Decompression Sickness

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Scope of Diving Practice

- Recreational/advanced recreational/technical diving
- Professional diving
  - Inland/inshore diving
  - Offshore diving
  - Archaeological and scientific diving
  - Media diving
  - Recreational instructors and guides
  - Police, military

Breathing Apparatus

- Diving bell
- Diving helmet
- Open-circuit SCUBA
- Rebreather
  - Closed circuit oxygen rebreather
  - Closed circuit mixed gas rebreather
  - Semi-closed rebreather
    - Constant mass flow
    - Constant ratio
- Modern hose-supplied diving equipment

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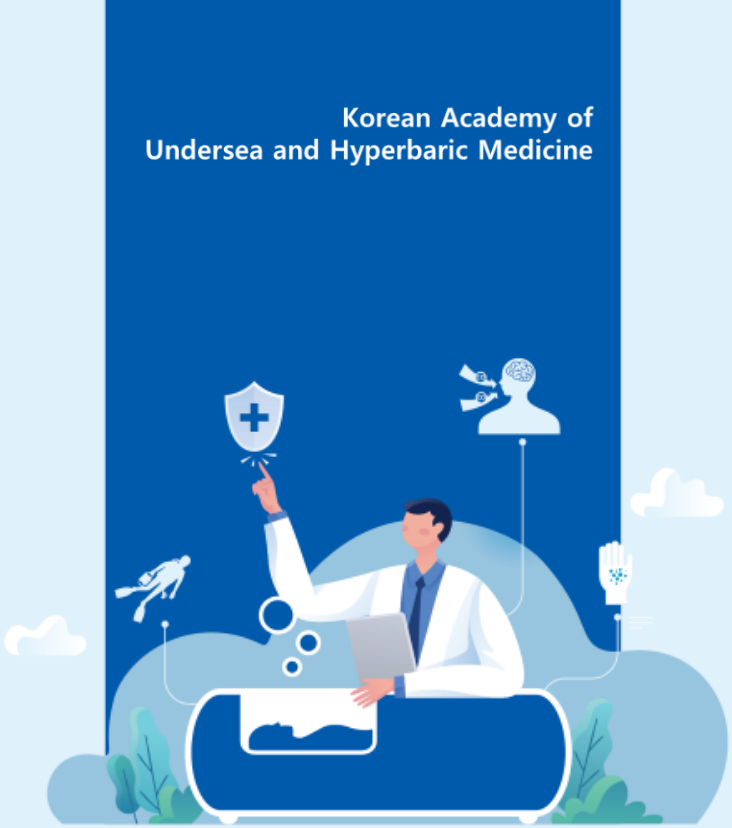
잠수 물리

Diving Physics

Boyle's law

Dalton's law

Henry's law



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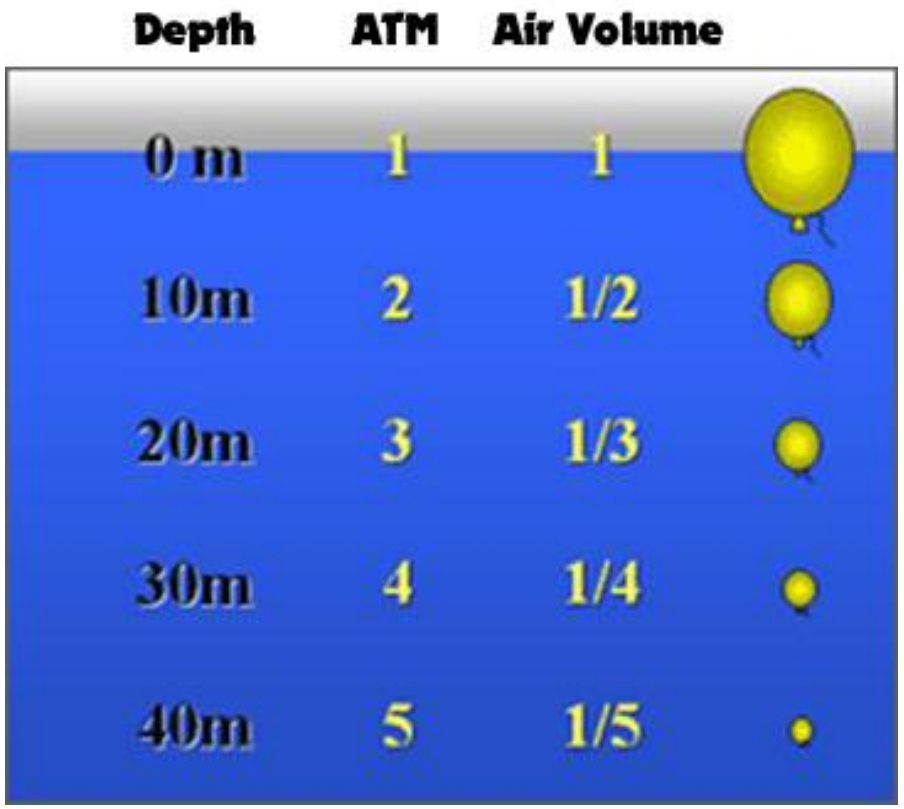
압력 단위

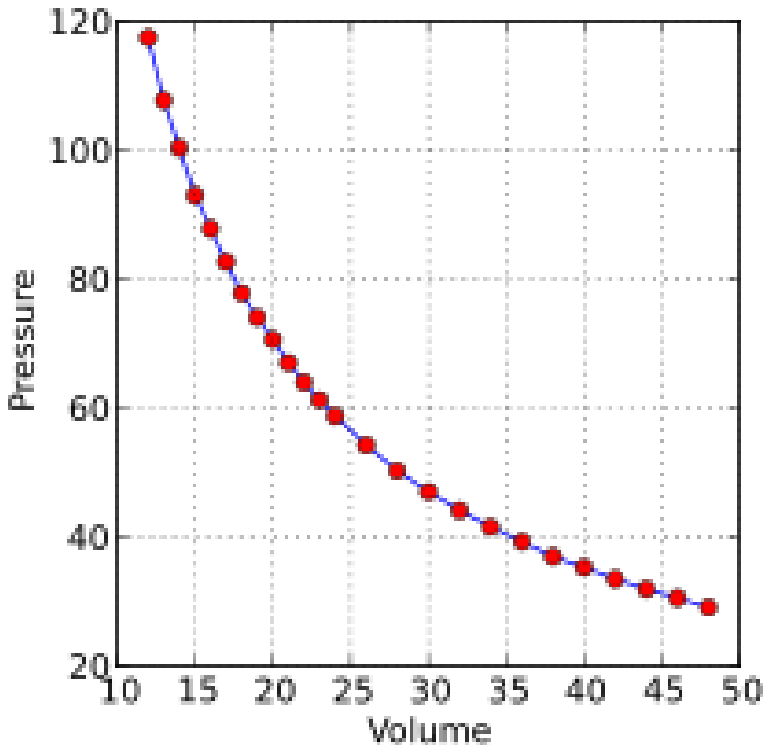
- 1 Atmosphere(ATA)

=101.325 kPa	=100 kPa
=1,013 millibars	=1,013 millibars
=760 mmHg(torr)	=760 mmHg(torr)
=14.696 psi	=14.7 psi
=1.013 bar	=1 bar
=10.08 meters of seawater	=10 meters of seawater
=33.07 feet of seawater	=33 feet of seawater

Boyle's law

- At a constant temperature, the volume of a gas is inversely proportional to the pressure (P1V1 = P2V2)





