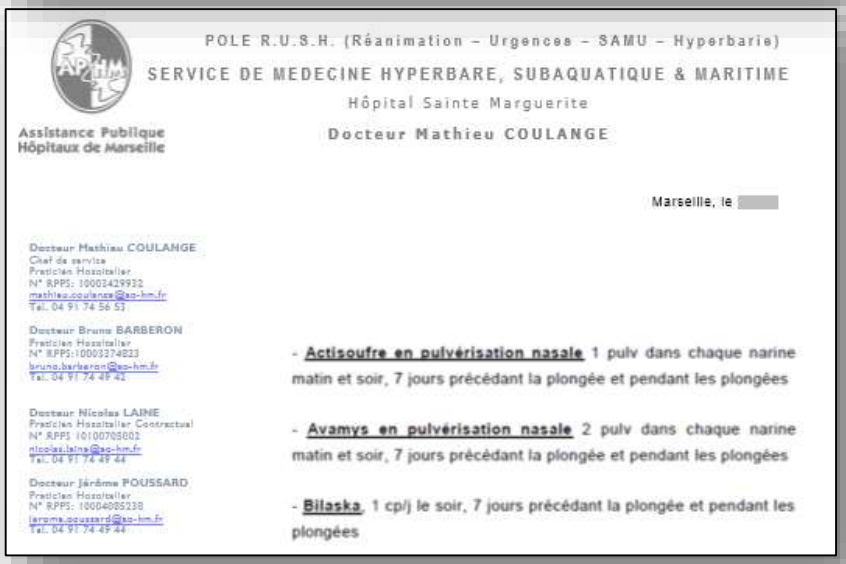
Victime :	Médecin référent :	COH :	Date : __ / __ / __
Surveillant (Manip Caisson) :	Hyperbariste (Diver Medic) :	Hyperbariste de secours :	



Air
O_2

INDICATIONS - DGT
- Accident de désaturation ostéo-arthro-musculaire
- Accident de désaturation cutané
- Accident de désaturation potentiellement grave
- Embolie gazeuse d'origine barotraumatique

NOM DU DIVER MEDIC	± MAJO	DEPART SURFACE	PROF. MAX.	DEPART FOND	ARRIVEE 1ER PALIER	DUREE TRAVAIL	PALIER	HEURE SORTIE



POLE R.U.S.H. (Réanimation – Urgences – SAMU – Hyperbarie)

SERVICE DE MEDECINE HYPERBARE, SUBAQUATIQUE & MARITIME

Hôpital Sainte Marguerite

Docteur Mathieu COULANGE

Assistance Publique
Hôpitaux de Marseille

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jerome.poussard@ap-hm.fr
Tél. 04 91 74 49 44

- **Actisoufre en pulvérisation nasale** 1 pulv dans chaque narine matin et soir, 7 jours précédant la plongée et pendant les plongées

- **Avamys en pulvérisation nasale** 2 pulv dans chaque narine matin et soir, 7 jours précédant la plongée et pendant les plongées

- **Bilaska**, 1 cp/j le soir, 7 jours précédant la plongée et pendant les plongées

Docteur Anne ESTEVE

Oto-Rhino-Laryngologie
Chirurgie de la face et du cou
Chirurgie esthétique du visage
Explorations des surdités et des vertiges

Pulmicort 1mg /2 ml : 1 ampoule x 3 / jour, pendant 3 jours

Aturgyl : 2 pulvérisations par narines, le soir uniquement, 10 minutes avant l 'aerosol

Solacy (vit A + souffre): 1 cp x 3 / jours pendant 8 jours

Serum physiologique dosette: 1 dosette x 3 : jour, pendant 3 jours

1 kit MSI avec 1 tubulure pression, 1 tubulure vibration, 1 nébuliseur, 1 embout narinaire

Location d'un aerosol manosonique Amsa à pression positive :

Faire une aerosol de 10 minutes x 3 / jr , pendant 3 jours

Avec matin, midi et soir: 1 ampoule de pulmicort 1mg/2ml + serum physiologique

Le soir : faire 2 pulvérisations par narine d'Aturgyl, 10 minutes avant l'aerosol

Dr

DYSPERMEABILITE TUBAIRE

VERTIGE ALTERNO-BARIQUE

- A la remontée (2/3 des cas) à faible profondeur
- Dysperméabilité tubaire unilatérale avec asymétrie pressionnelle entre les deux vestibules
- Sensation de vertige intense (risque de panique)
- Transitoire, sans séquelle en surface

- CAT : stopper la remontée, redescendre de quelques mètres ou série de déglutitions ou manoeuvre de Toynbee

- Prévention : apprentissage des manœuvres d'équilibrage peu traumatisantes

PARALYSIE FACIALE DYSBARIQUE

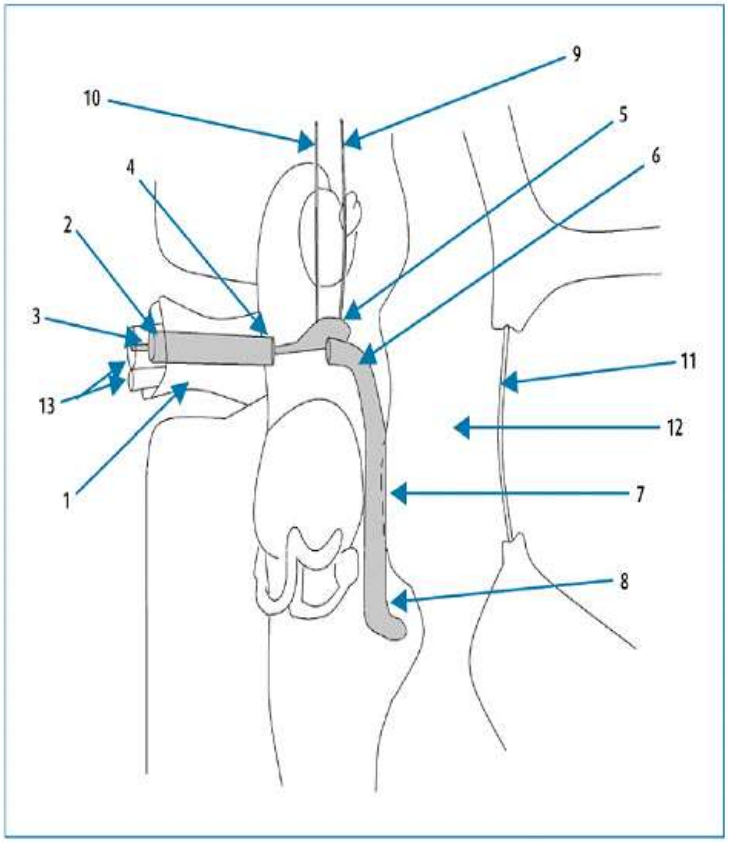


FIGURE 1

Vue supérieure du nerf facial

1 : Méat acoustique interne ; 2 : nerf facial (VII) ; 3 : nerf intermédiaire (VII bis) ; 4 : partie labyrinthique du VII ; 5 : ganglion géniculé ; 6 : genou du nerf facial ; 7 : déhiscence de la partie tympanique du VII ; 8 : coude du VII ; 9 : nerf petit pétreux ; 10 : nerf grand pétreux ; 11 : membrane tympanique ; 12 : caisse du tympan ; 13 : nerf vestibulocochléaire.

BAROTRAUMATISME SINUSIEN

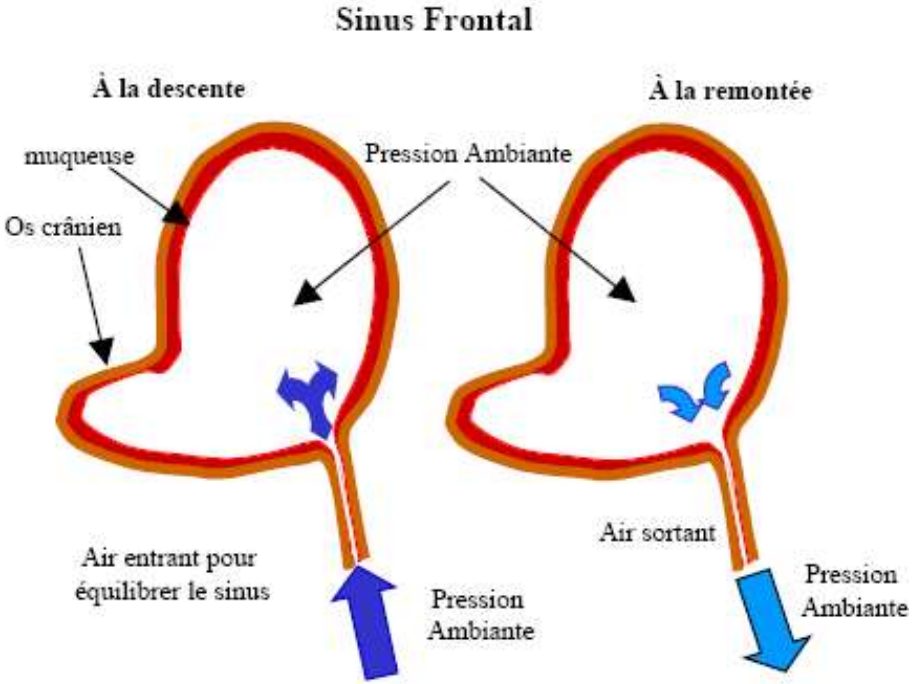


Figure 4 : sinus fonctionnement normalement

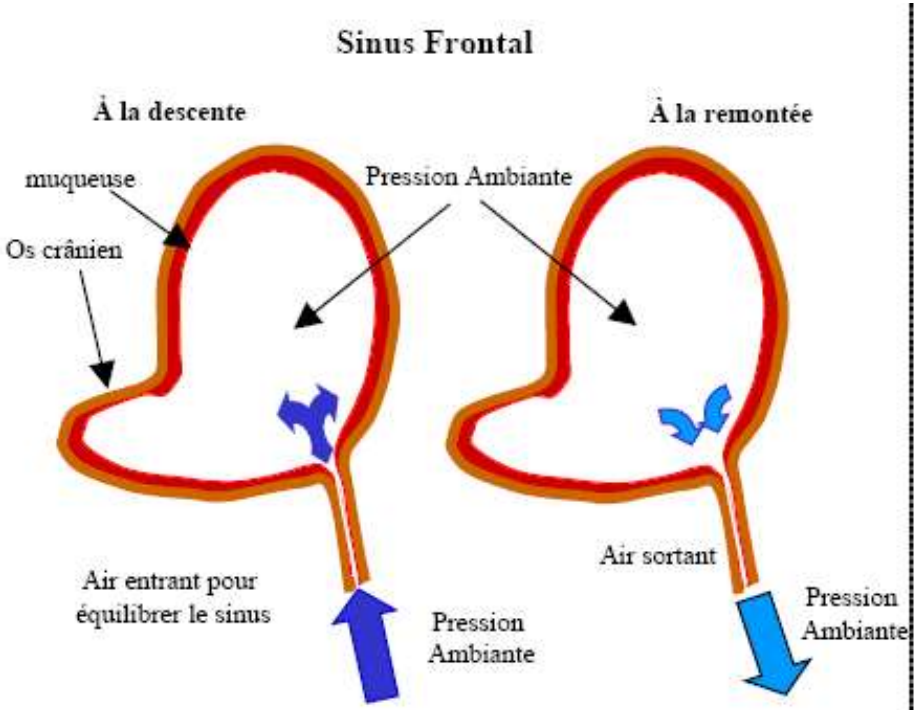


Figure 4 : sinus fonctionnement normalement

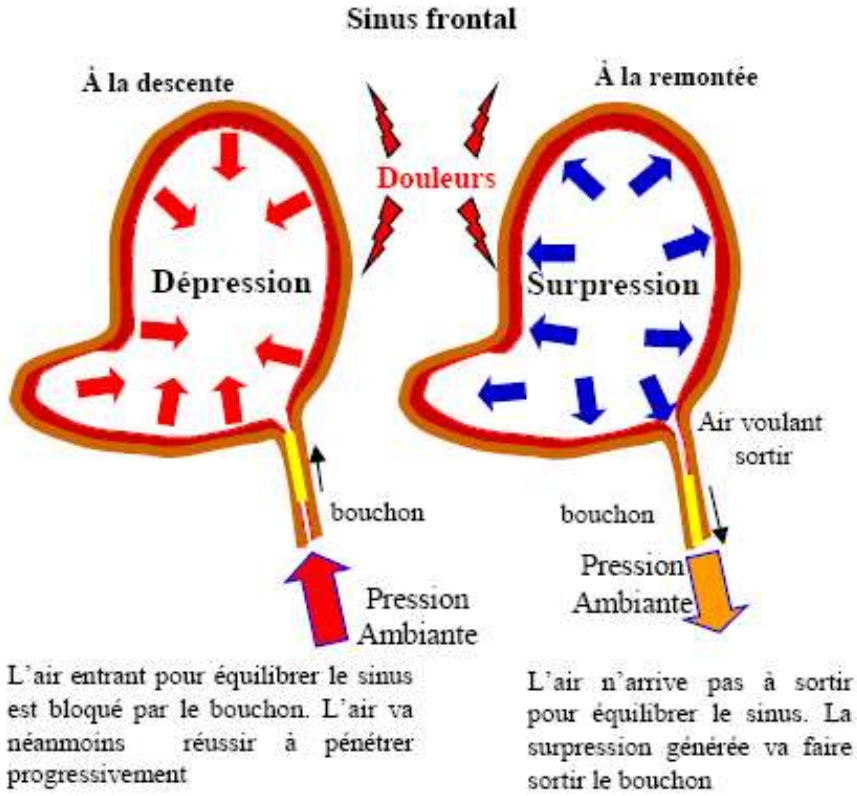
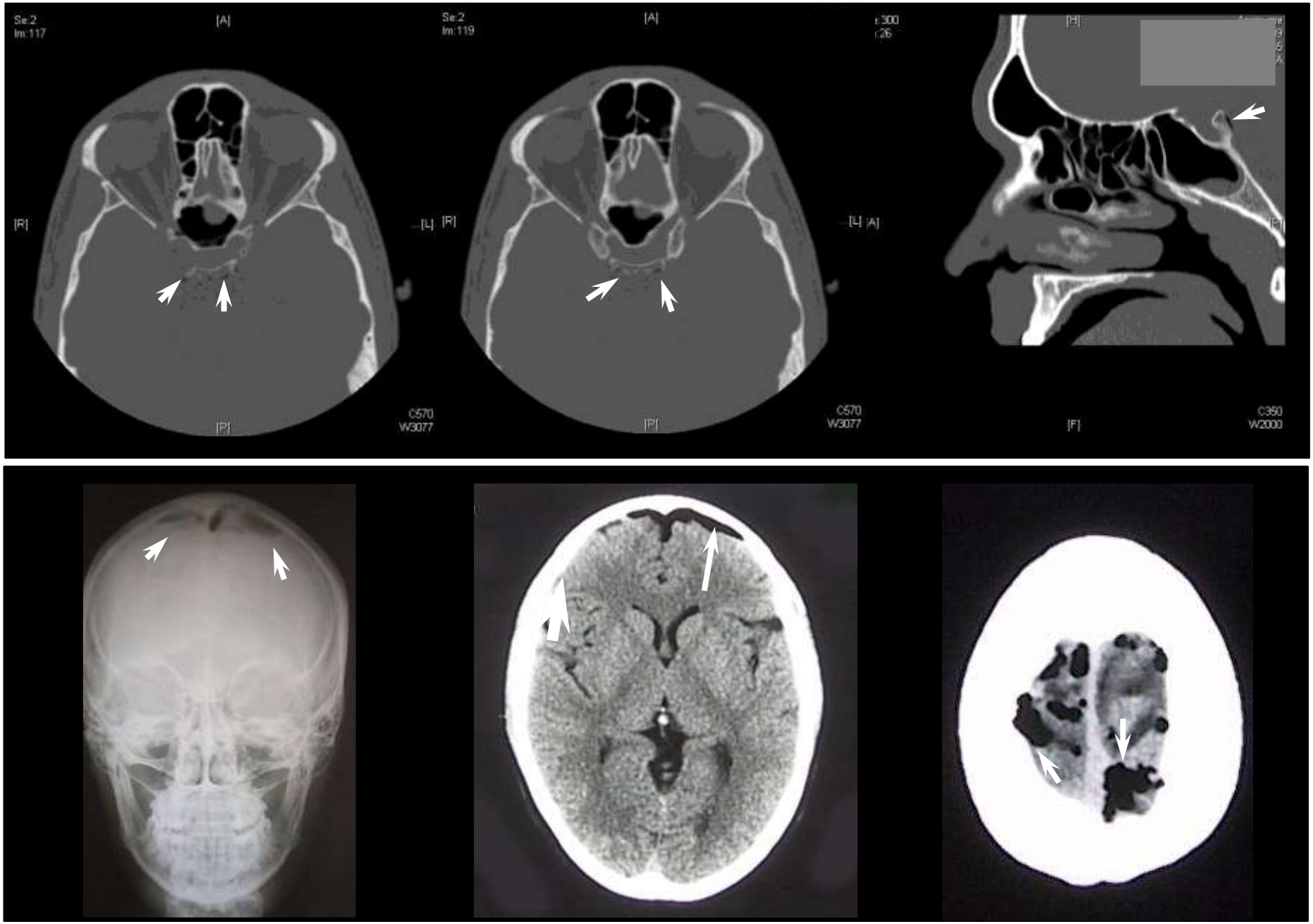