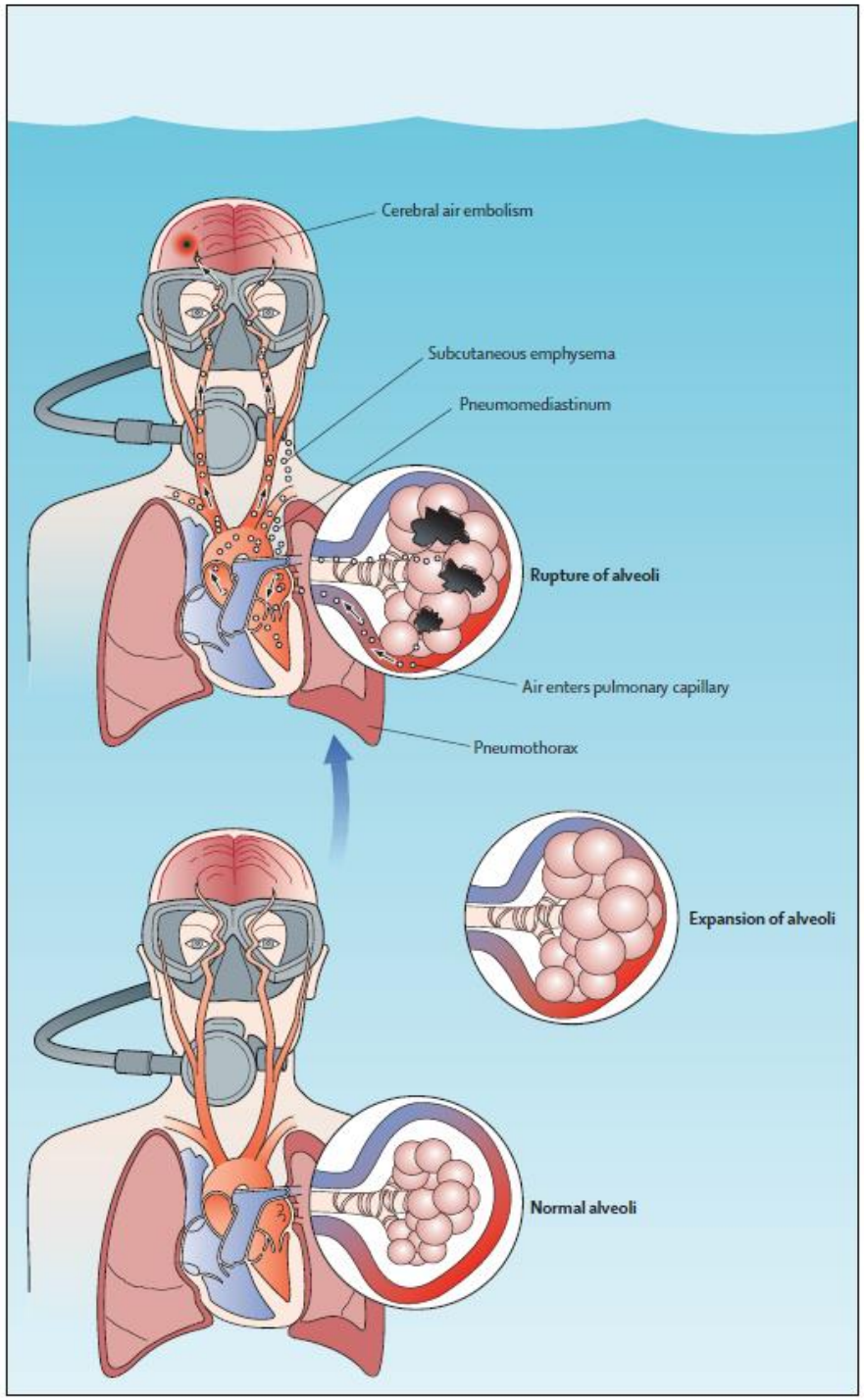
Barotrauma

Arterial gas embolism

Boyle's law

Pulmonary barotrauma in a diver during breath-hold ascent

The Lancet, v.377 issue 9760, 2011,p.153-64



Barotrauma of descent and ascent

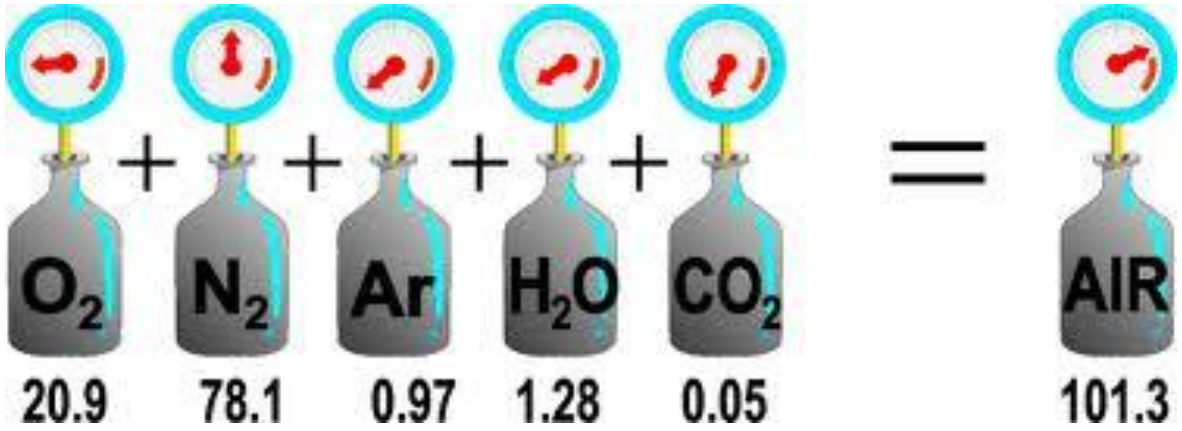
Barotrauma	Clinical Features	Treatment
Barotrauma of descent		
Otic barotrauma ("ear squeeze")	Pain, fullness, vertigo, conductive hearing loss from inability to equalize middle ear pressure	Decongestants, consider antibiotics
Sinus barotrauma ("sinus squeeze")	Pain over affected sinus, possible bleeding from nares	Decongestants, consider antibiotics
Inner ear barotrauma	Sudden onset of sensorineural hearing loss, tinnitus, severe vertigo after forced Valsalva	Head of bed up, no nose blowing, antivertigo medications, and urgent otolaryngology consultation as some surgeons advocate early exploration
Barotrauma of ascent		
Pulmonary overinflation syndromes (pulmonary barotrauma)	Dyspnea, chest pain, subcutaneous air, extra-alveolar air on radiograph; usually occurring secondary to rapid or uncontrolled ascent	Pneumomediastinum requires only symptomatic care and does not require recompression Pneumothorax requires drainage and does not require recompression (if recompression is instituted for treatment of arterial gas embolism, then the pneumothorax must be drained before recompression)
Arterial gas embolism	Neurologic symptoms occurring immediately after uncontrolled or rapid ascent or neurologic symptoms in the setting of pulmonary barotrauma	Airway, breathing, circulation, high-flow oxygen, IV hydration, immediate recompression (hyperbaric oxygen), consider adjunctive lidocaine Any neurologic symptom in the setting of documented pulmonary barotrauma must be treated as an arterial gas embolism

Dalton's law

- **The sum of partial pressures of gases in a mixture must equal the total pressure of the mixture.**

- SCUBA at 66fsw = 2 atm
  + 1 atm = 3 ATA

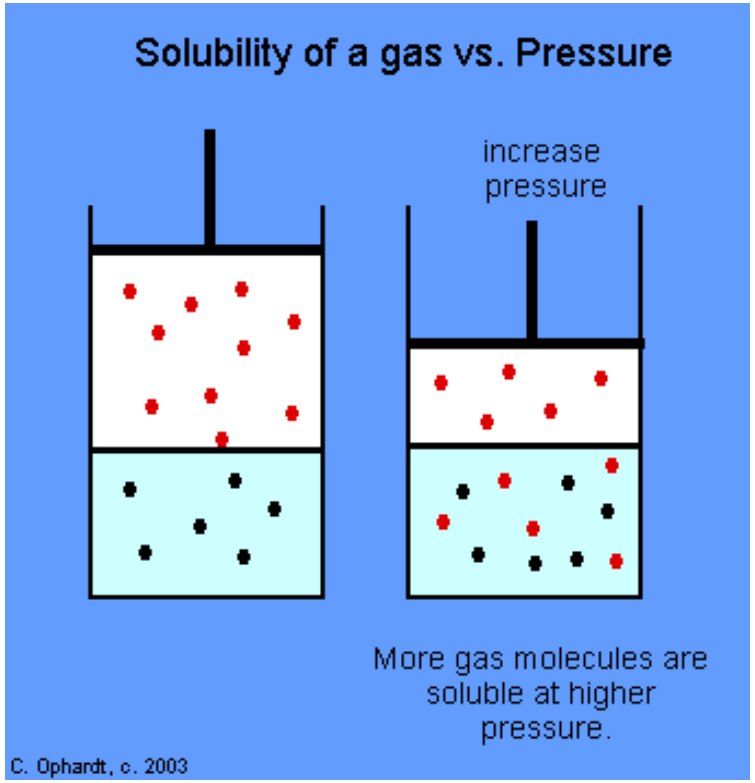
- pO2 = 3 ATA x 0.21 = 0.63 ATA
- pN2 = 3 ATA x 0.78 = 2.34 ATA

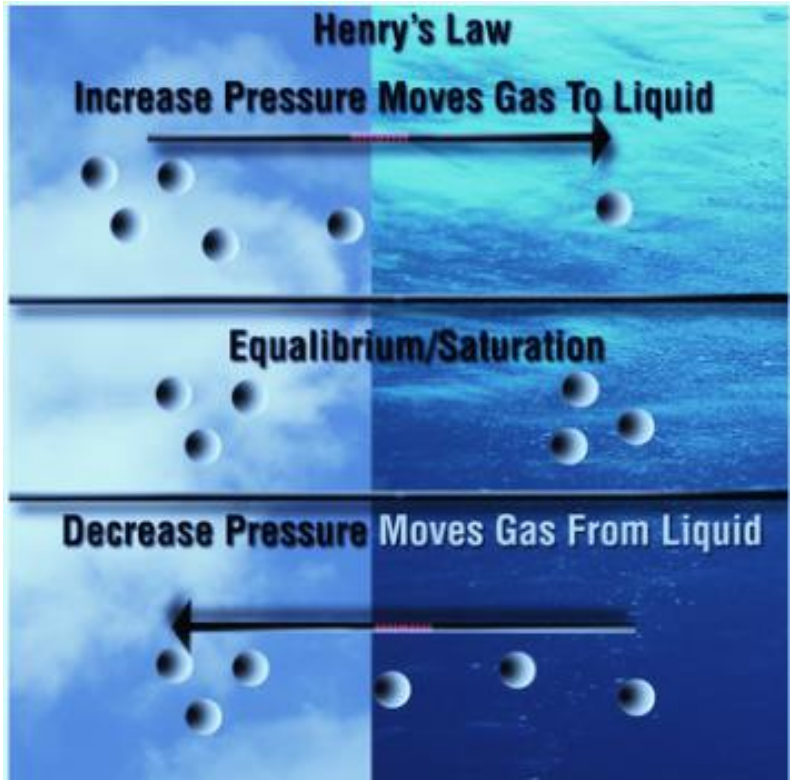


O2 toxicity
N2 narcosis

Henry's law

- **Amount of gas dissolved into a liquid is directly proportional to the partial pressure of that gas.**





Diving injury

Barotrauma

Pulmonary Barotrauma
Ear Barotrauma
Sinus Barotrauma
Other Barotrauma

Decompression Sickness

Decompression Sickness

Abnormal gas pressures

Inert gas narcosis
Hypoxia
Oxygen toxicity
Carbon dioxide toxicity
High-pressure neurological syndrome

Aquatic disorder

Drowning syndrome
Seasickness
Cold and hypothermia
Scuba divers' pulmonary edema

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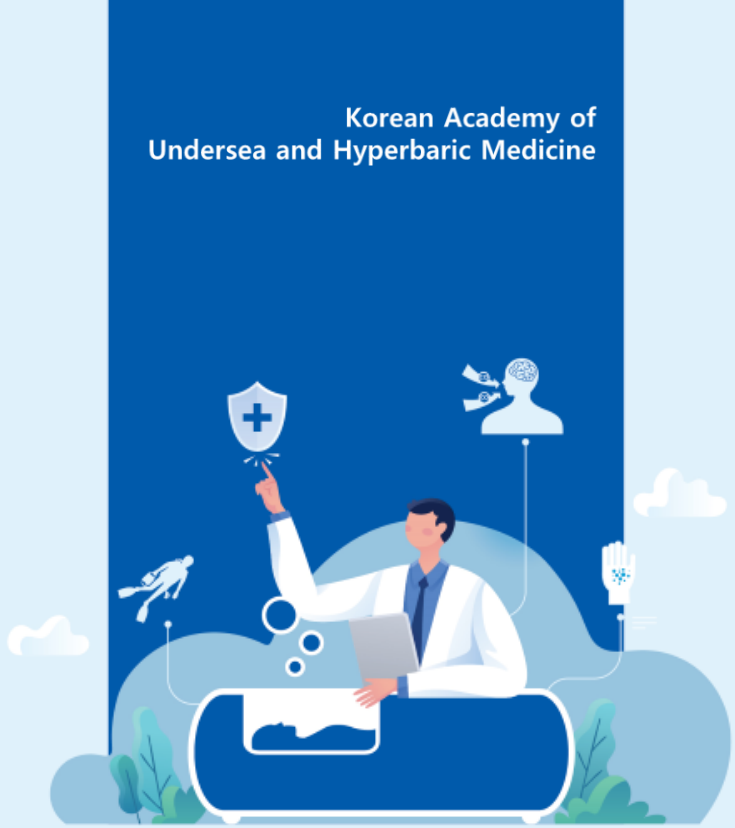
잠수병

Decompression Sickness

- Caisson's disease
- Dysbarism
- Bends



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Decompression illness(DCI)

- Caused by **bubbles** in blood or tissue
  during or after a **reduction** in environmental pressure(decompression)

I. Decompression sickness(DCS):
   - **In-situ bubble** formation from dissolved **inert gas**

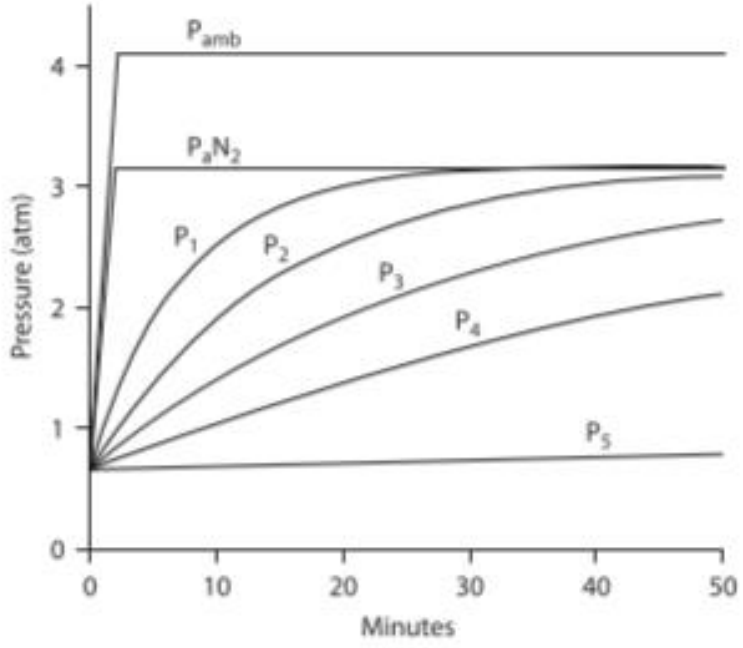
II. Arterial gas embolism(AGE):
   - **Alveolar gas or venous gas** emboli into the **arterial circulation**