Figure 5 : sinus bouchés



Barthélémy A, Coulange M, Ranque S, Bergmann E, Sainty JM. Barotraumatic pneumocephalus in scuba diver. *In : Grandjean B, Meliet JL, editors. Proceedings of the 30th Annual Scientific Meeting of the European Underwater and Baromedical Society ; 2004 Sep 15-19 ; Ajaccio, France ; 2004. p 63-7.*

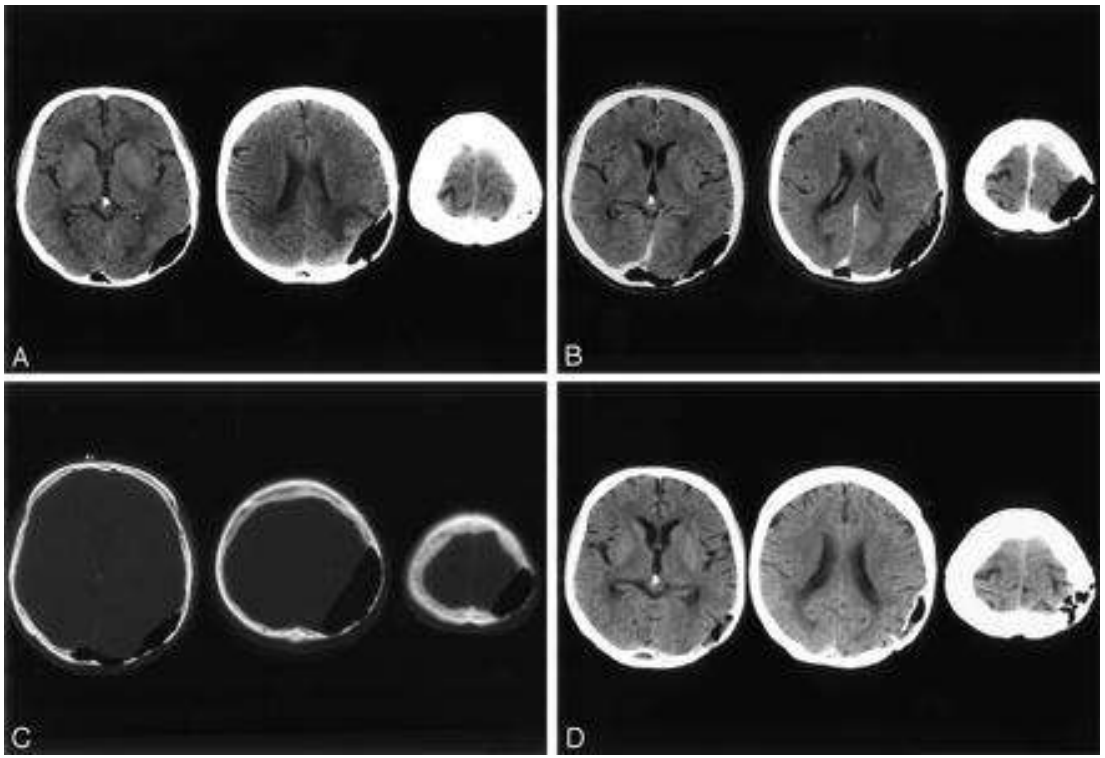
PNEUMENCEPHALIE

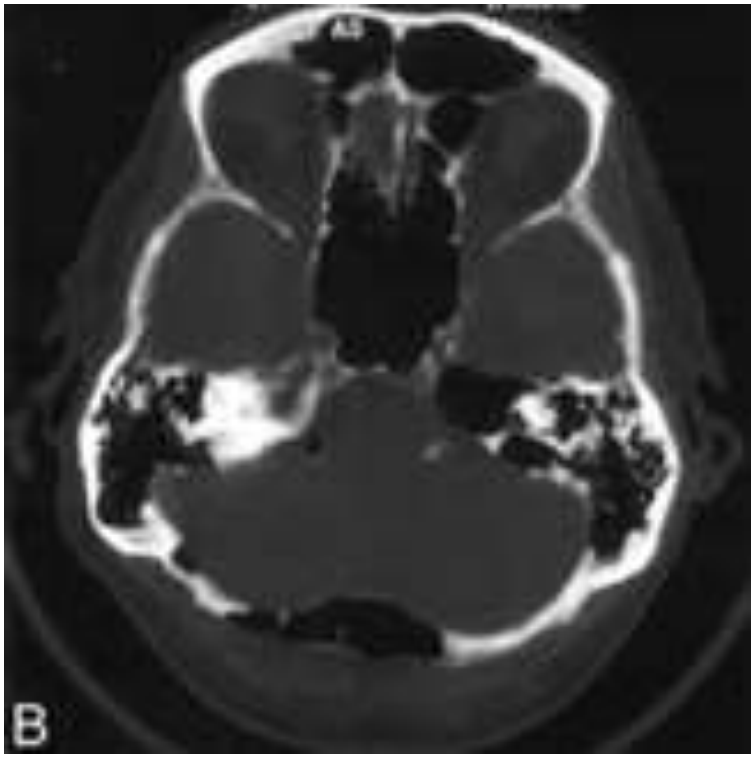
AJNR Am J Neuroradiol 25:491–493, March 2004

Case Report

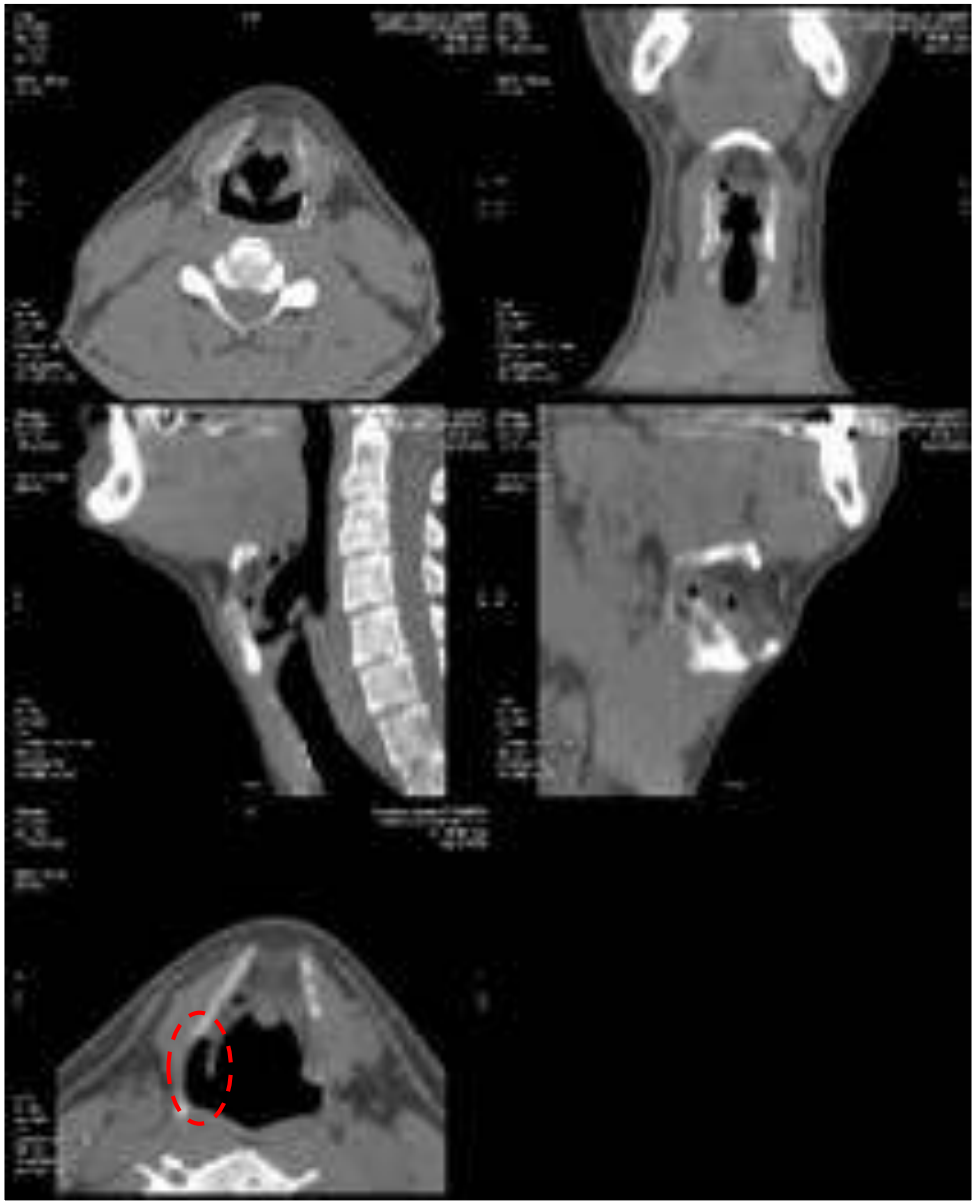
Progressive Calvarial and Upper Cervical Pneumatization Associated with Habitual Valsalva Maneuver in a 70-Year-Old Man

Laurel A. Littrell, Patrick H. Leutmer, John I. Lane, and Colin L.W. Driscoll



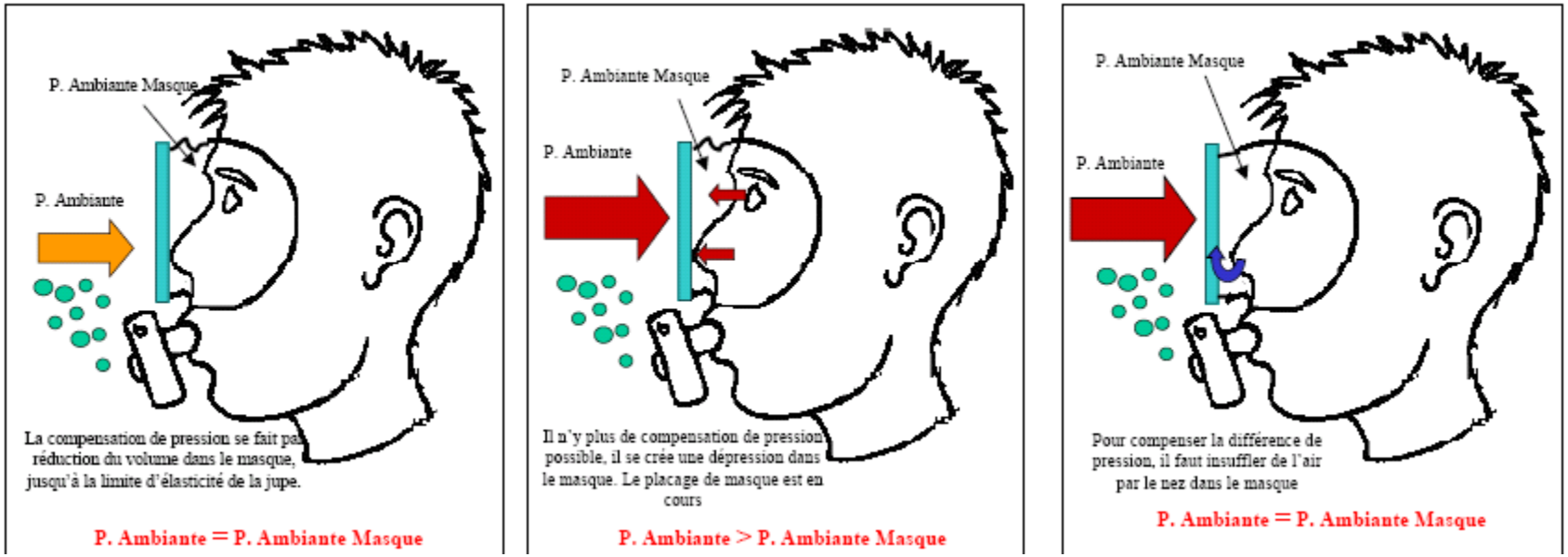


BAROTRAUMATISME LARYNGOCELE



PLACAGE DE MASQUE

Effet «ventouse»



Absence de compensation de la différence de pression entre l'extérieur et l'intérieur du masque à la descente