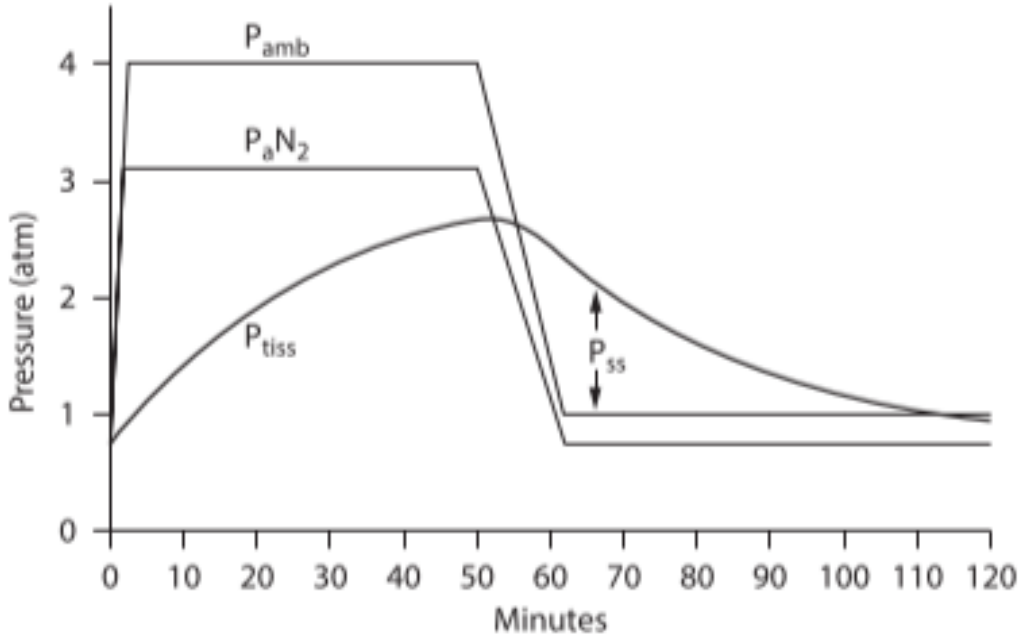
- 증상만으로 신경계 DCS와 AGE의 구분이 매우 어려움
- 보통 신경계 DCS와 AGE의 치료법 동일

Pathophysiology

Uptake and elimination of inert gas

- Perfusion & Solubility
- Faster tissue: lung, brain, heart, kidney
- Slower tissue: bone, fat

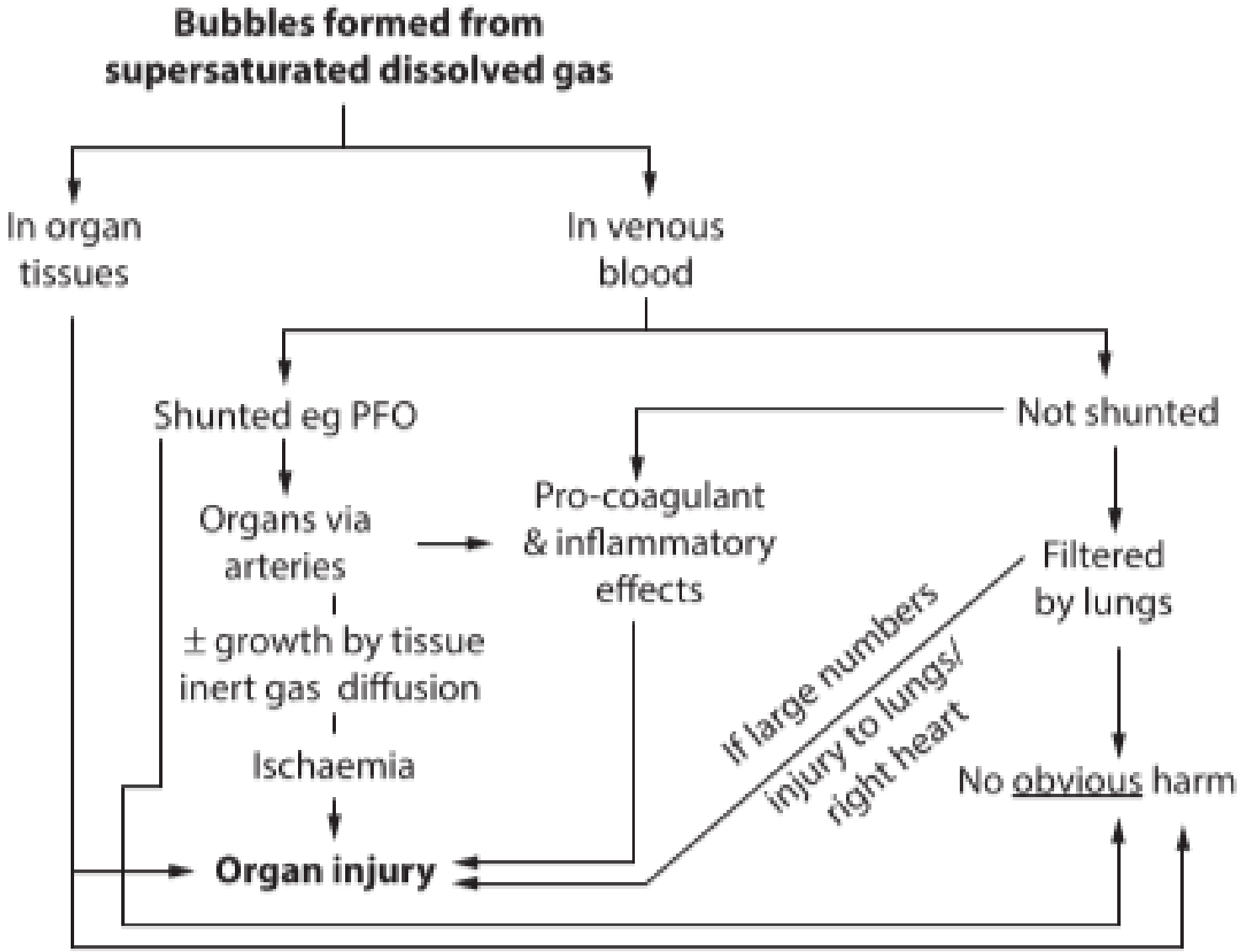




Pathophysiology; Bubble mechanism

- Direct mechanical disruption of tissue.
- Occlusion of blood flow, platelet deposition
- Coagulation cascade activation
- Endothelial dysfunction
- Capillary leakage
- Endothelial cell death, complement activation
- Inflammation
- Leukocyte-endothelial interaction

Pathophysiology



잠수병 발생 상황

- 잠수 중 급상승
- 반복잠수 (불충분한 휴식)
- 잠수 후 항공기를 타고 비행
- 터널이나 케이슨(고압환경) 작업
- 여압장치가 없거나 고장난 항공기를 타고 고공비행
- 저압챔버 훈련

잠수병 증상 발생 시간

after surfacing

- Immediate ~ 10 minutes: AGE
- Within 1 hour: 42 %
- Within 3 hours: 60 %
- Within 8 hours: 83 %
- Within 24 hours: 98 %

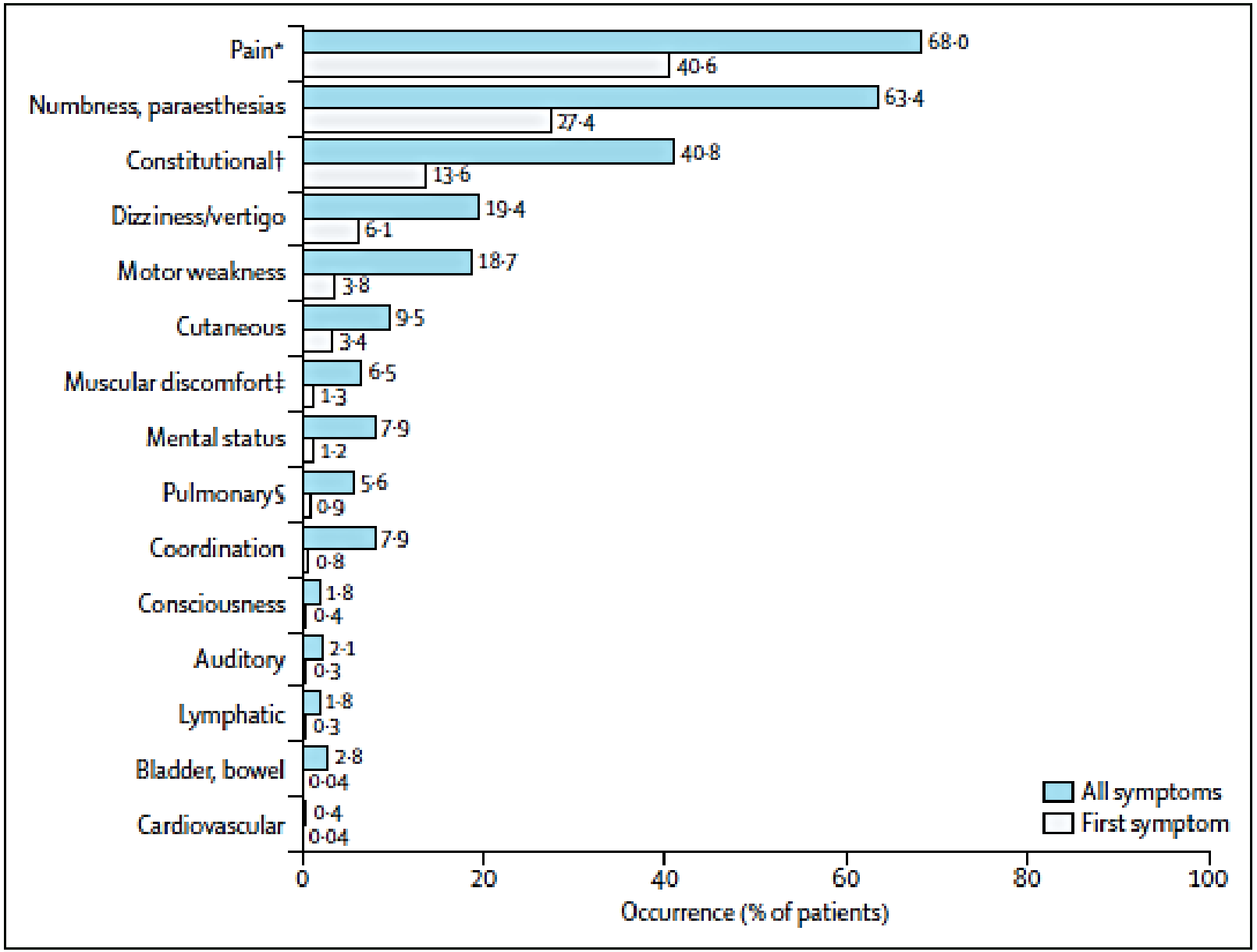
  - 일주일 뒤에 발생도 가능

Classification of Decompression sickness

Classification	Clinical Features	Comments
Type I: "pain-only" DCS	Deep pain in joints and extremities, unrelieved but not worsened with movement	Usually single joint, most commonly knees and shoulders
	Skin changes—mottling, pruritus, and color changes	Lymphatic obstruction can occur and takes days to resolve despite recompression therapy
Type II: "serious" DCS	Pulmonary ("chokes")—cough, hemoptysis, dyspnea, and substernal chest pain	
	Cardiovascular collapse can occur	
	Neurologic—sensation of truncal constriction, ascending paralysis, usually rapid in onset	More commonly affects the lower cervical and thoracic regions; may see scattered lesions
		Autonomic dysfunction may be seen
	Vestibular ("staggers")—vertigo, hearing loss, tinnitus, and disequilibrium	Usually occurs after deep, long dives
Type III: combination of DCS and arterial gas embolism	Symptoms of DCS II noted above plus a variety of stroke syndromes, symptoms, and signs	Symptoms occur on ascent or immediately upon surfacing
		Symptoms of arterial gas embolism may spontaneously resolve

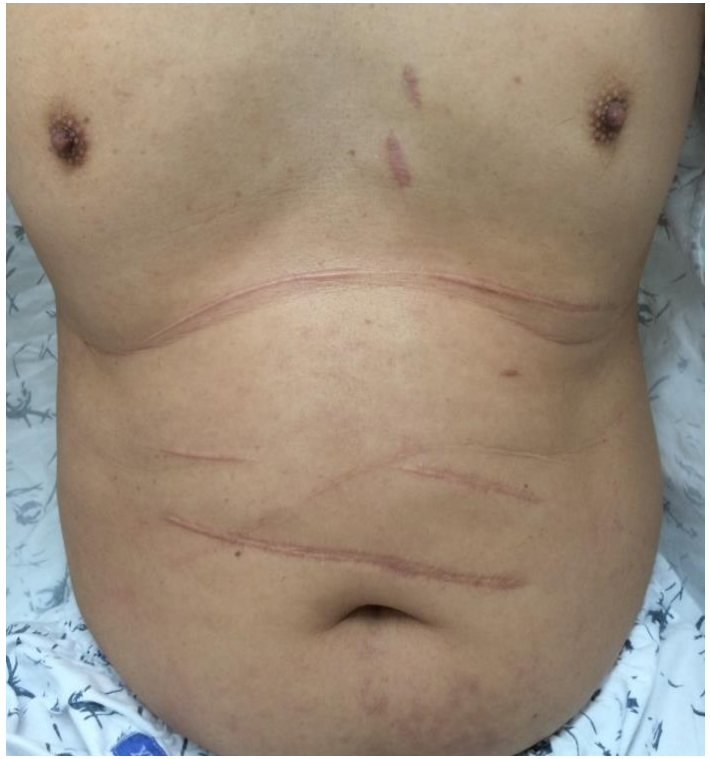
Manifestations of Decompression illness

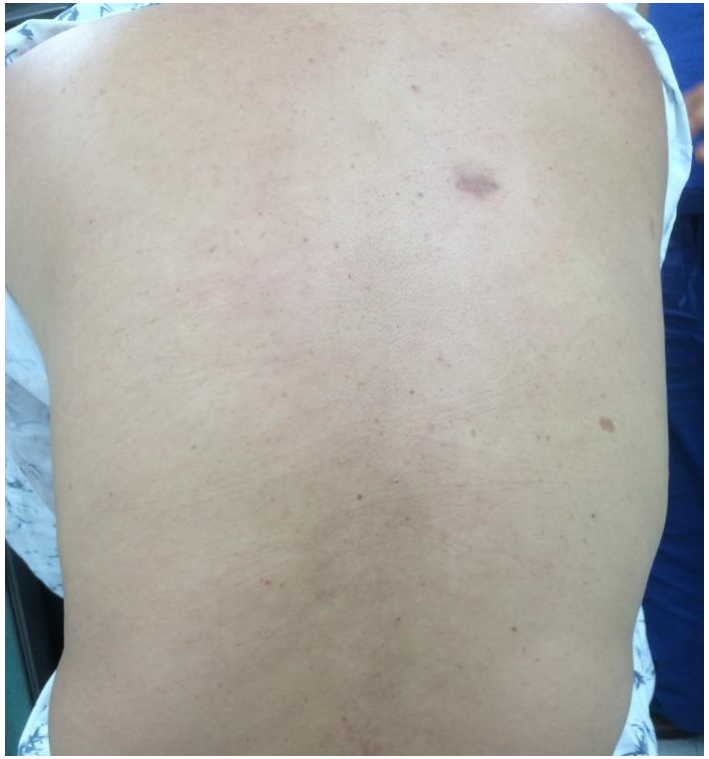
The Lancet, v.377 issue 9760, 2011,p.153-64