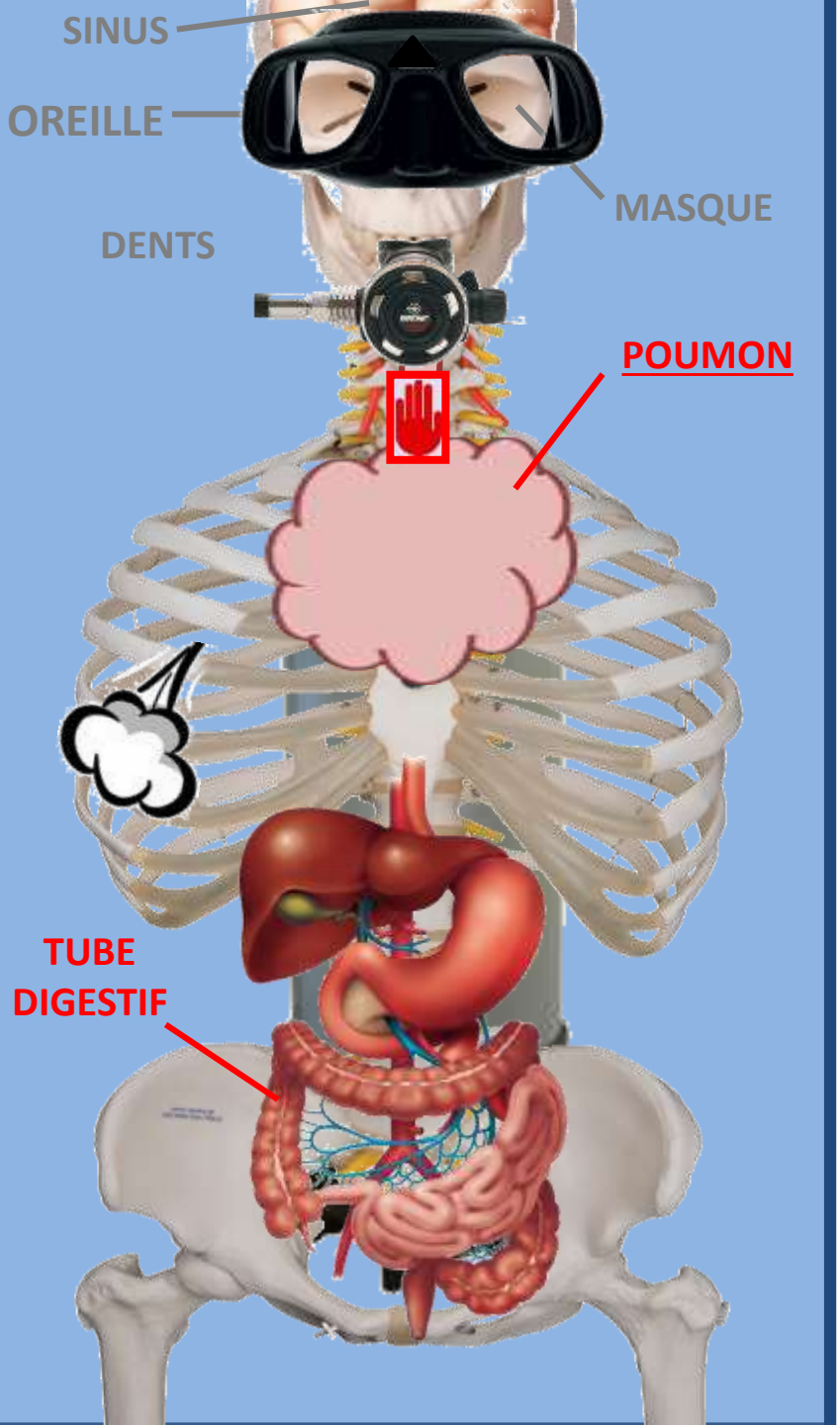
Douleurs oculaires augmentant à la descente

Œdème palpébral, hémorragie sous conjonctivale, épistaxis

URGENCE si troubles visuels ou oculomoteurs

BAROTRAUMATISME DENTAIRE

ET LORS DE LA DECOMPRESSION…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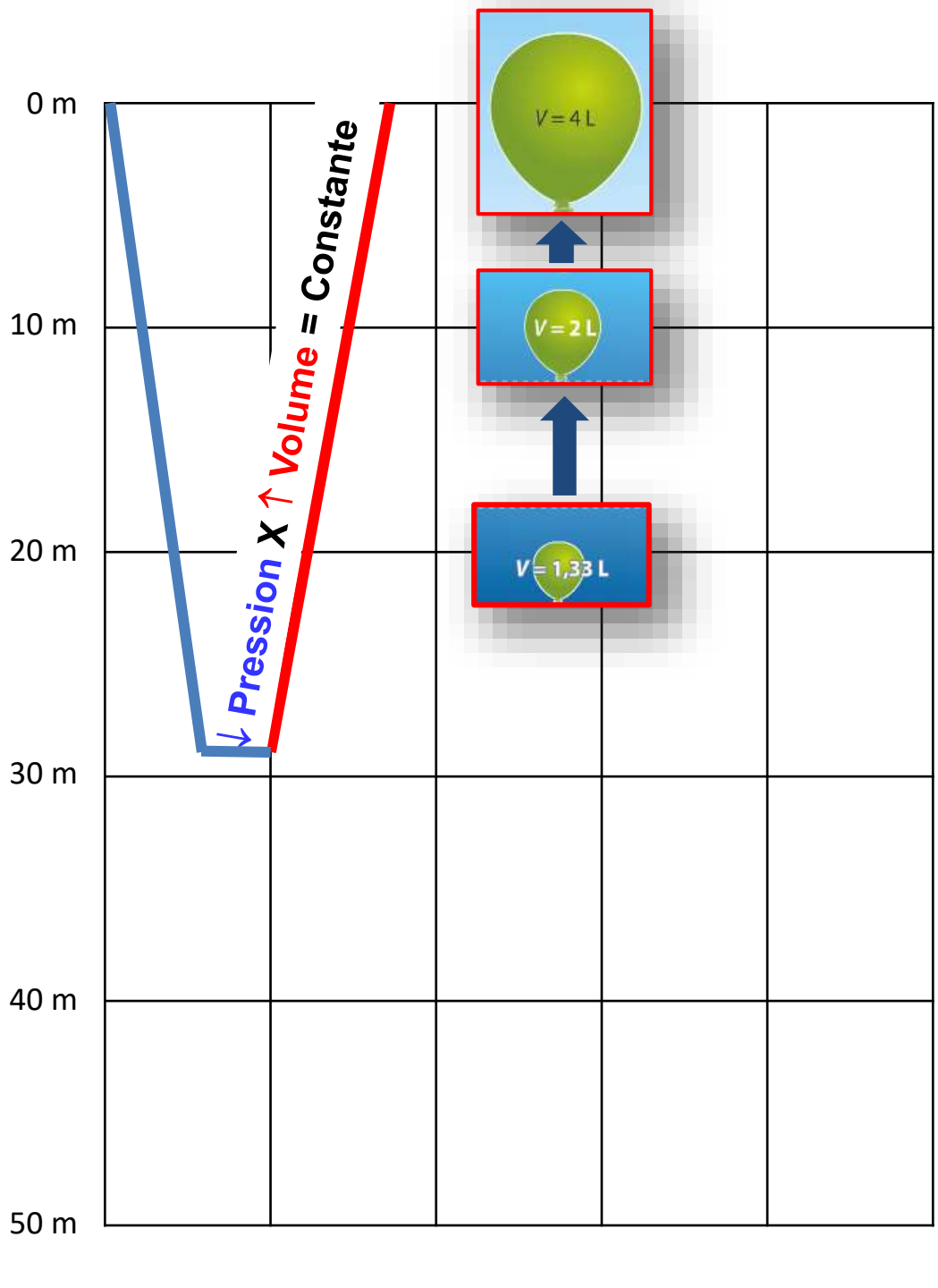
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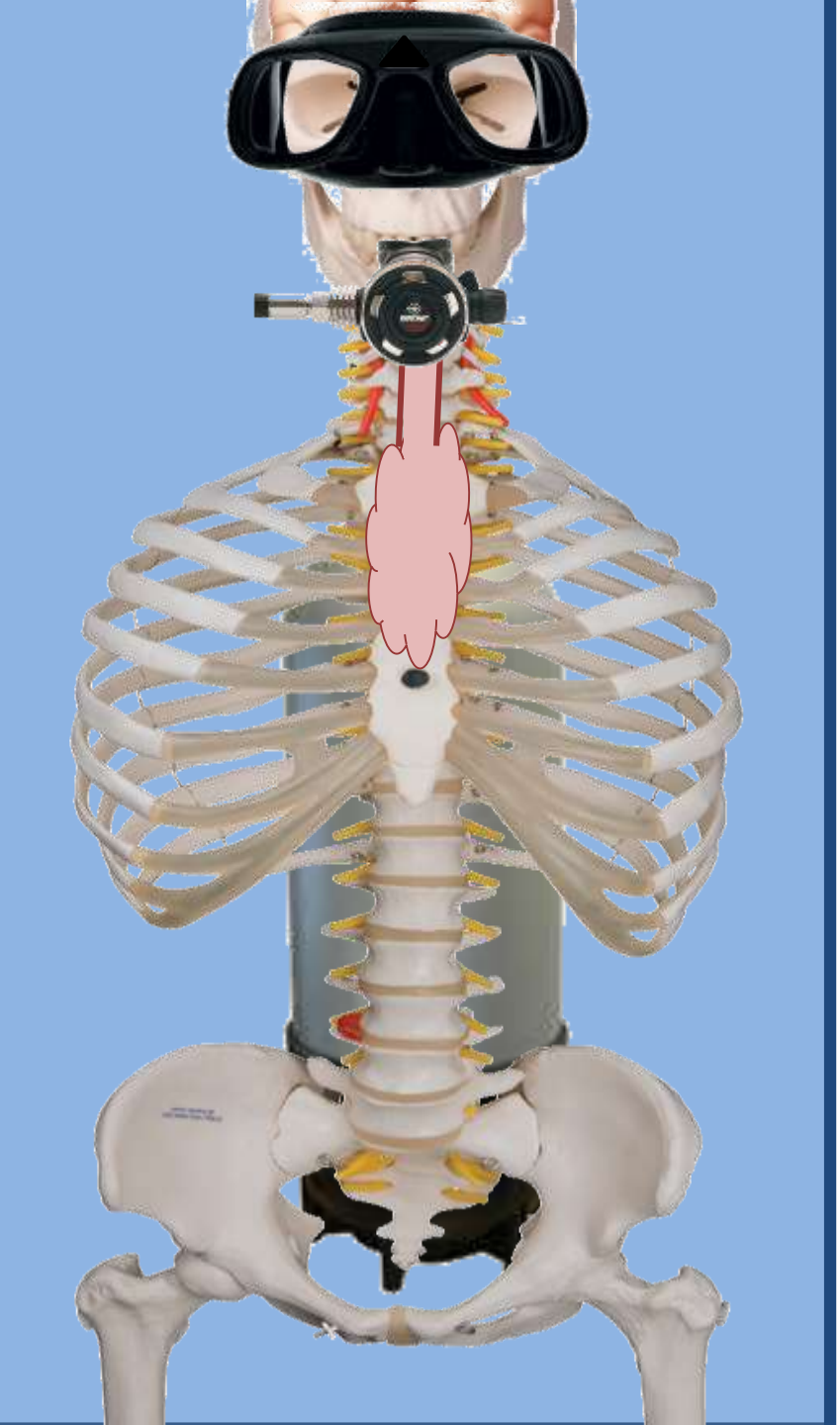
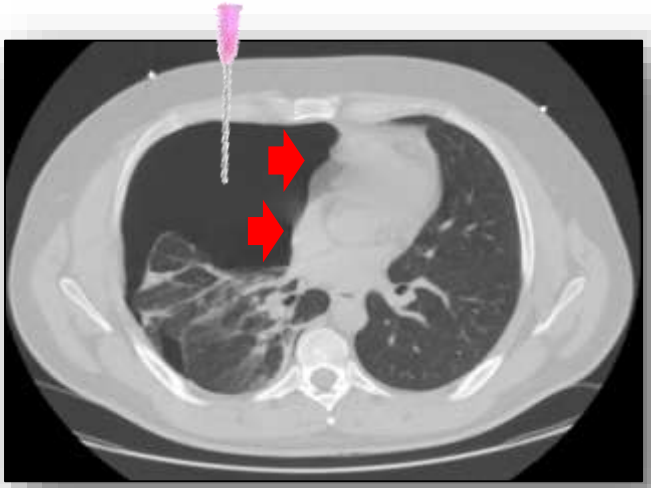