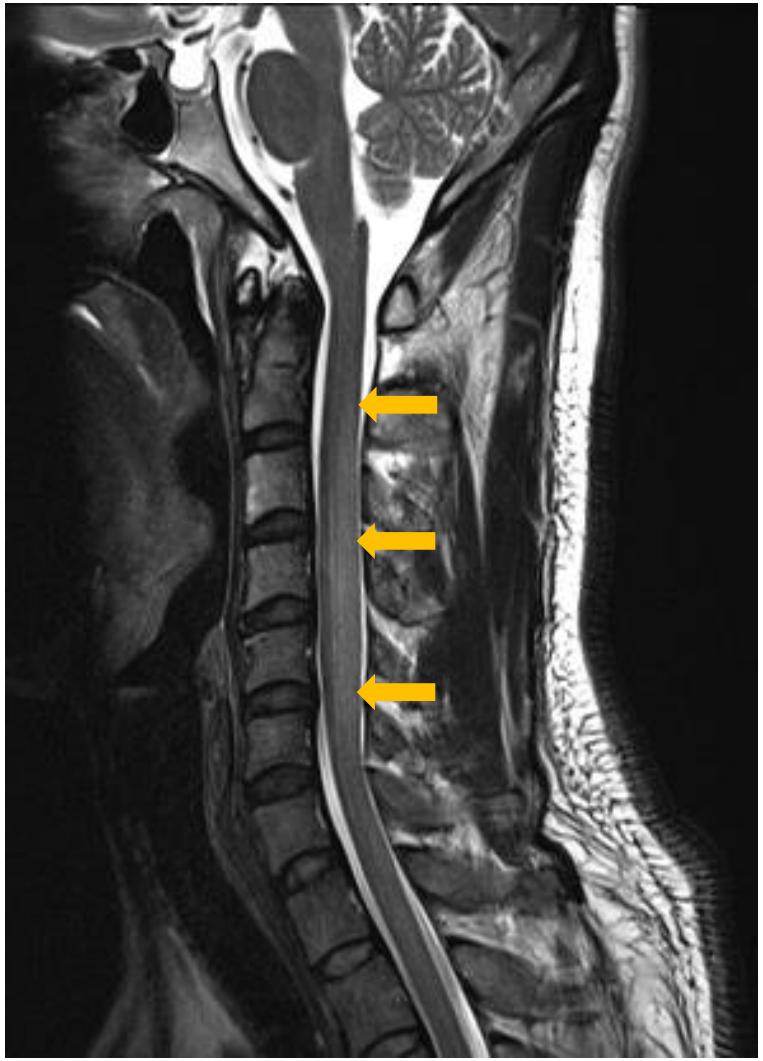
Cutis marmorata

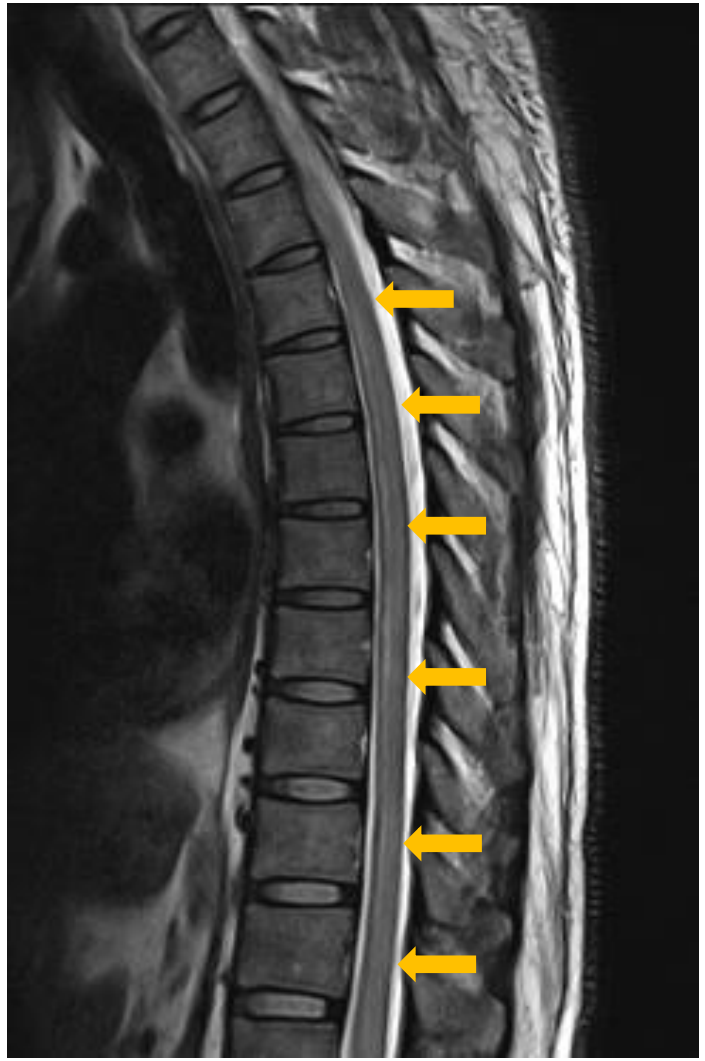
Cutis marmorata: 치료 후



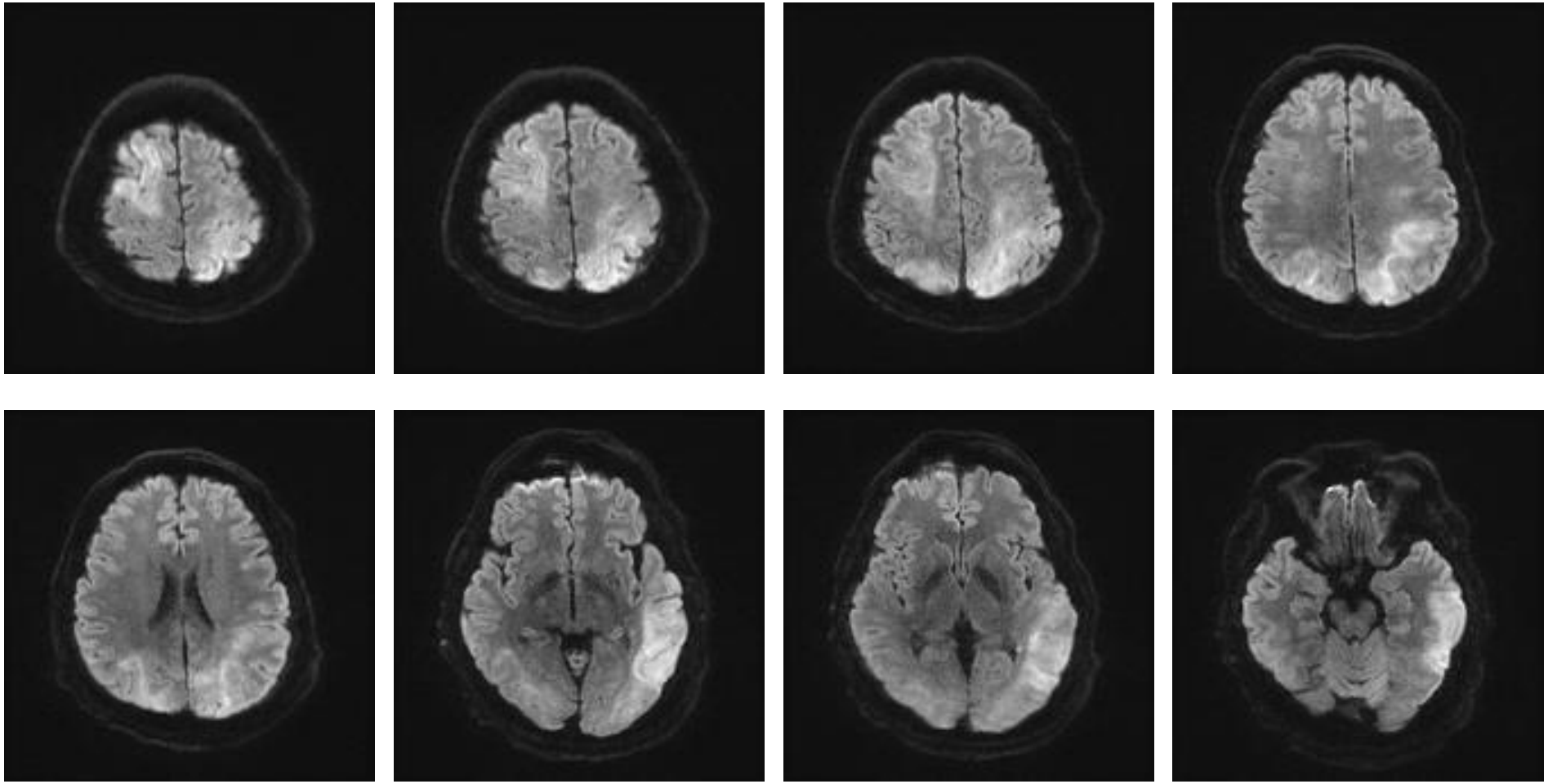


Spinal DCS

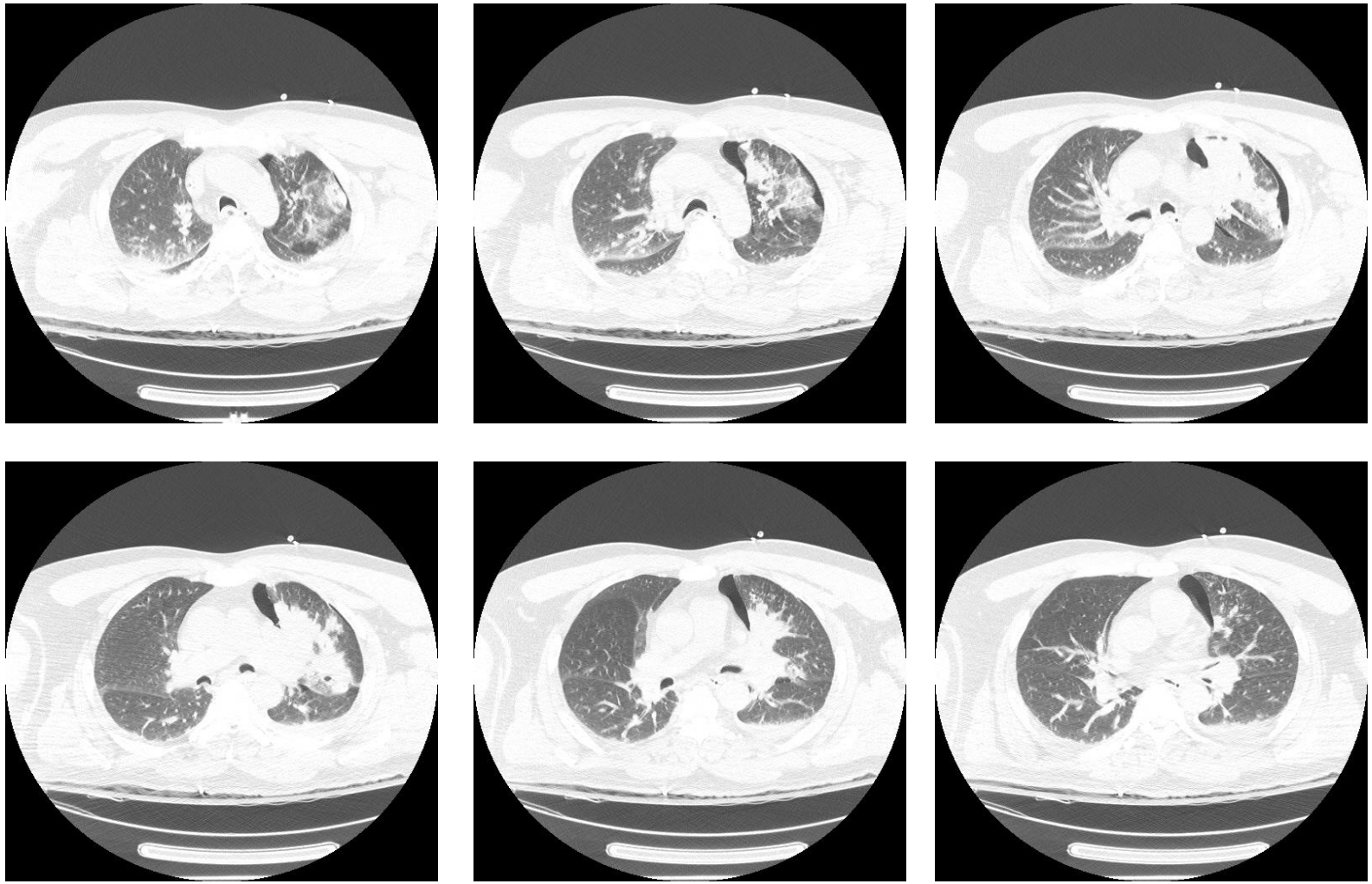




Cerebral DCI(AGE)



Cerebral DCI(AGE)



A Case of Cerebral Decompression Sickness with Spontaneous Pneumothorax Caused by Undiagnosed Lung Cancer

Se-Hyun Oh, Hui-Dong Kang, Sang-Ku Jung

Hyperbaric Oxygen Treatment Center, Department of Emergency Medicine, Gangneung Asan Hospital, Gangneung, Korea

Introduction

A health scuba diver presented with severe cerebral decompression sickness, spontaneous pneumothorax after diving.

Case presentation

A 46-year-old man, previous healthy experienced diver and diving instructor, was transferred to our emergency department. Immediately after a controlled surfacing from 33 MSW, his mentation changed to stupor after complaint of a shortness of breath, rigid extremities. At other medical center, intubation was done. The brain CT scan showed no abnormal finding. And then he was transferred to our hospital. The chest CT scan revealed pneumothorax in the left side and the obstruction of left upper lobe bronchus with obstructive pneumonia.

Hyperbaric oxygen therapy(HBOT) was given with U.S. Navy treatment table 6A after closed thoracostomy. Brain MR diffusion image taken after the HBOT showed acute infarction in both MCA and PCA territories. After transferring to intensive care unit, we started therapeutic hypothermia to prevent worsening of cerebral function; cooling to 33 ± 1℃ for 24 hours using Arctic Sun®, rewarming by 0.25℃ per hour, and then normothermia(37℃) for 72 hours under the ventilator care with sedatives, muscle relaxants. Finishing the therapeutic hypothermia, we repeated HBOTs with U.S. Navy treatment table 5 and rehabilitation therapy. He gained normal neurological and physical function.

Searching for the cause of the obstructing lesion seen on the chest CT scan, bronchoscopic biopsy was done. The result was squamous cell carcinoma. Because the cancer stage was far advanced(T4N1M0), neoadjuvant chemotherapy and radiotherapy were given before thoracic surgery. He is in recovering state with respiratory rehabilitation after left pneumonectomy.

Conclusion

This is the first case of cerebral decompression sickness with spontaneous pneumothorax caused by undiagnosed lung cancer. Therapeutic hypothermia may be helpful to salvage the penumbra in severe cerebral decompression sickness with consecutive HBOT.

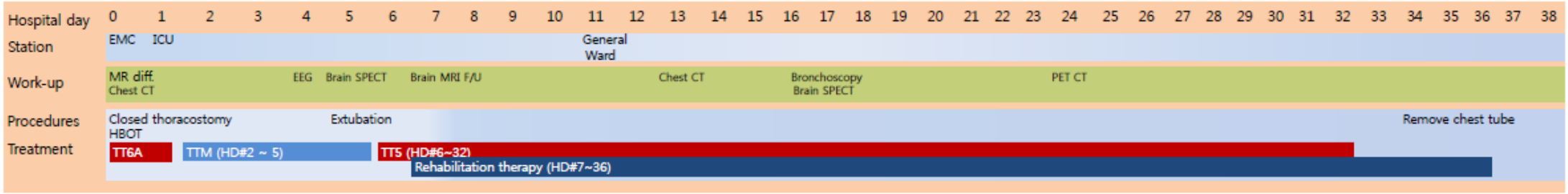


Figure 1. Overview of the hospital course, diagnostic work-up and treatments(HBOT; hyperbaric oxygen therapy, TTM; targeted temperature management).

Figure 1. Initial chest CT scan showing obstruction of left upper lobe bronchus with obstructive pneumonia(arrow) and hemopneumothorax(✻).

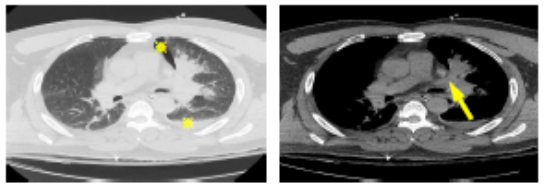
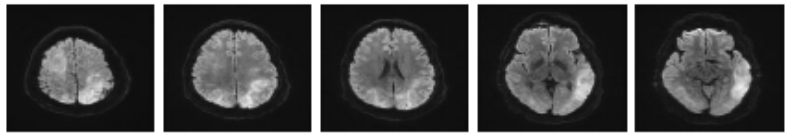


Figure 2. MR diffusions, taken pre-(A) and post-therapeutic hypothermia(B).

(A) Images showing acute infarction in both MCA and PCA territory.



(B) There was no marked swelling, edema and new ischemic infarct(HD#7).

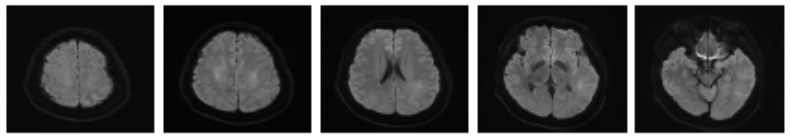
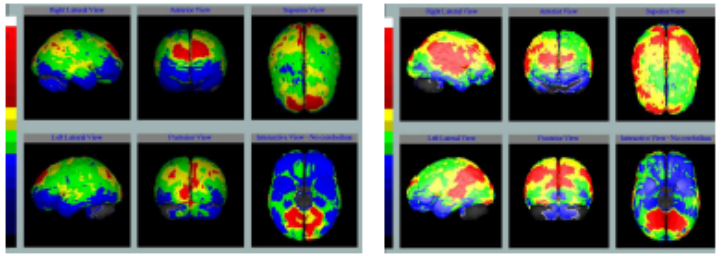
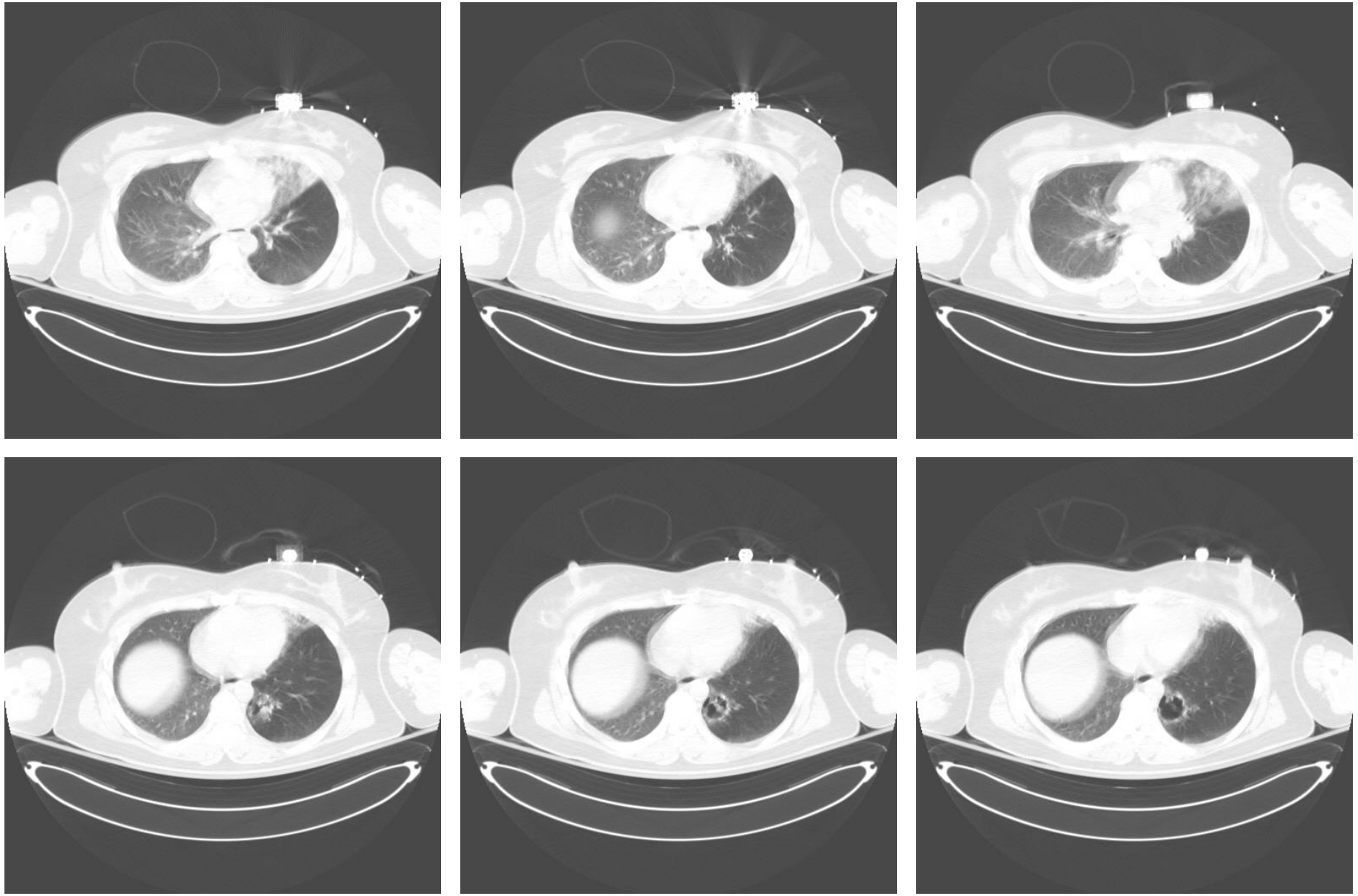


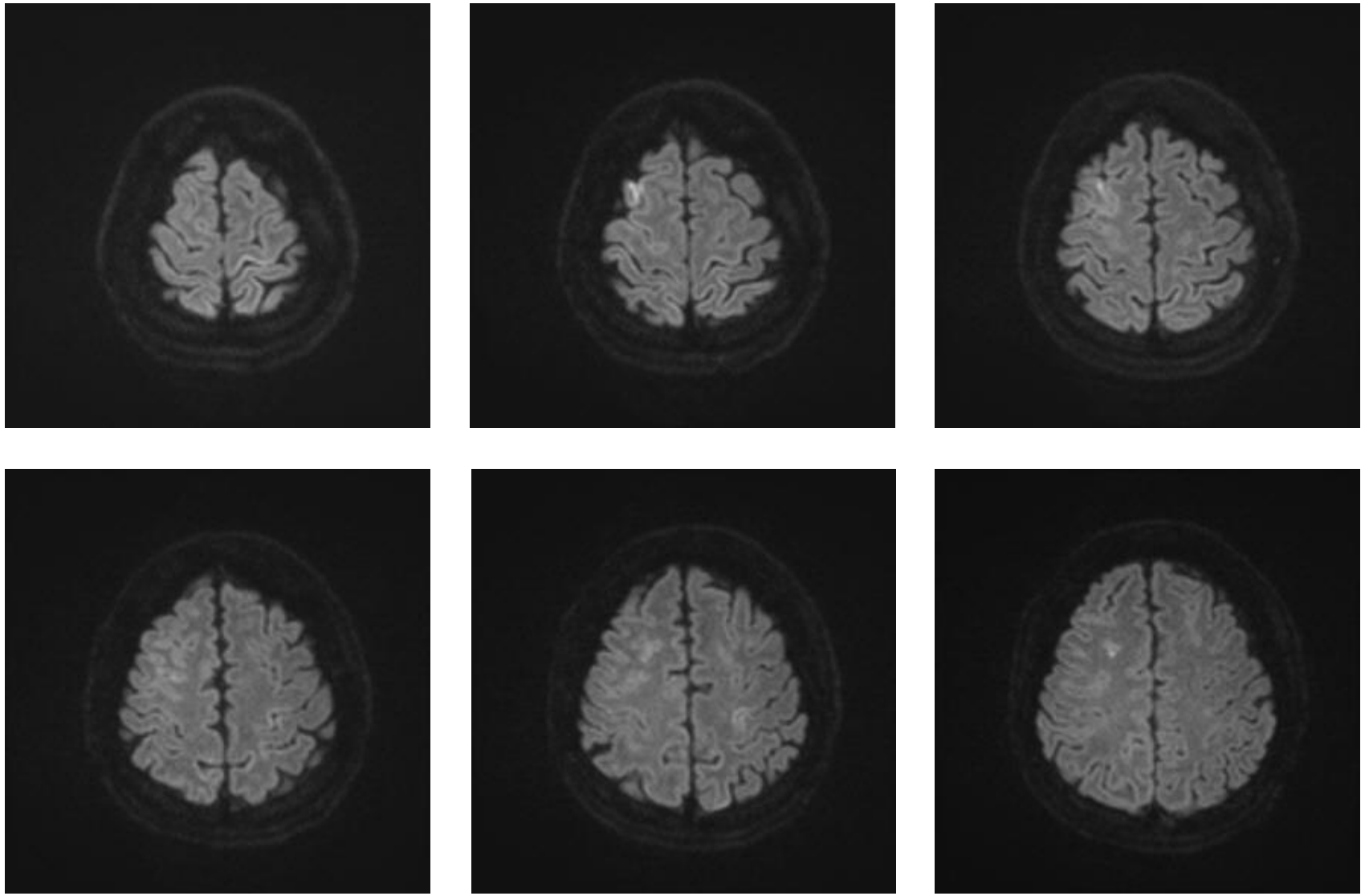
Figure 3. Brain perfusion SPECT images, taken on HD#5(left), showed segmental decreased perfusion in right parieto-occipital region and left upper parietal region. There was much improved segmental decreased perfusion on follow up perfusion SPECT taken on HD#17(right).