BAROTRAUMATISME THORACIQUE



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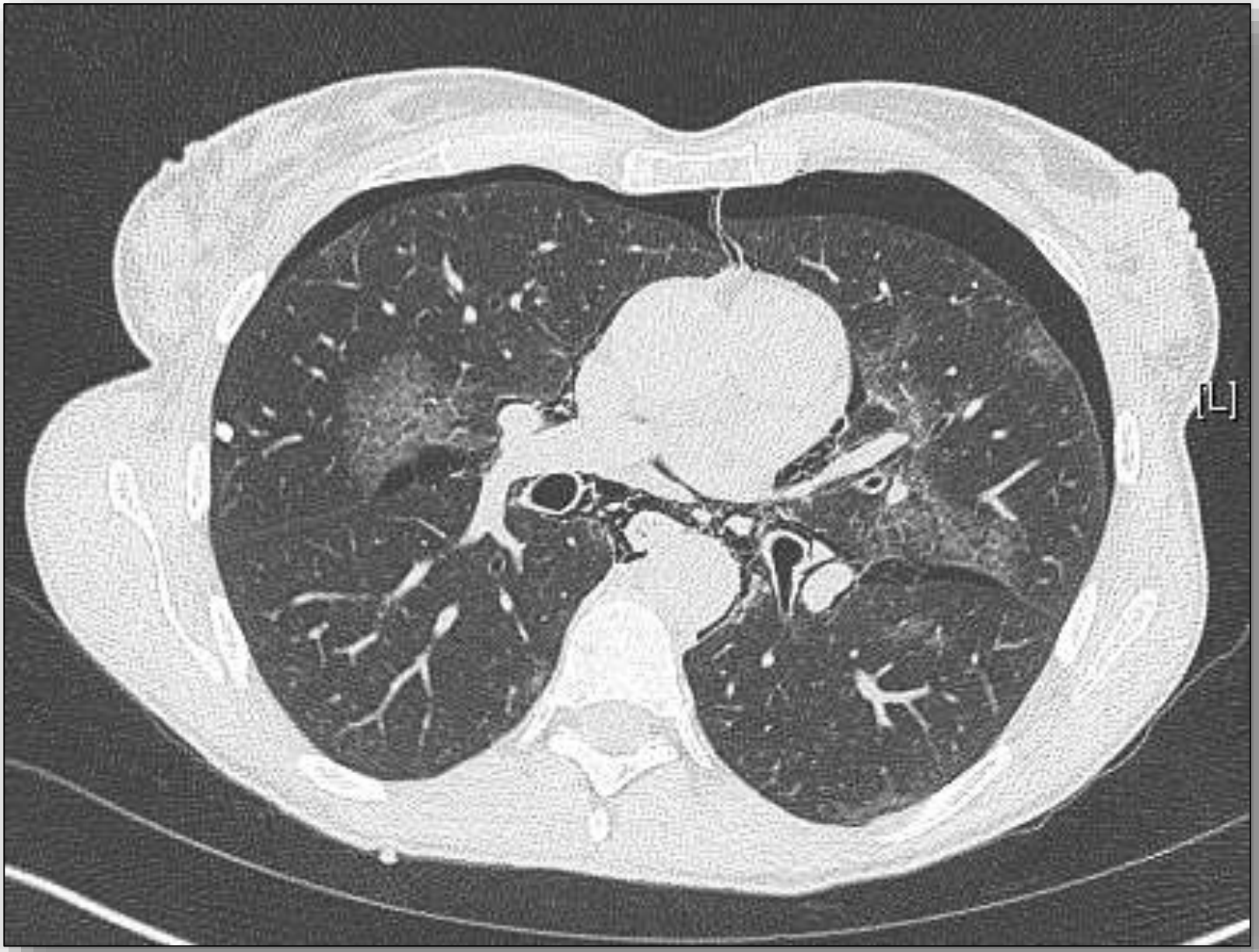
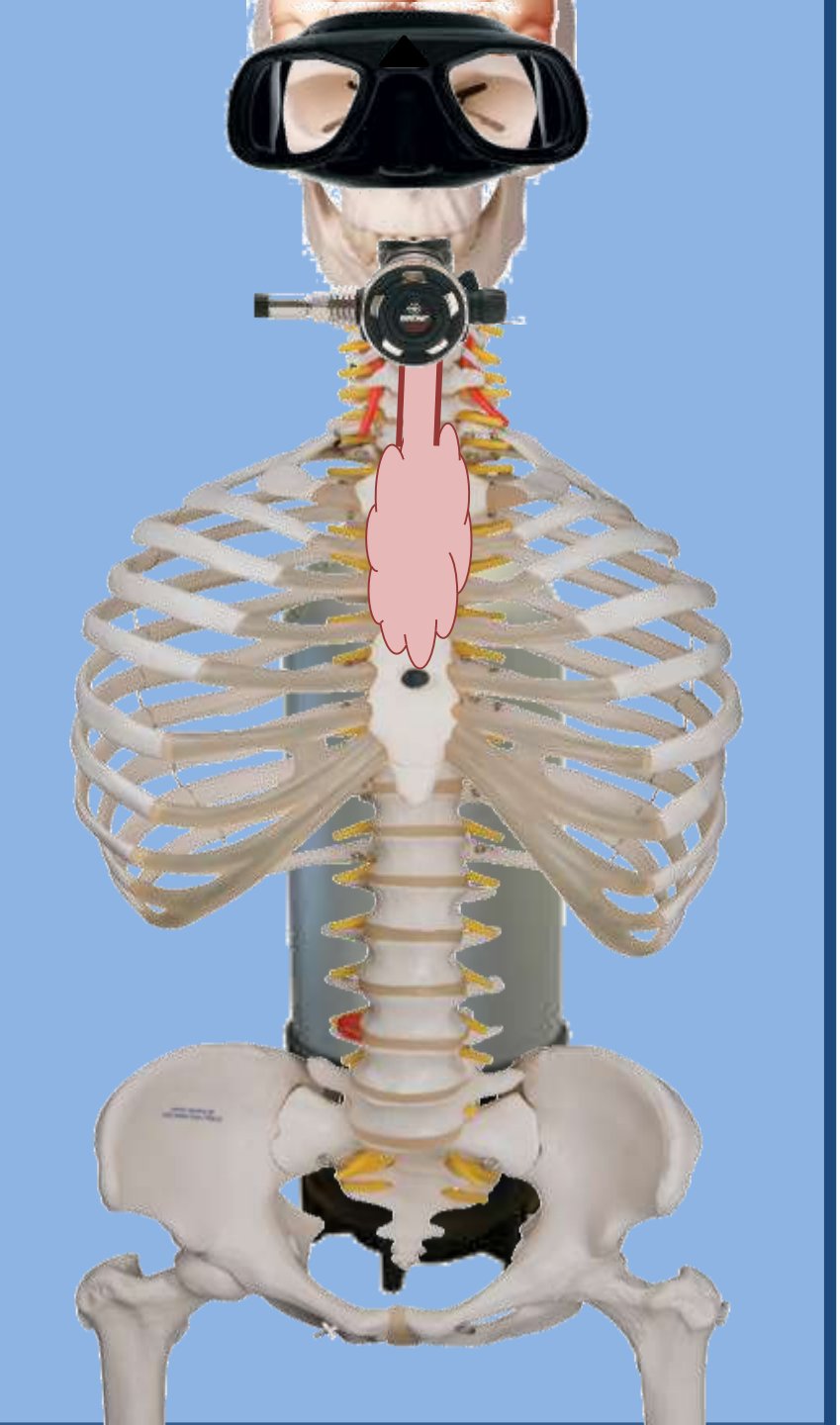
BAROTRAUMATISME THORACIQUE





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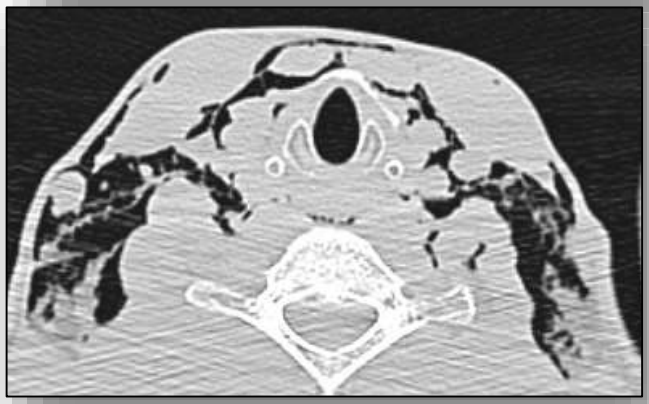

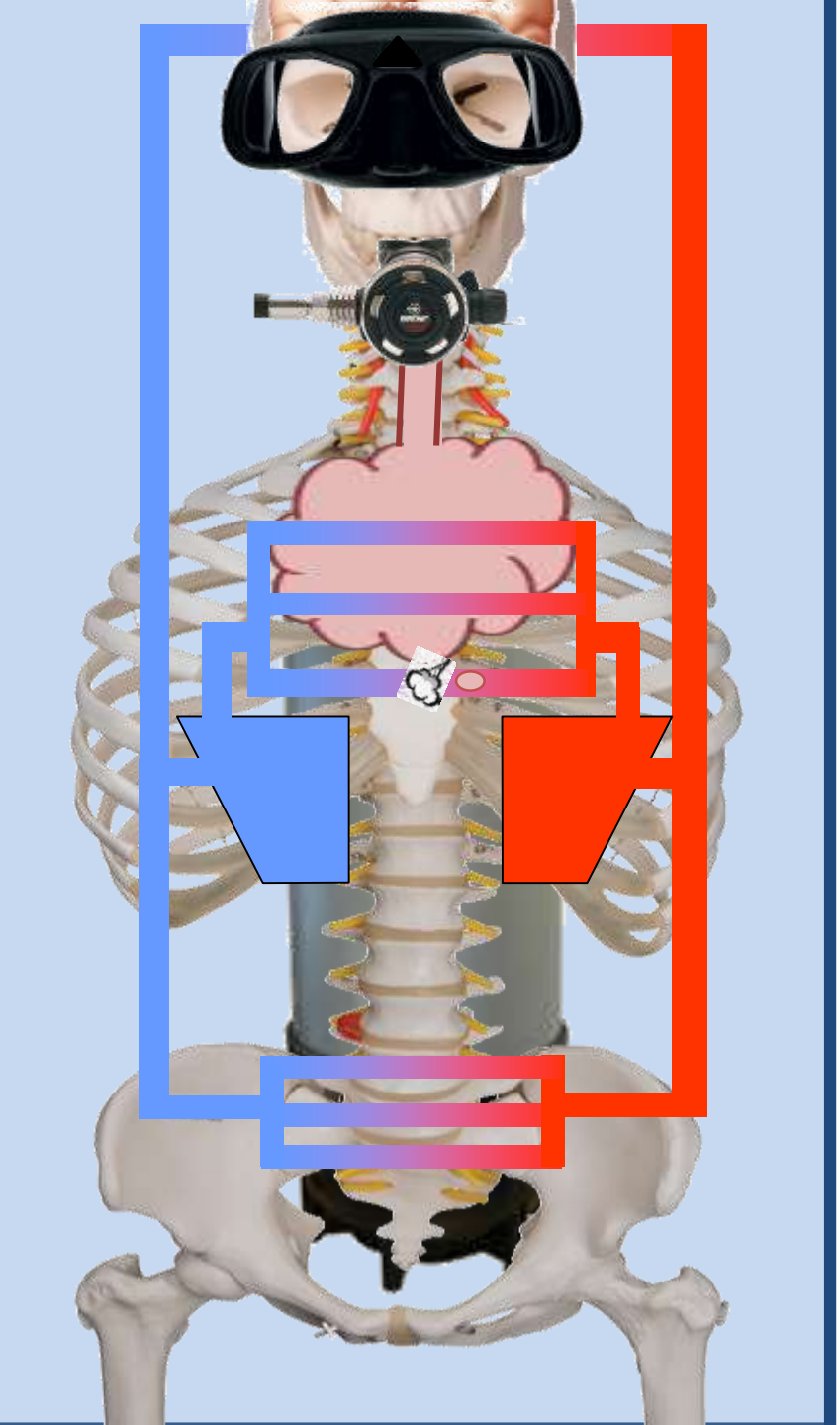

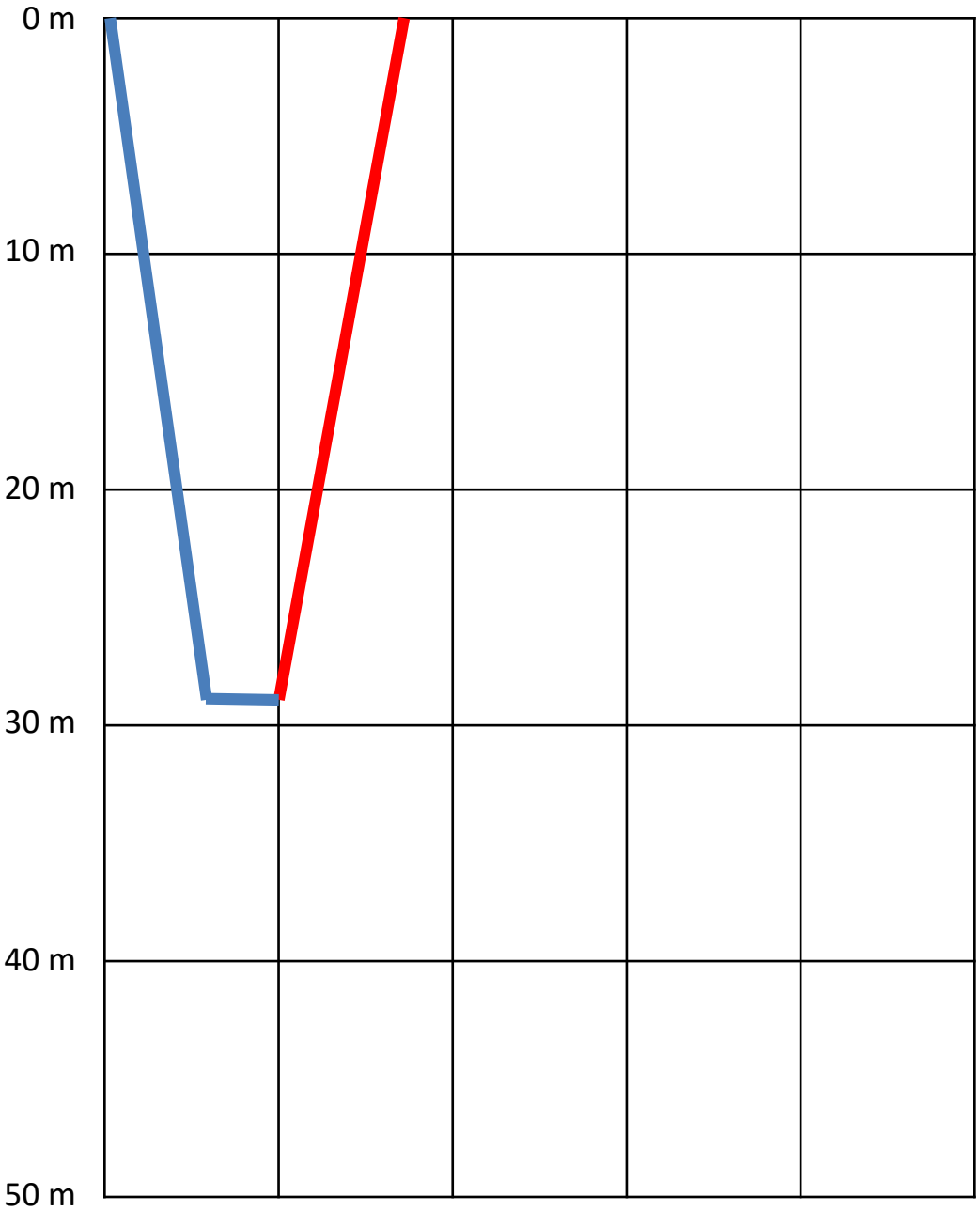
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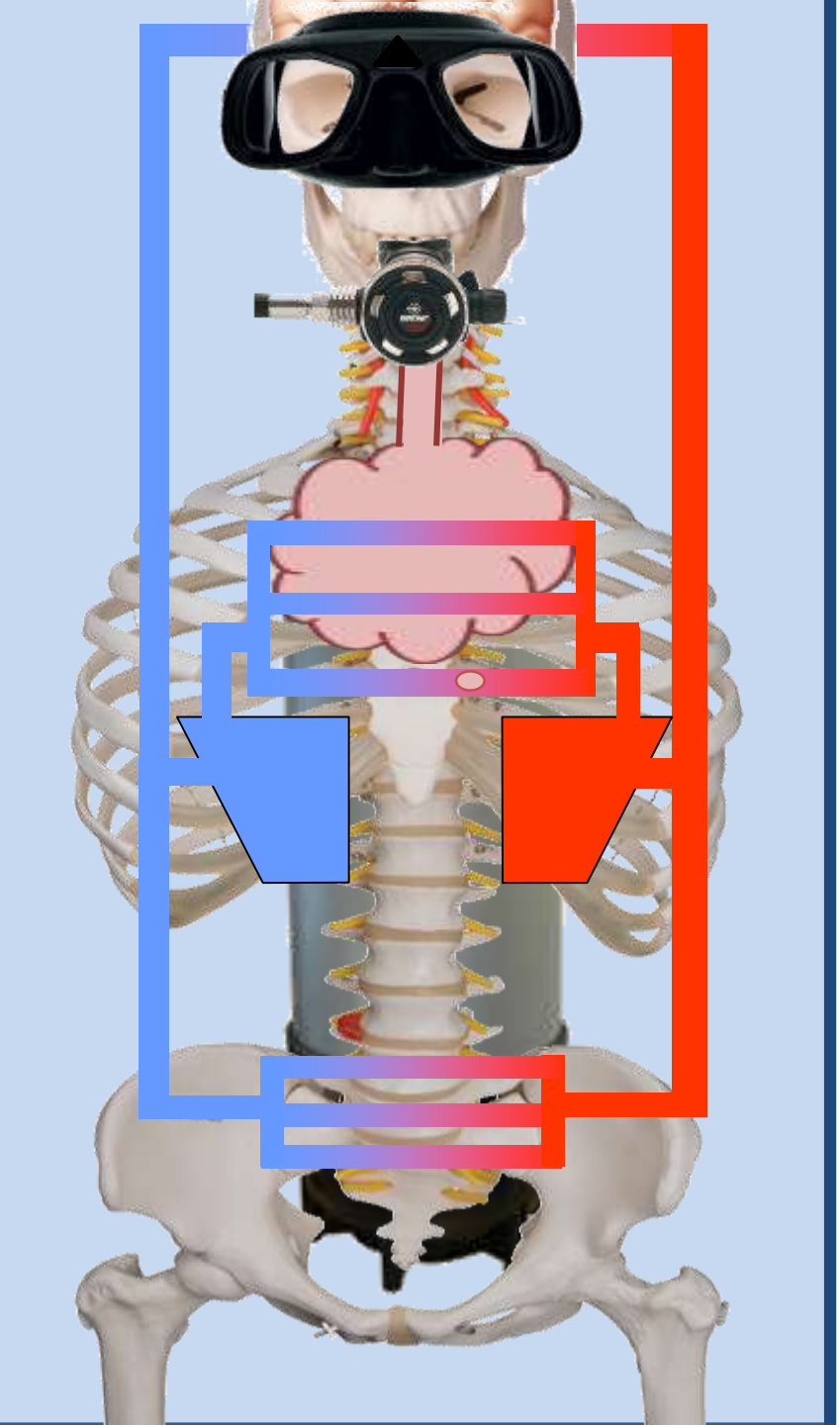