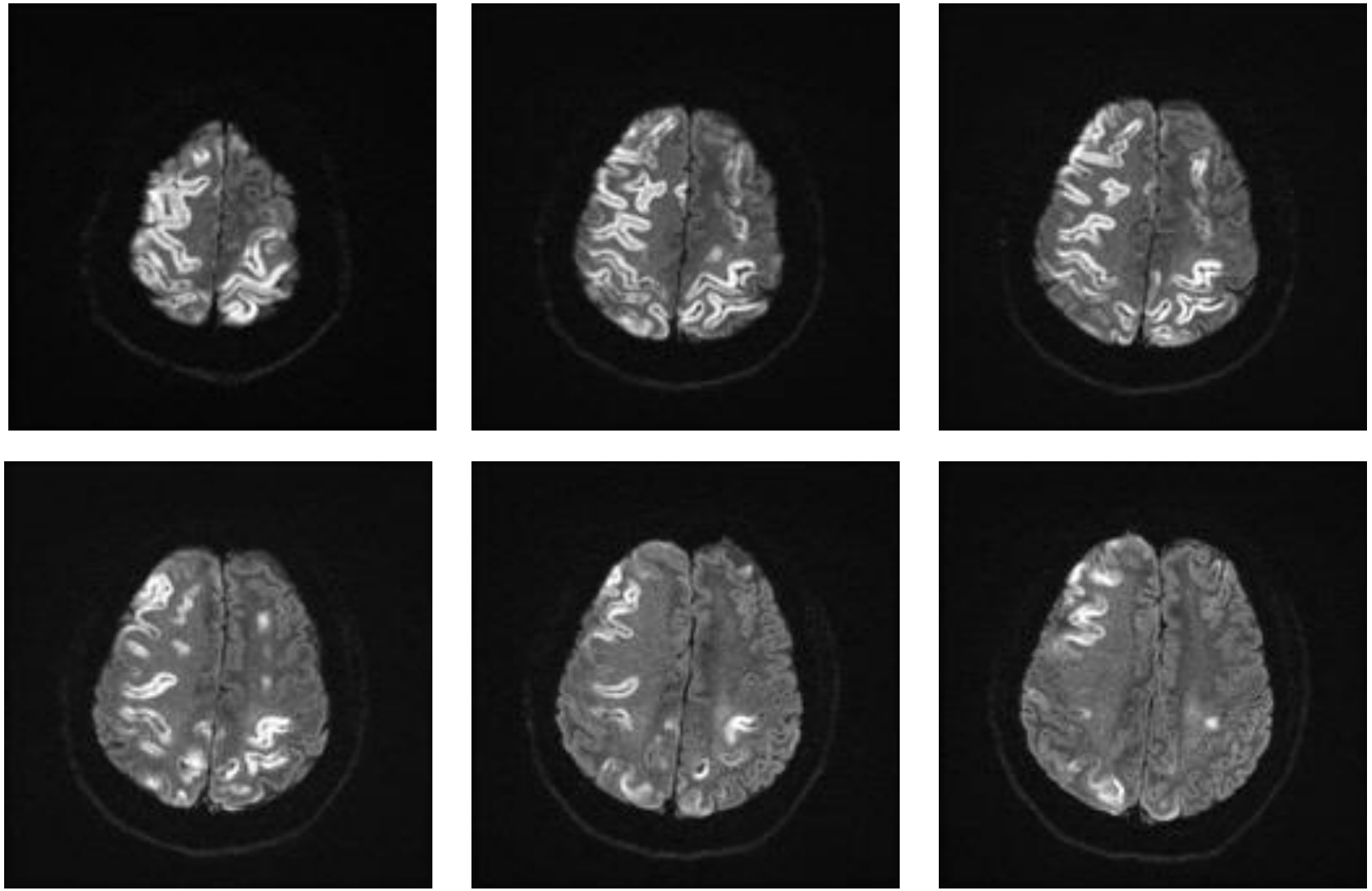
Cerebral DCI(AGE); 41/F



HBOT 직후



5일 뒤



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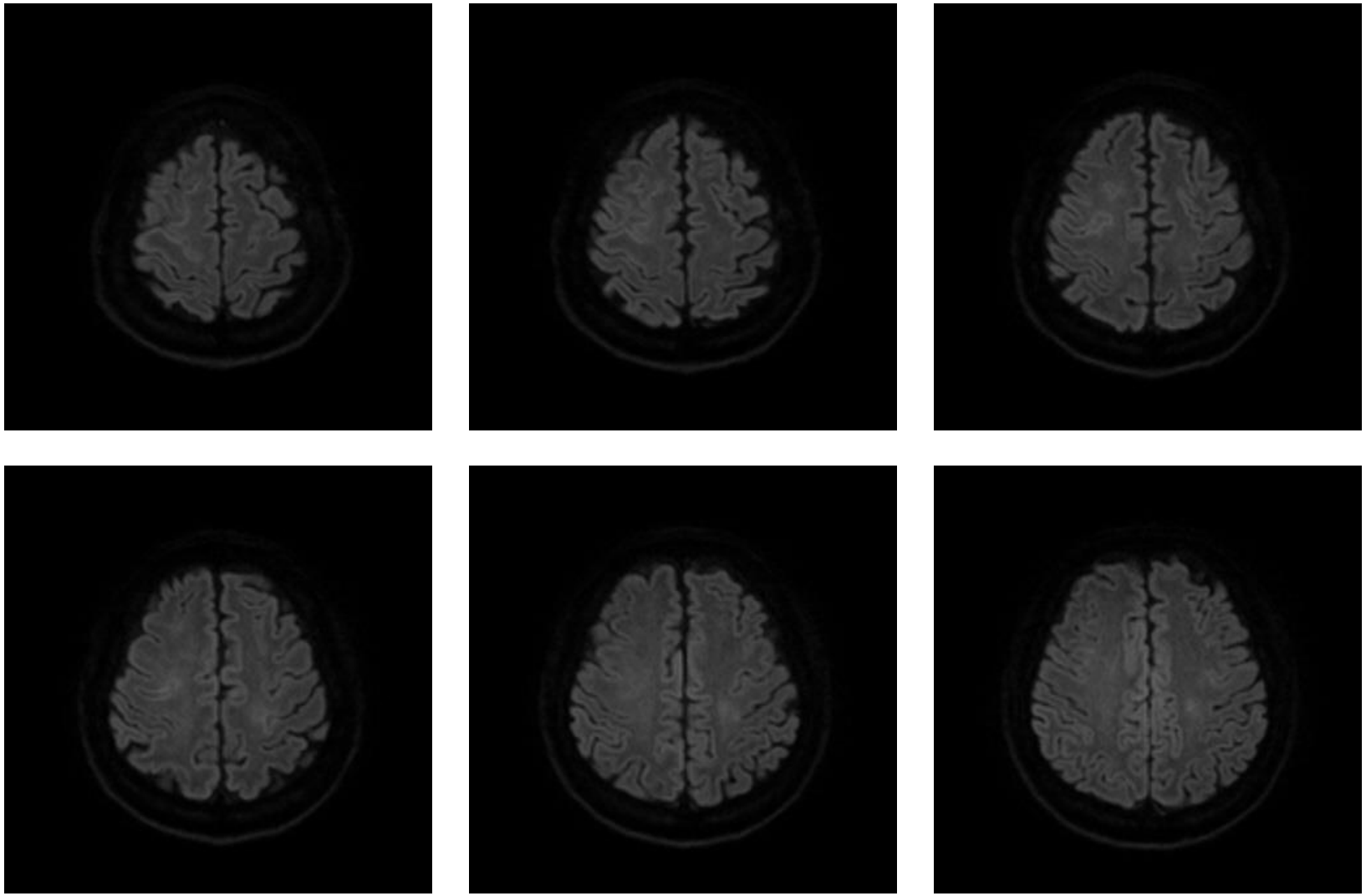

A Case of Decompression Sickness in a Surface-supplied Air Dive Caused by Rapid Ascent after Facial Blunt Trauma Struck by Weight of Ascent Line

Se-Hyun Oh, Hui-Dong Kang, Sang-Koo Jung, Won-Seok Yang, You-Jin Lee

Hyperbaric oxygen treatment center, Department of Emergency Medicine, Gangneung Asan Hospital, Gangneung, Korea

Introduction

Case Presentation

Conclusions

References

INTRODUCTION

- Rapid ascent :
  - most common mechanism leading to injuries or fatalities related to dive
- Causes of rapid ascent ;
  a. Poor buoyancy control
  b. Drysuit/BCD control malfunction/mis-use
  c. Panic / anxiety / rush for surface
  d. Weighting or weight related issues
  e. Equipment problems
  f. Delayed SMB problems
  g. Out of air / gas
  h. Free flows

- We present a rare case of a patient with a decompression sickness developed from a rapid ascent at a depth of 30 meters sea water after facial blunt trauma

Photo. Weight with rope which is used to guide divers ascending and decompression stops (33 × 7cm , 7kg)

Template provided by aPosterBoards

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CASE PRESENTATION

BRIEF HISTORY

- 45-year-old fishermen-diver, harvesting marine products using surface-supplied compressed air dive
- Finishing his work at 30 meters sea water, his forehead struck by weight of ascent line thrown by the tender on the boat.
- His face mask was broken and he blown up to the surface rapidly.
- By the time he drove to a near clinic to treat his forehead wound, he had no symptoms.
- But on arrival at that place, he complained generalized weakness and shortness of breath, and then his mentation changed to drowsy.
- He was transported to our emergency department by 119 fire service.

EXAMINATIONS

- Drowsy mentality, vital sign: BP 103/77 mmHg, PR 72/min, RR 19/min, BT 36.0, SpO2 94 %