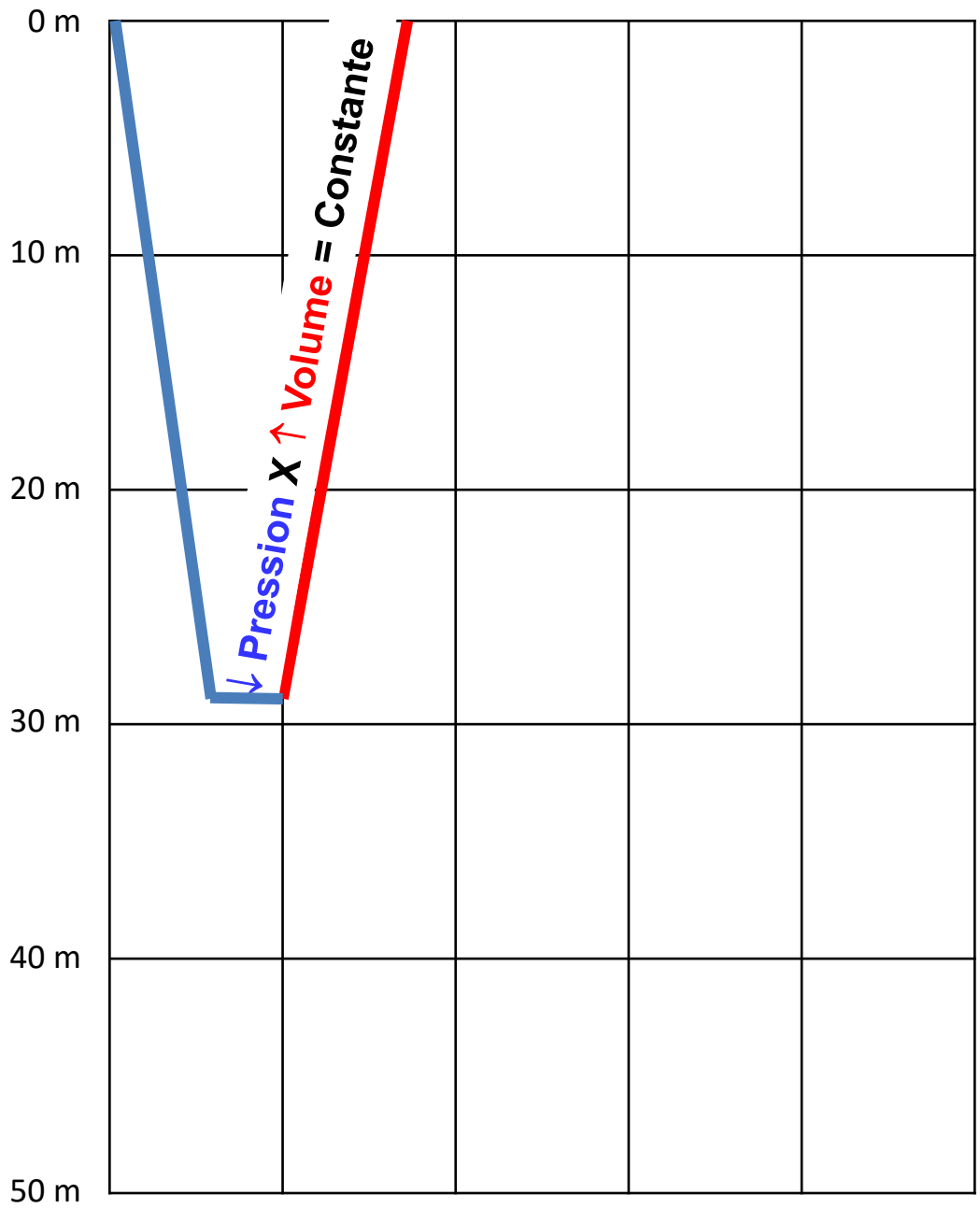
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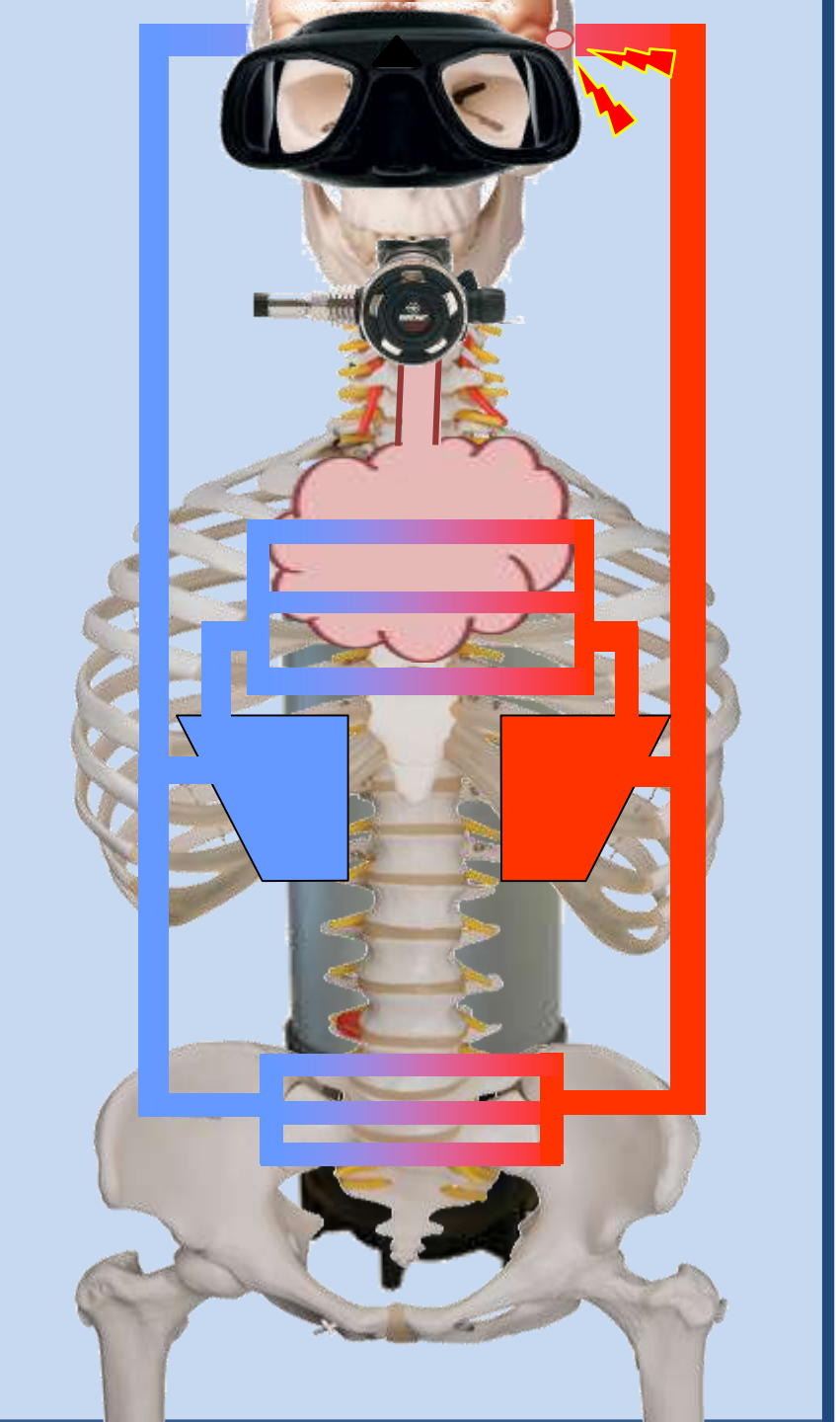
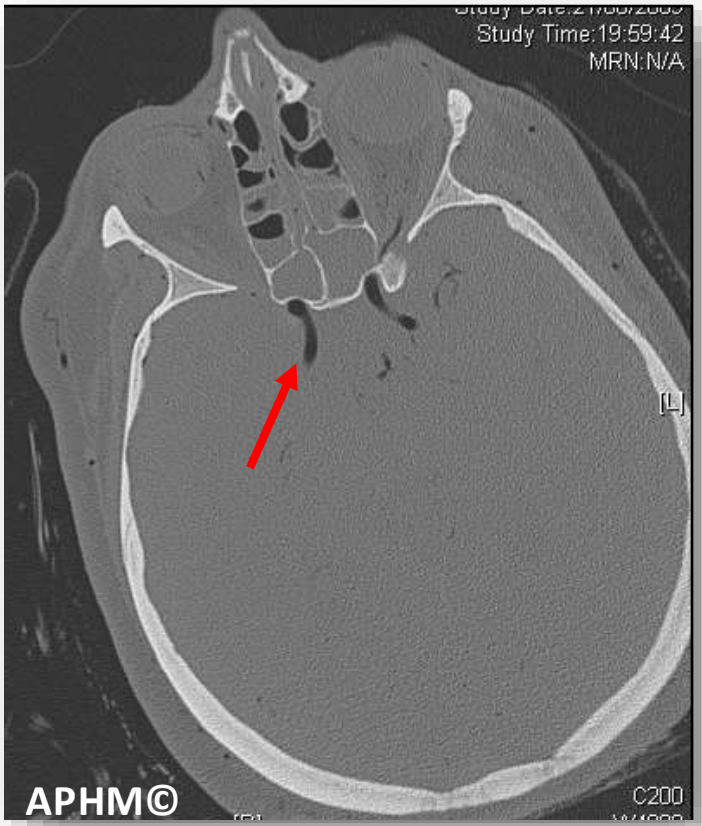


EMBOLIE GAZEUSE sur BAROTRAUMATISME THORACIQUE

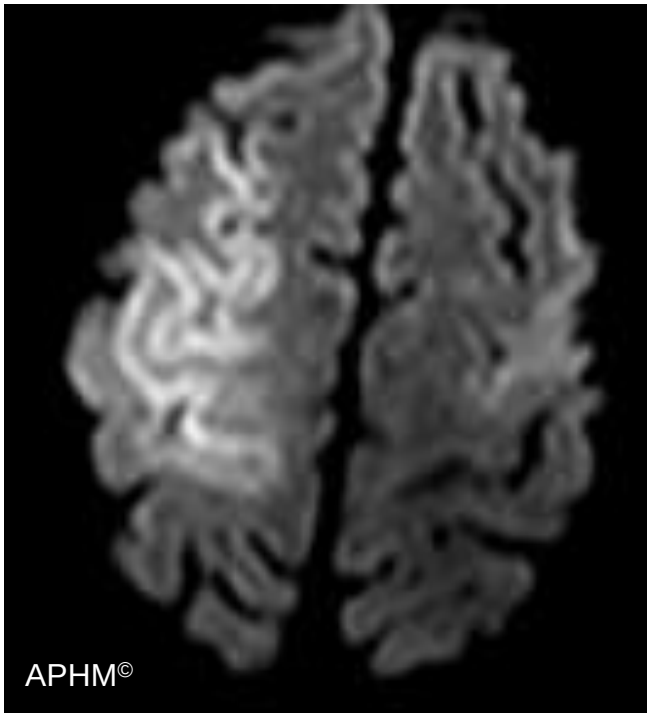


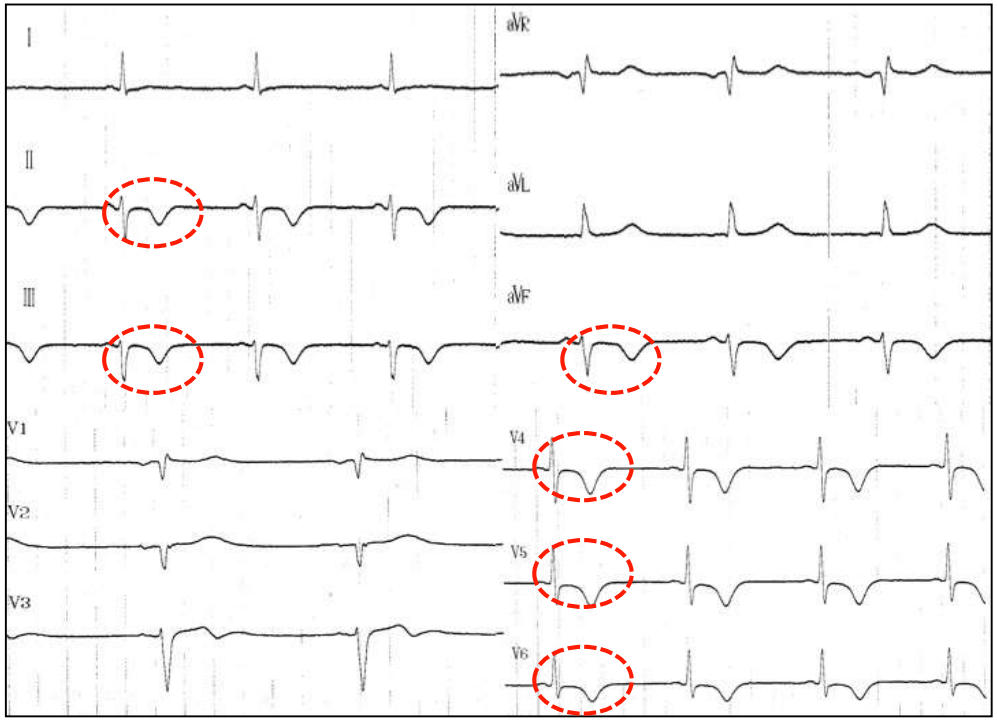
EG SYSTEMIQUE D'ORIGINE BT

Case Report

Acute coronary syndrome and cerebral arterial gas embolism in a scuba diver

Pierre-Julien Moro MD[a], Mathieu Coulange MD, PhD[b], Olivier Brissy MD[a], Thomas Cuisset MD, PhD[a], Jacques Quilici MD[a], Jean-Philippe Mouret MD[a], Jean-Louis Bonnet MD[a] and Alain Barthélémy MD[b]





Case Report

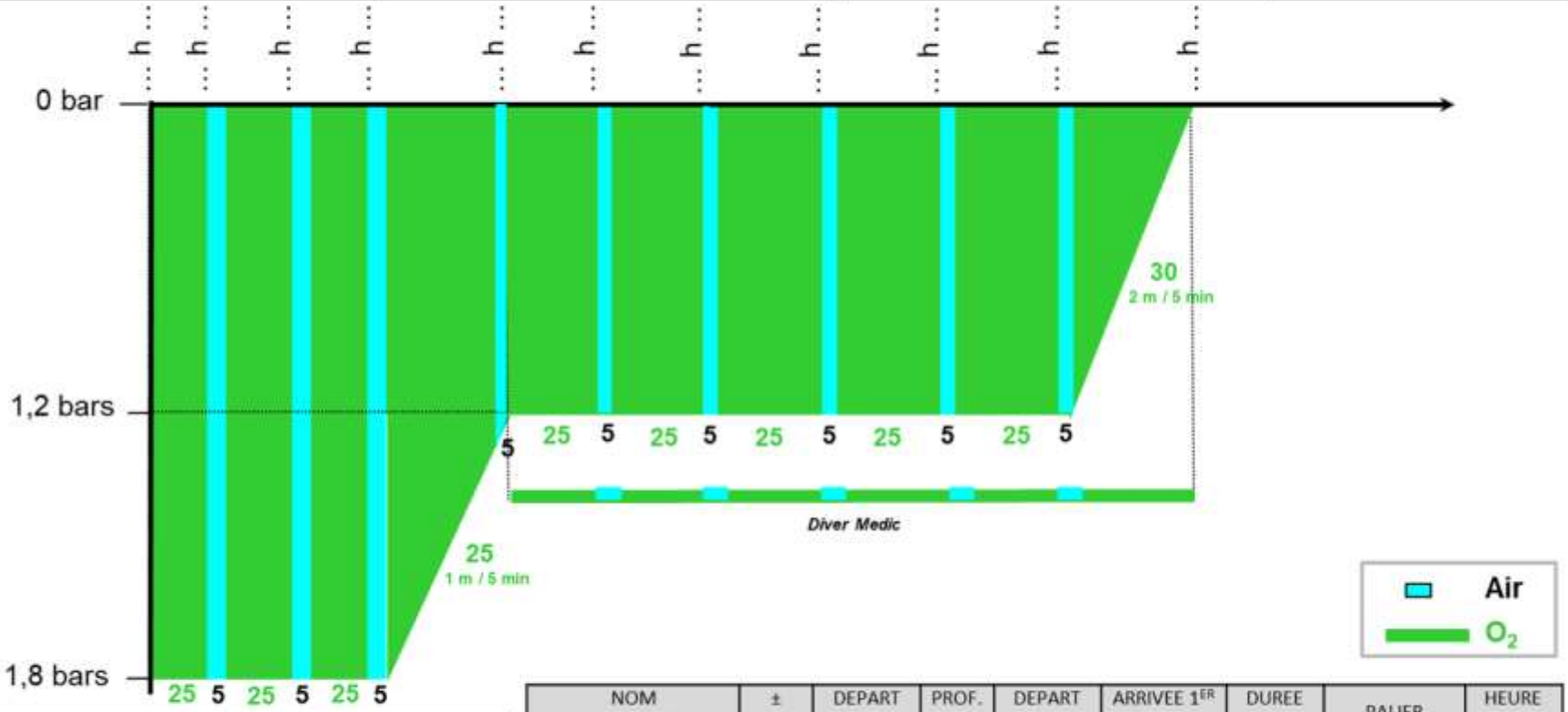
Acute coronary syndrome and cerebral arterial gas embolism in a scuba diver

Pierre-Julien Moro MD[a], Mathieu Coulange MD, PhD[b], Olivier Brissy MD[a], Thomas Cuisset MD, PhD[a], Jacques Quilici MD[a], Jean-Philippe Mouret MD[a], Jean-Louis Bonnet MD[a] and Alain Barthélémy MD[b]

PHYMAREX ©

TABLE D'URGENCE N°2 - OXY / 1,8 bar / 300 min

Victime :	Médecin référent :	COH :	Date : __ / __ / __
Surveillant (Manip Caisson) :	Hyperbariste (Diver Medic) :	Hyperbariste de secours :	



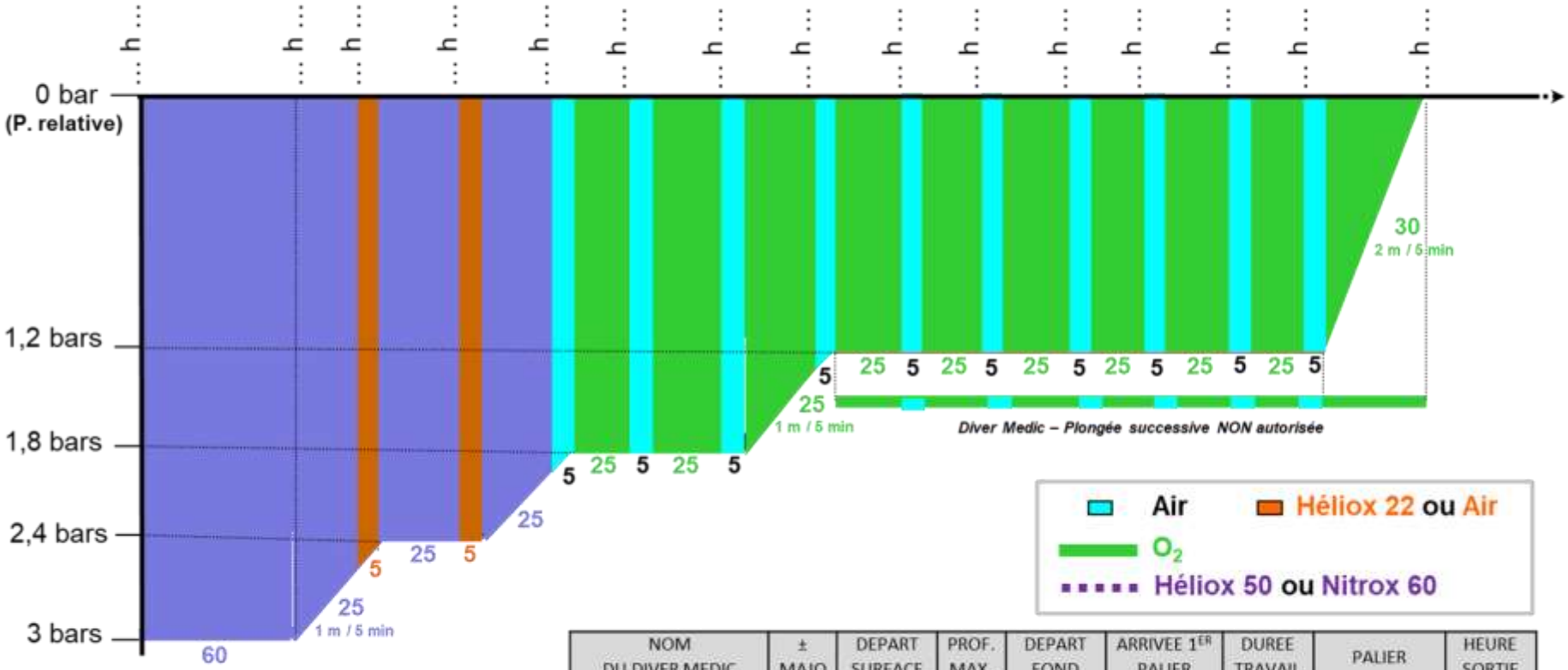
INDICATIONS - DGT
- Accident de désaturation ostéo-arthro-musculaire - Accident de désaturation cutané - Accident de désaturation potentiellement grave - Embolie gazeuse d'origine barotraumatique

NOM DU DIVER MEDIC	± MAJO	DEPART SURFACE	PROF. MAX.	DEPART FOND	ARRIVEE 1ER PALIER	DUREE TRAVAIL	PALIER	HEURE SORTIE

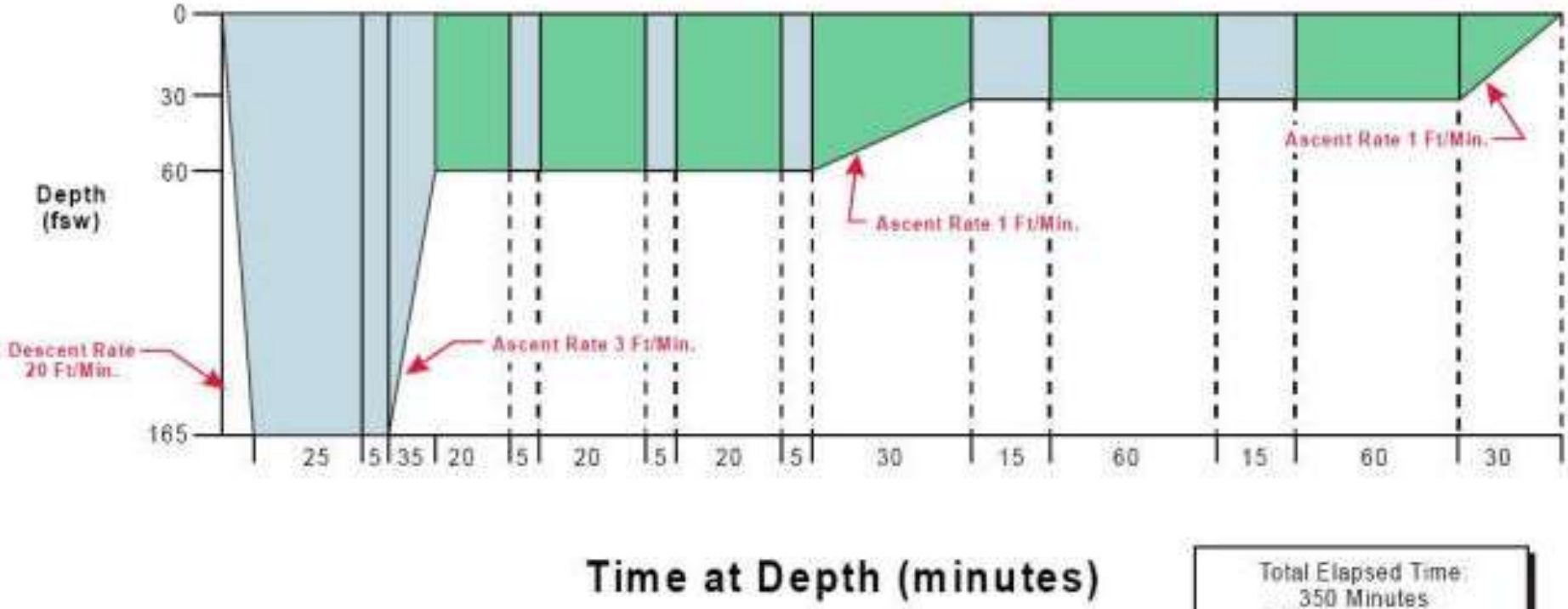
PHYMAREX ©

TABLE D'URGENCE N°3 - CX30 - SUROX / 3 bars / 450 min

Victime :	Médecin référent :	COH :	Date : __/__/__
Surveillant (Manip Caisson) :	Hyperbariste (Diver Medic) :	Hyperbariste de secours :	

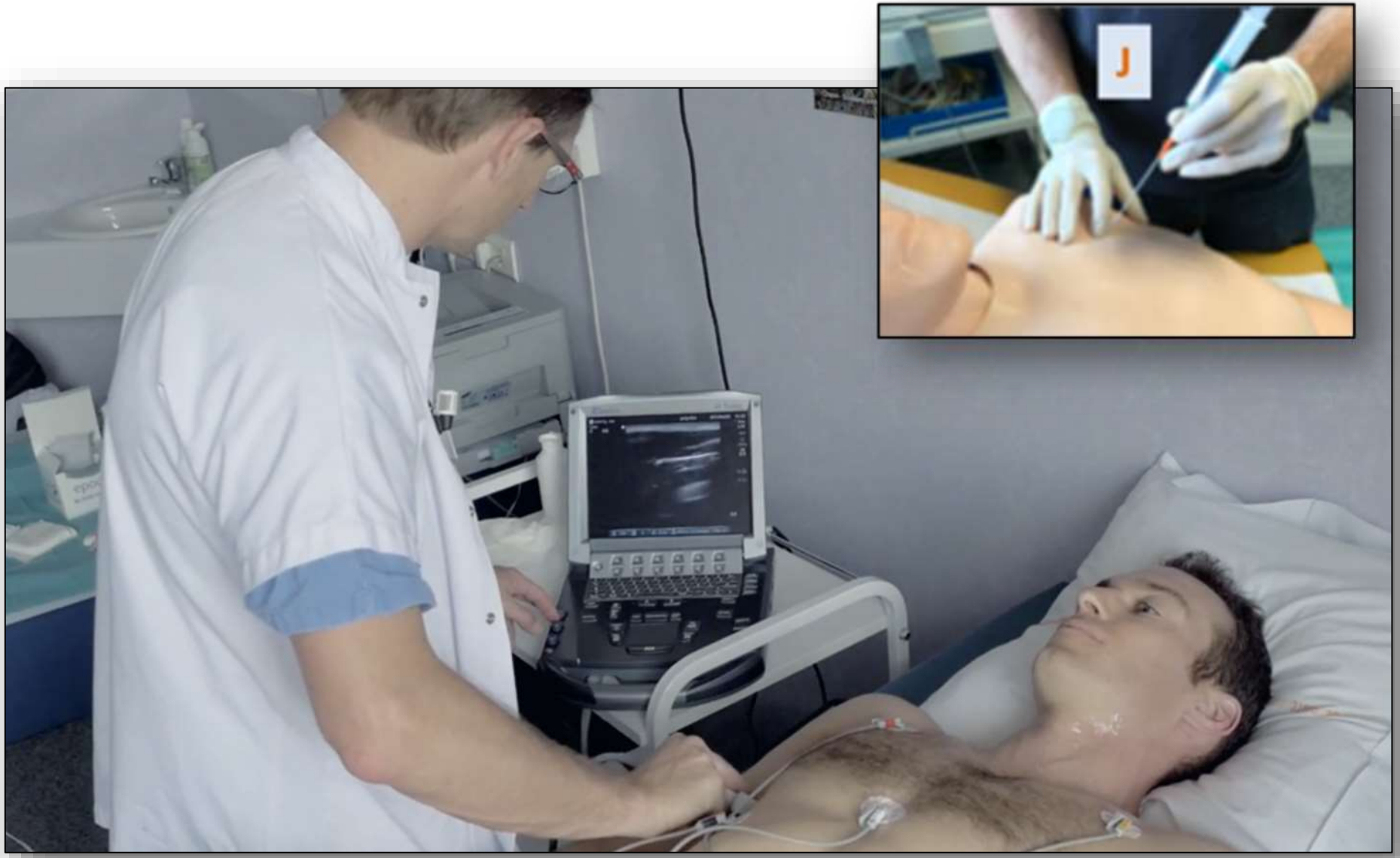

h
0 bar
(P. relative)
1,2 bars
1,8 bars
2,4 bars
3 bars
60
25
1 m / 5 min
5
25
5
25
5
25

Treatment Table 6A Depth/Time Profile



Total Elapsed Time:
350 Minutes
5 Hours 50 Minutes
(Not Including Descent Time)

1 *ATM* ≈ 33 *fsw*


J

Accident barotraumatique grave chez un enfant lors d'un baptême de plongée

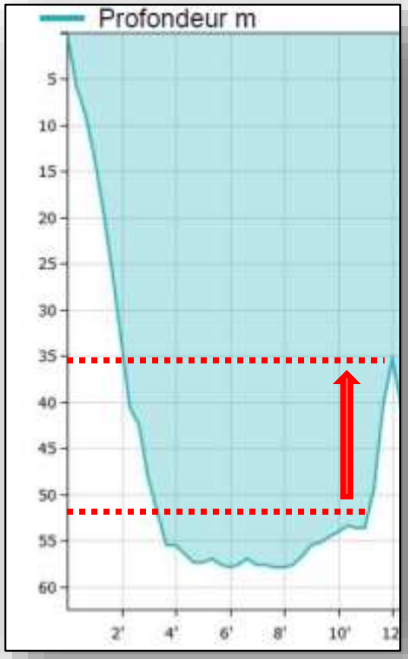
Serious pulmonary barotrauma in a child after first-time scuba dive

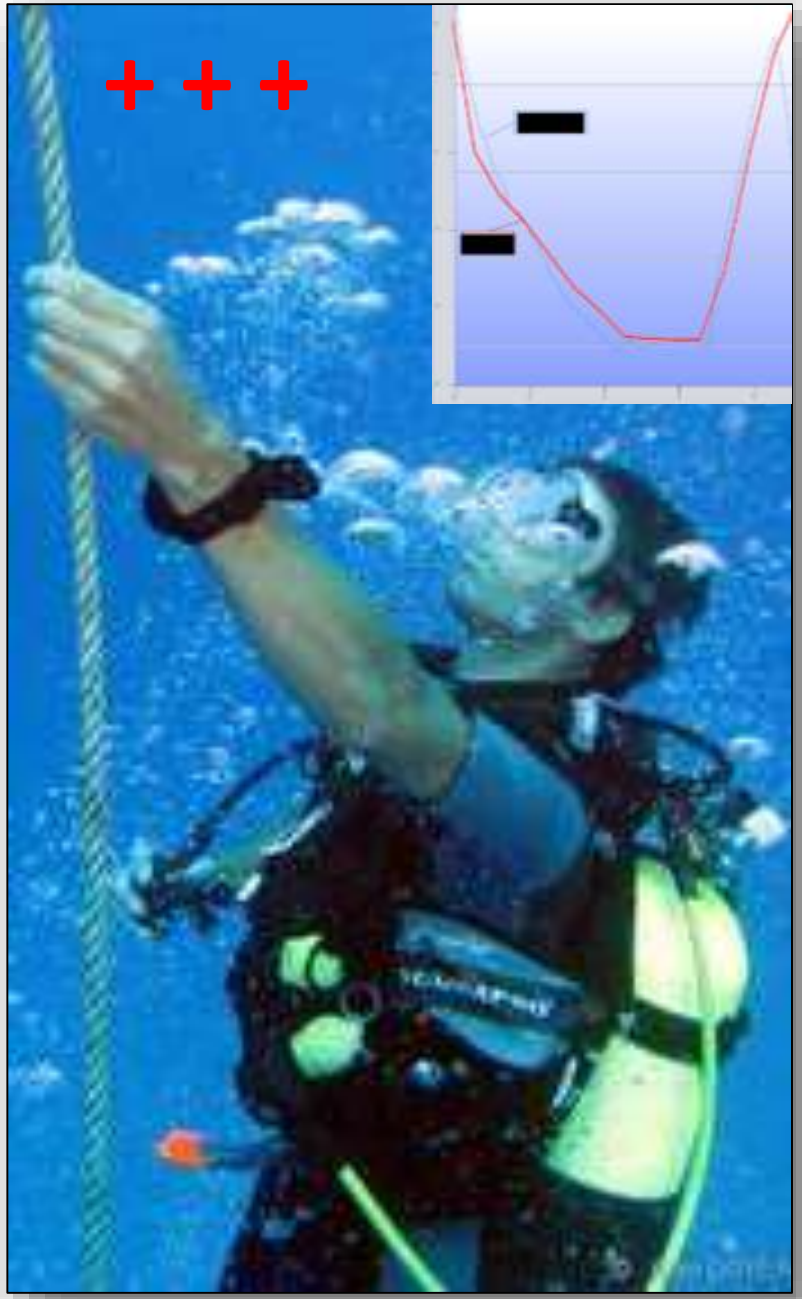
H. Le Guen[a], C. Halbert[b], C. Gras Le Guen[c,*], M. Coulange[d,e]

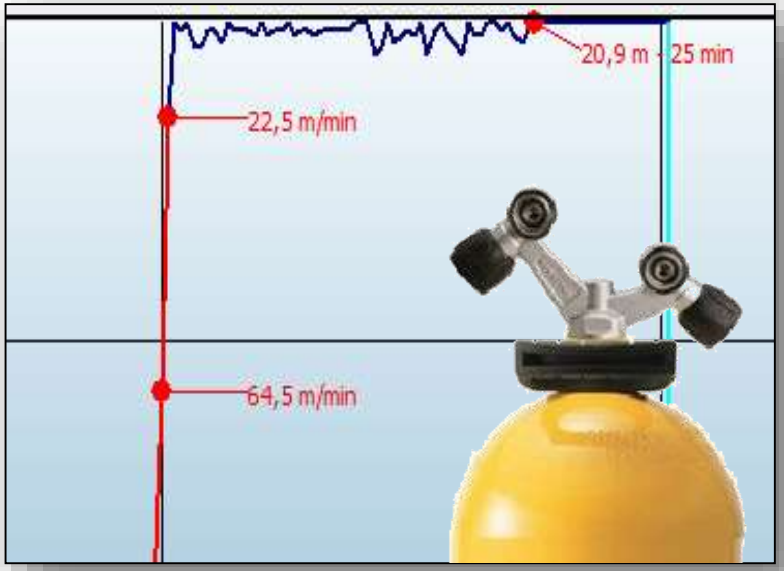
[a] Département d'anesthésie-réanimation, polyclinique de l'Atlantique, Saint-Herblain, France
[b] Service de pédiatrie, CHU la Timone, AP-HM, Marseille, France
[c] Urgences pédiatriques, hôpital Mère-Enfant, CHU de Nantes, Nantes, France
[d] Pôle RUSH, centre de médecine hyperbare, CHU Sainte-Marguerite, AP-HM, Marseille, France
[e] UMR MD2 physiologie et physiopathologie en condition d'oxygénation extrême, Aix-Marseille Université, Marseille, France

Archives de Pédiatrie 2012;19:733-735

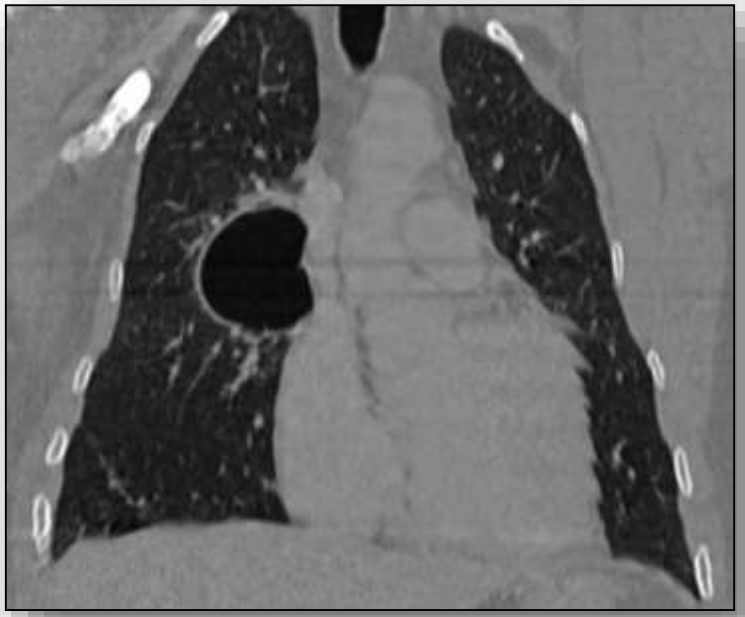
x 1,3

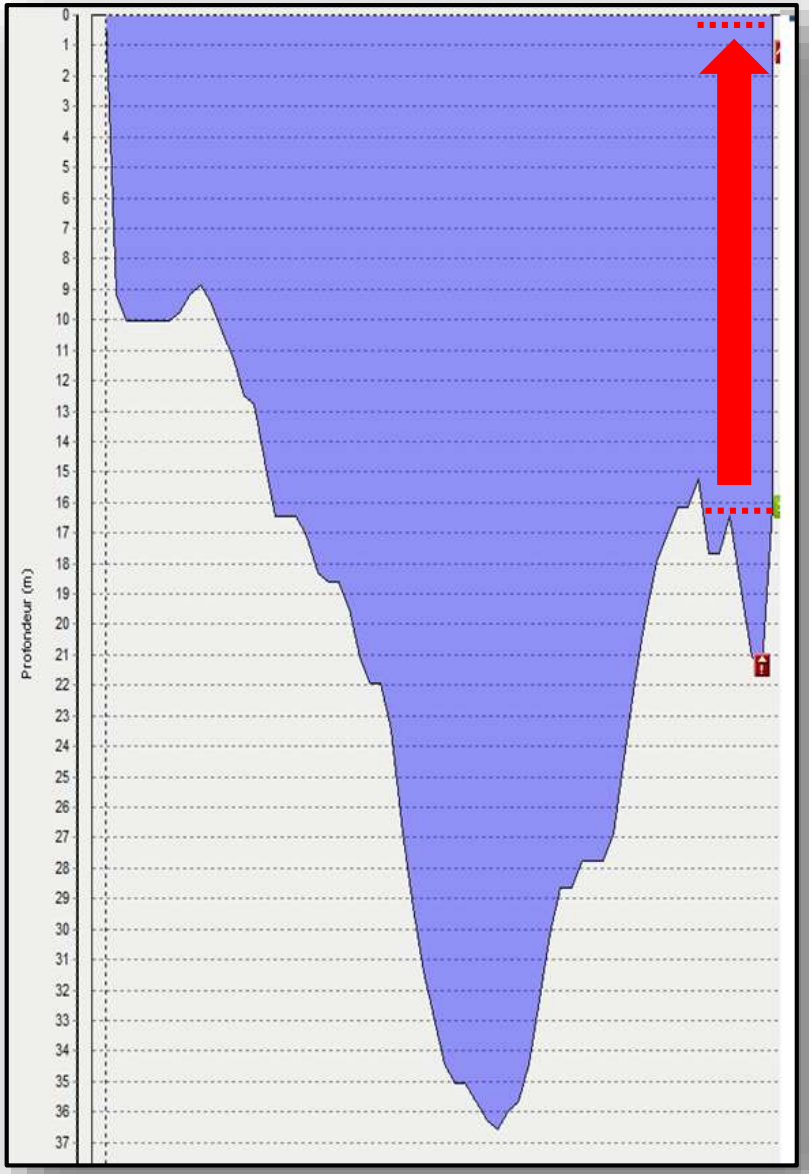



+ + +


20,9 m
25 min
22,5 m/min
64,5 m/min

YouTube




Profondeur (m)
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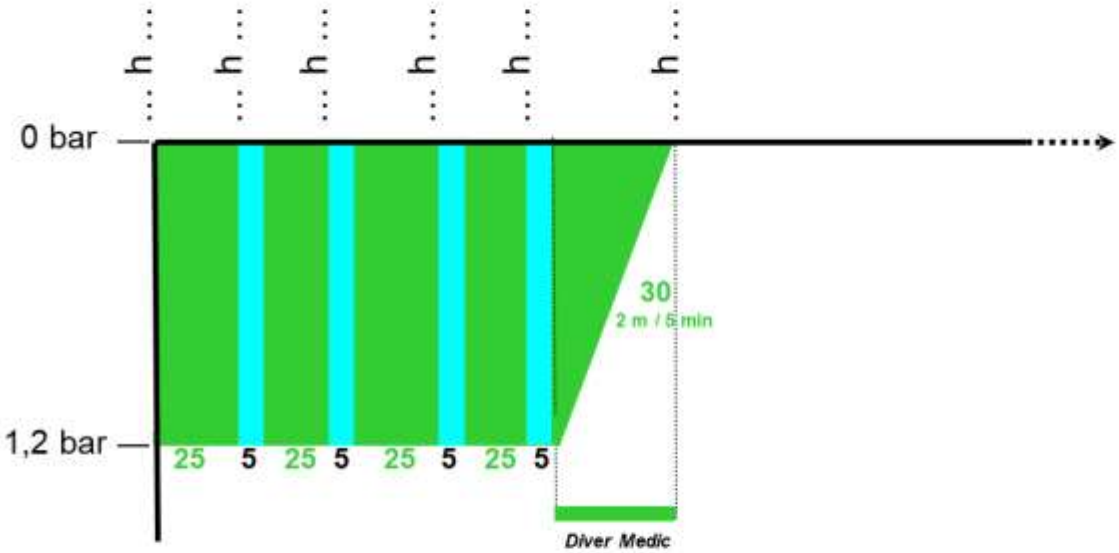
PHYMAREX ©

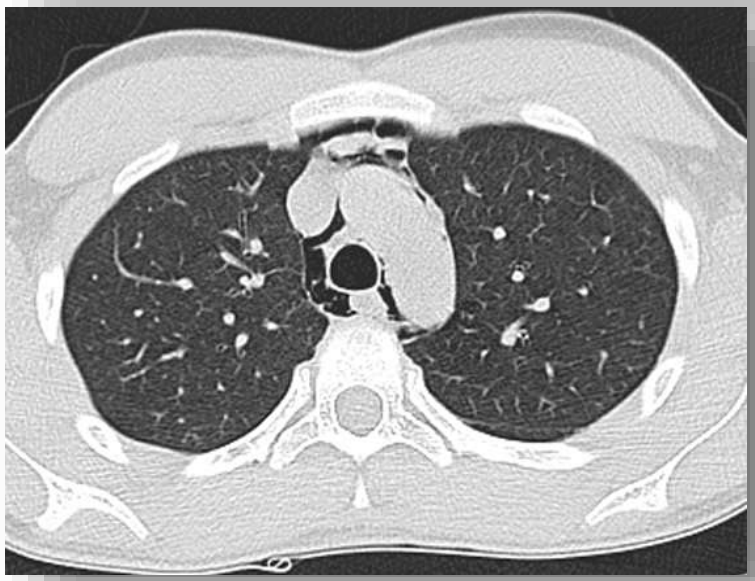
TABLE D'URGENCE N°1 - OXY / 1,2 bar / 150 min

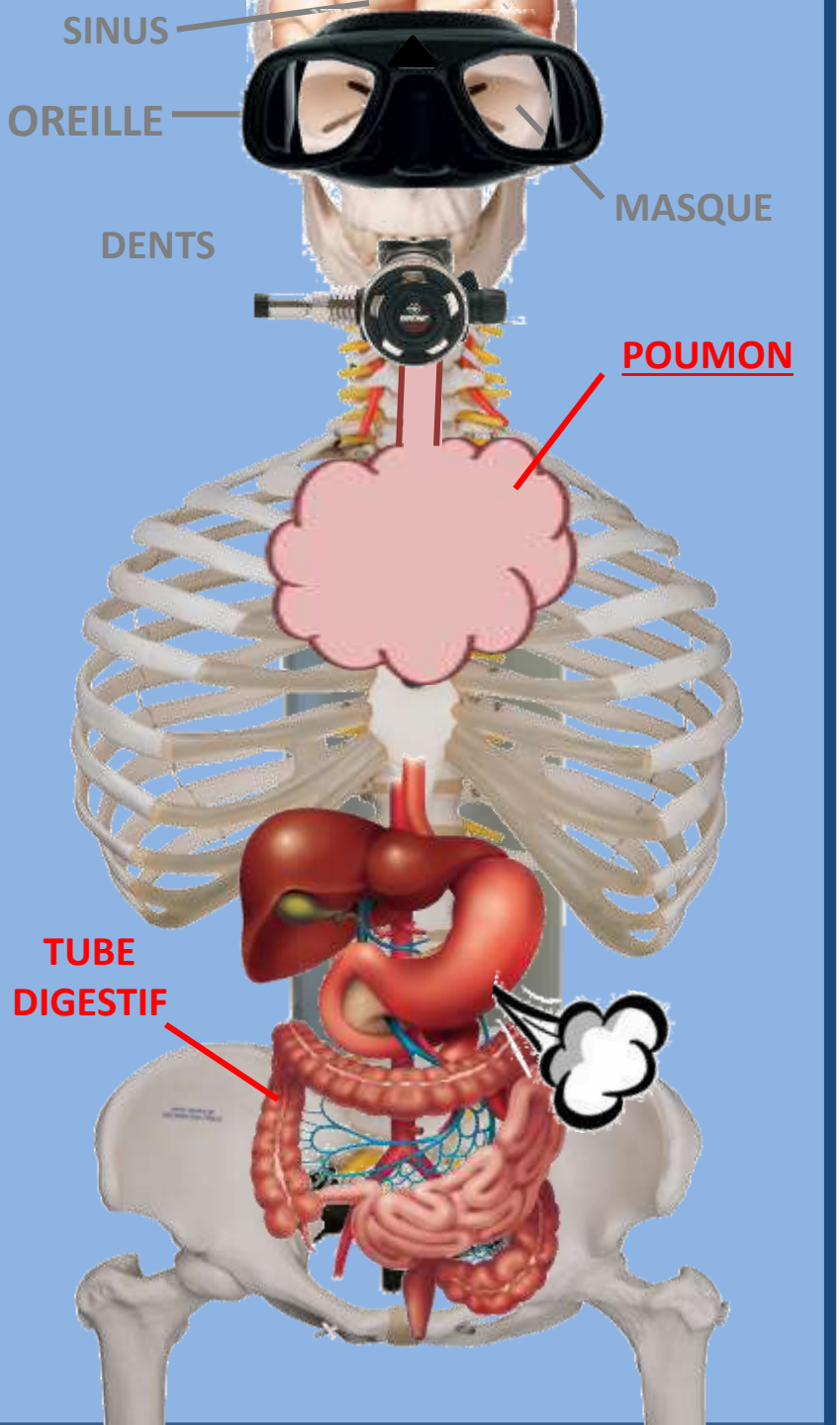
Victime :	**Médecin référent :**	**COH :**	**Date : ___ / ___ / ___**
Surveillant (Manip Caisson) :	**Hyperbariste (Diver Medic) :**	**Hyperbariste de secours :**	

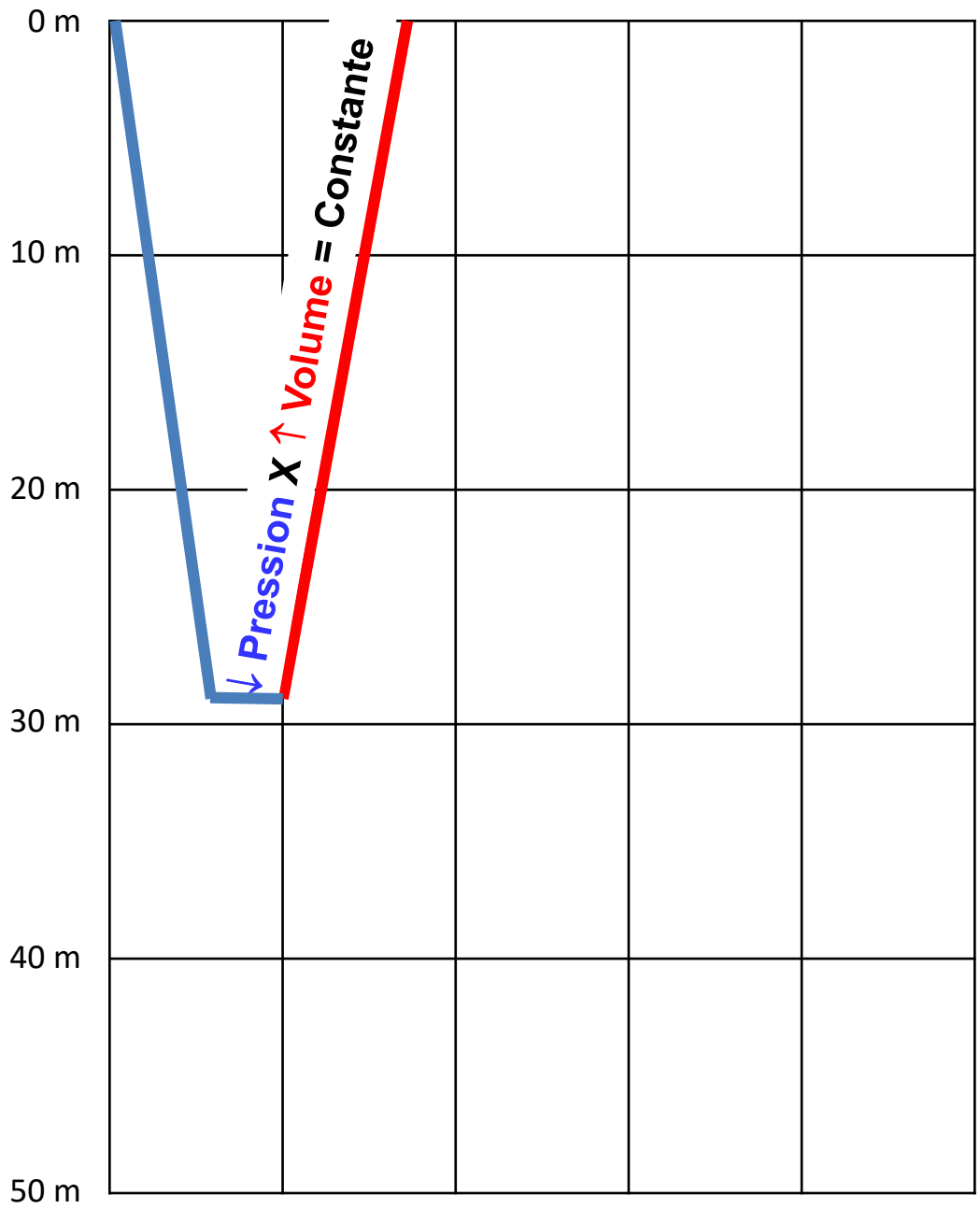


INDICATIONS - DGT
- Erreur de procédure de décompression sans signe

NOM DU DIVER MEDIC	± MAJO	DEPART SURFACE	PROF. MAX.	DEPART FOND	ARRIVEE 1ER PALIER	DUREE TRAVAIL	PALIER	HEURE SORTIE




SINUS
OREILLE
MASQUE
DENTS
POUMON
TUBE
DIGESTIF


0 m
10 m
20 m
30 m
40 m
50 m
↓ Pression X ↑ Volume = Constante

BAROTRAUMATISME DIGESTIF

BAROTRAUMATISME GASTRO-INTEST.

- **Troubles mineurs ou colique du scaphandrier**
- **Troubles graves avec lésions pariétales gastriques**

CROATIAN MEDICAL JOURNAL
CMJ
43(1):42-44,2002
CASE REPORT

Gastric Rupture in a Diver Due to Rapid Ascent

Nadan M. Petri, Lena Vranjković-Petri[1], Nebojša Aras[2], Nikica Družijanić[2]

Undersea and Hyperbaric Medicine Department, Naval Medical Institute, Split; [1]Krka Farm
[2]Department of Surgery, Split University Hospital, Split, Croatia

Case Report

A 37-year-old experienced female diver was diving with her partner to the depth of 37 meters in the vicinity of a remote Croatian island in the Adriatic Sea. Around 2 h before the dive, she had a heavy meal based on meat, during which she also consumed almost 1.5 L of mineral water. This was her second dive that day, the first dive being within no-decompression limits (12). Descent time was 7 min. Within 2 min after reaching the bottom, she started panicking because of equipment failure and headed rapidly for the surface.

It seems that the rupture typically occurs at the lesser gastric curvature, probably because the lesser curvature has a single muscular layer and fewer mucosal folds, which makes it less elastic than other gastric structures. Increased air volume in the stomach causes significant gastric distension and closes the esophagogastric junction (Fig. 1), thus blocking the release of air through the mouth (10,11).

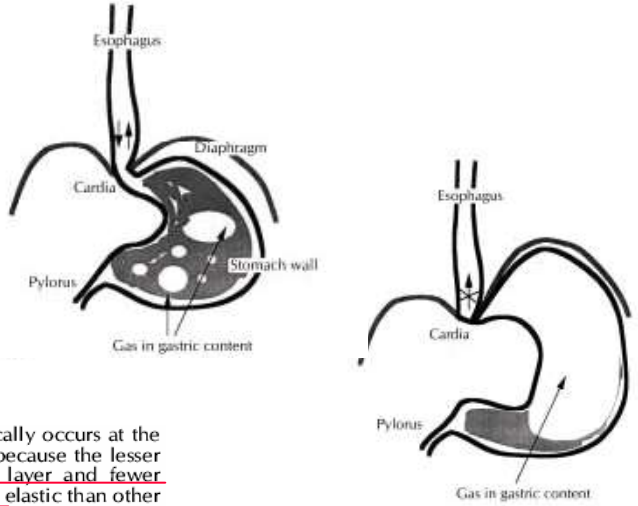


Figure 1. Intake of soda beverages before the dive can result in gas collection (**top**) and air distention during rapid ascent (**bottom**). The left lobe of the diaphragm is pushed upwards, and the esophagogastric junction is blocked and locked.

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ACCIDENTS
DE LA PLONGÉE SOUS-MARINE

M. Coulange, A. Boussuges, A. Barthélémy, J.-M. Sainty †

des gaz contenus dans le tube digestif (colique du scaphandrier). De façon exceptionnelle, la distension du volume des gaz contenus dans l'estomac lors de la remontée entraîne la fermeture de l'angle de His et la coudure du bas œsophage contre le pilier droit du diaphragme ainsi que le ralentissement de la vidange pylorique. Ce mécanisme peut être aggravé par une déglutition accidentelle d'eau de mer ou une sténose duodénale et provoquer la rupture gastrique [13].

Intensive Care Med (2005) 31:1595
DOI 10.1007/s00134-005-2756-4

CORRESPONDENCE

Abdominal compartment syndrome after scuba diving

Stefan Tschopp
Marius Keel
Joerg Schmutz
Marco Maggiorini

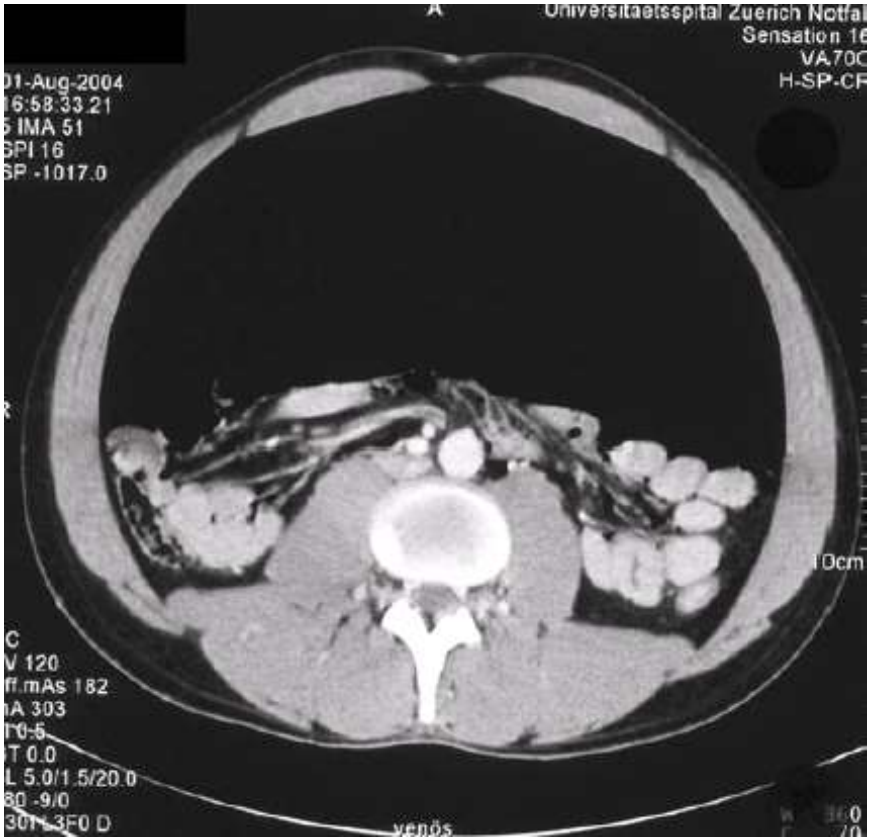

Fig. 1 Computed tomography of inferior abdomen with an extended pneumoperitoneum and compression of the gastrointestinal tract

Sir: A 30-year-old male amateur diver suffered a panic attack at a depth of 65 m and ascended to the surface within 2 min. He was referred to our emergency room because of hemoptysis and abdominal pain.

Emergency laparatomy was performed because of abdominal compartment syndrome and suspicion of viscus perforation. Air escaped explosively during laparotomy. The extended exploration of the anterior and posterior aspects of the stomach and the intestinum and temporarly clamping proximal to the pylorus with air insufflation through a gastric tube showed no perforation of the gastrointestinal tract.

Air probably escaped through a temporary leak in the stomach wall caused by the sudden distension.

Pneumoperitoneum is generally caused by a rupture in the gastrointestinal tract. About 20 cases of diving-related pneumoperitonea have been reported [1, 2, 3], most of them as consequence of a gastric barotrauma. However, pneumoperitoneum after scuba diving has also been reported after pulmonary barotrauma [3] or even without detectable organ perforation

- **Prévention**
  - ✓ **Contrôle des vitesses de descente et de remontée**
  - ✓ **Recherche de lésions préexistantes lors de la visite médicale**

- **A la descente : atteinte ORL, faciale ou stomatologique (pronostic fonctionnel)**

- **A la remontée : atteinte pulmonaire ou gastrique (pronostic vital)**

- **Indication OHB :**
  - ✓ **Embolie gazeuse cérébrale +/- coronarienne (éliminer un PNO associé !)**
  - ✓ **± Doute sur un ADD (diagnostic différentiel ? diagnostic associé ?)**
  - ✓ **± Erreur de procédure associée**

- **Reprise entre 3 j et 3 mois en l'absence de séquelles**

- **Ne pas passer à côté d'un OPI**