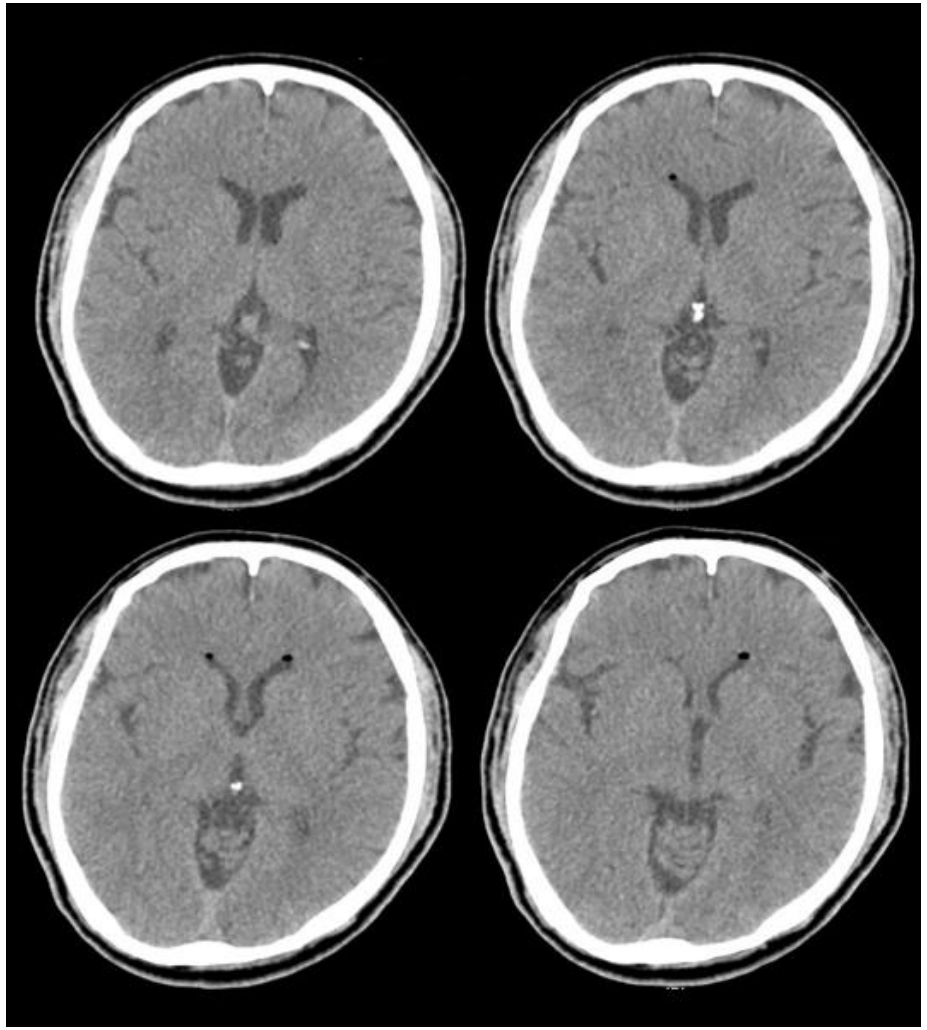
Eyebrow laceration wound

Cutis marmorata on thorax, abdomen and thigh

Template provided by aPosterBoards

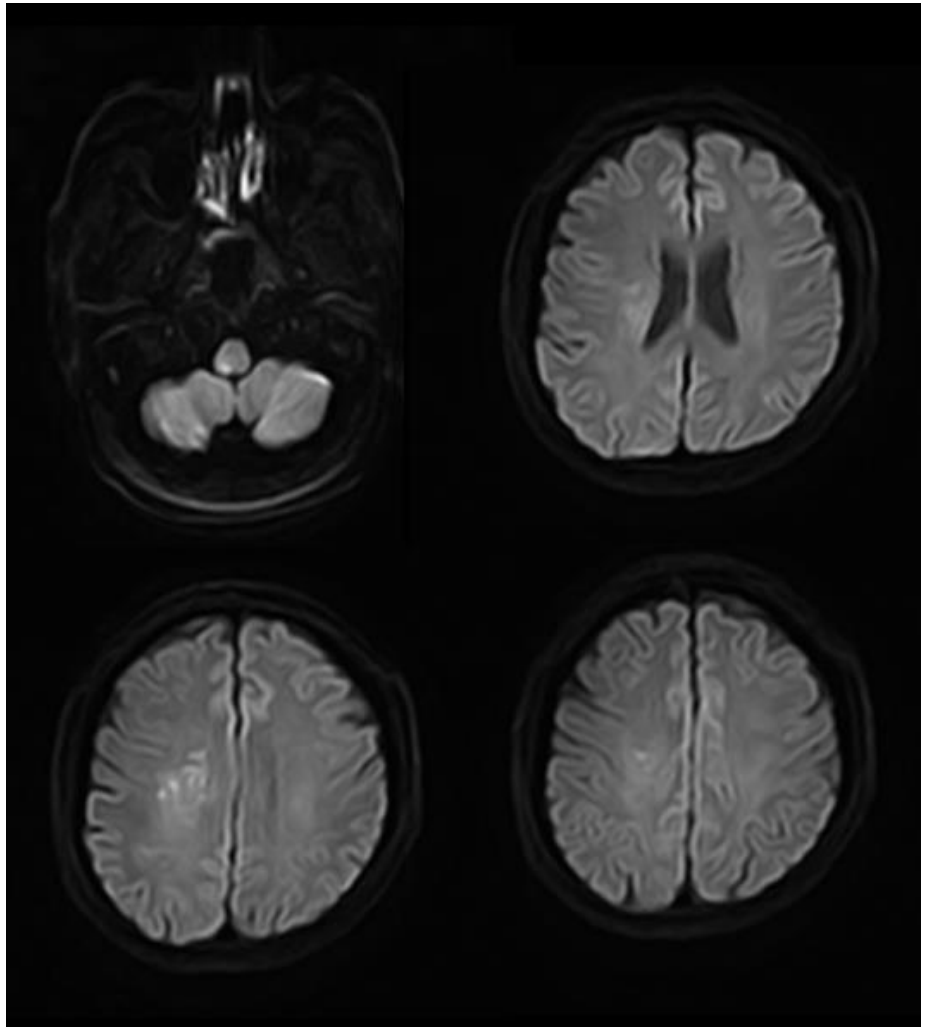
Case

- 58/M, Occupational diver, collapsed after the rapid ascending.
- Syncope, LOC.
- Initial CT presented with bubbles in both lateral ventricles at the regional emergency medical center



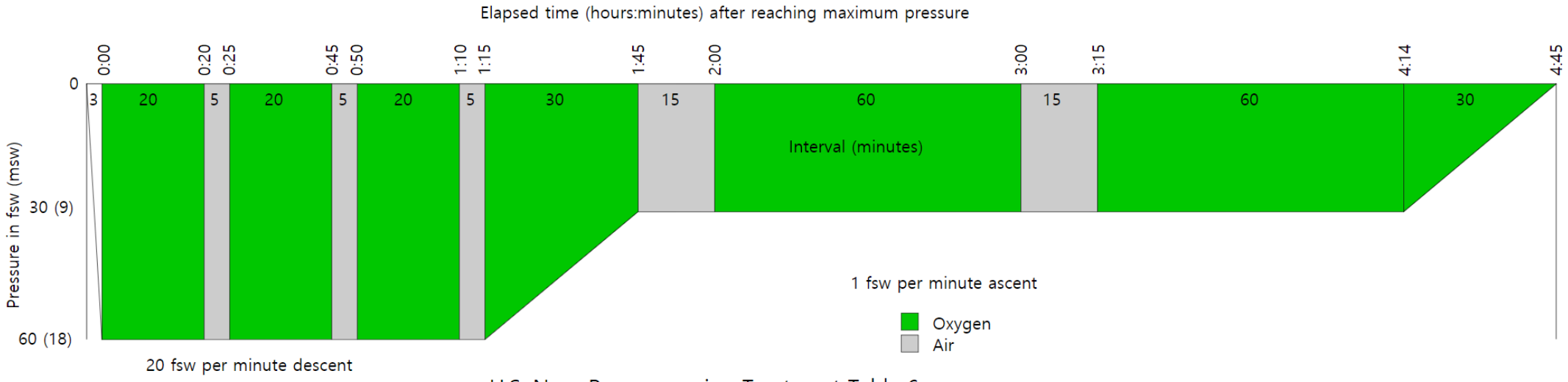
Case

- After 200 min from the symptom, the patient received the first HBOT at 1.5 ATA for 70 min
- After 2 additional sessions of 2.0 ATA for 120 min, the patient was transferred to the HBOT center with the UHMS certified diving physician.
- On arrival, both upper and lower extremities showed motor grade 2 with right shoulder joint pain.
- Brain MRI showed recent infarction in the right medulla and the right mid-cnetrum semiovale.



Case

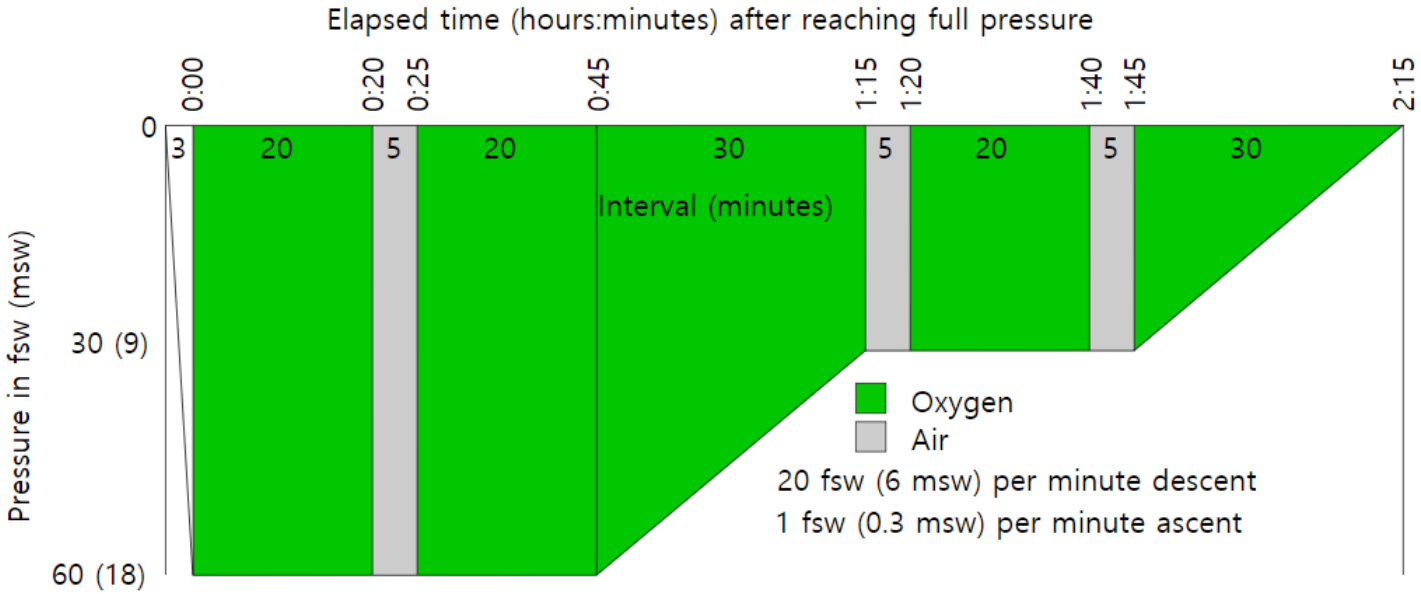
- USN TT6 with extended time was used.
- Additional HBOT with TT6 and TT5 was done.
- On arrival, both upper and lower extremities showed motor grade 2 with right shoulder joint pain.



U.S. Navy Recompression Treatment Table 6

Case

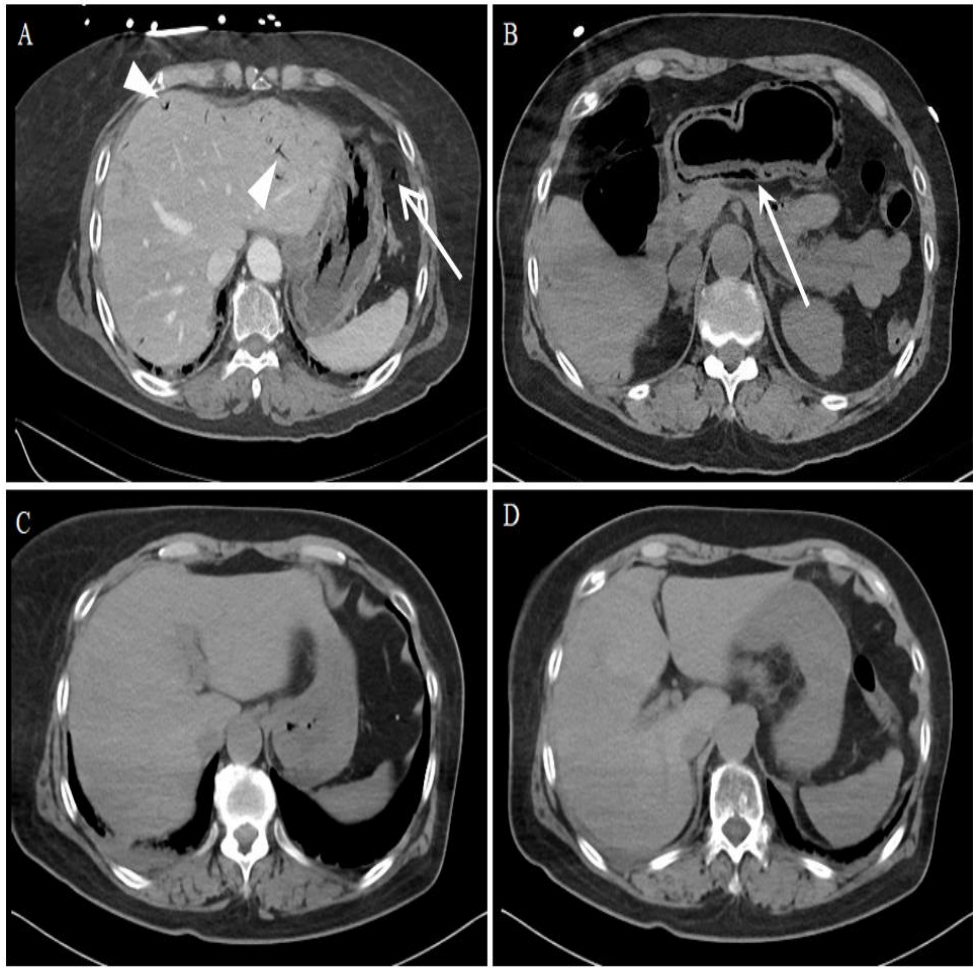
- After 14 treatment sessions of USN TT5, symptom recovery plateaued.
- Continued with rehabilitation for 2 weeks and discharged with a walker ambulation to local hospital for additional rehabilitation.



U.S. Navy Recompression Treatment Table 5

Case

- 69/F, ingested 200cc of H2O2 to relieve arthritis pain.
- Developed throat pain, chest pain, severe abdominal pain, nausea, and vomiting.
- After arrival to local hospital ER, M/S deteriorated to drowsy with hoarseness in voice.
- After the endotracheal intubation, CT scan presented with gas formation in the portal and mesenteric veins. No definite air in Brain CT.



Computed tomography of the abdomen showing gas in the portal (arrow heads) and mesenteric veins (arrow) (A) and gastric wall (B) before hyperbaric oxygen therapy, and computed tomography showing that the gas disappeared after hyperbaric oxygen therapy (C, D)

Case

- USNTT5 done, her abdominal symptom improved and m/s was alert.
- Follow-up CT showed no more gas.
- MRI after 12 hr of ingestion presented with lesion on left inferolateral aspect of the cerebellum.
- Dischaged without any neurological sequalae

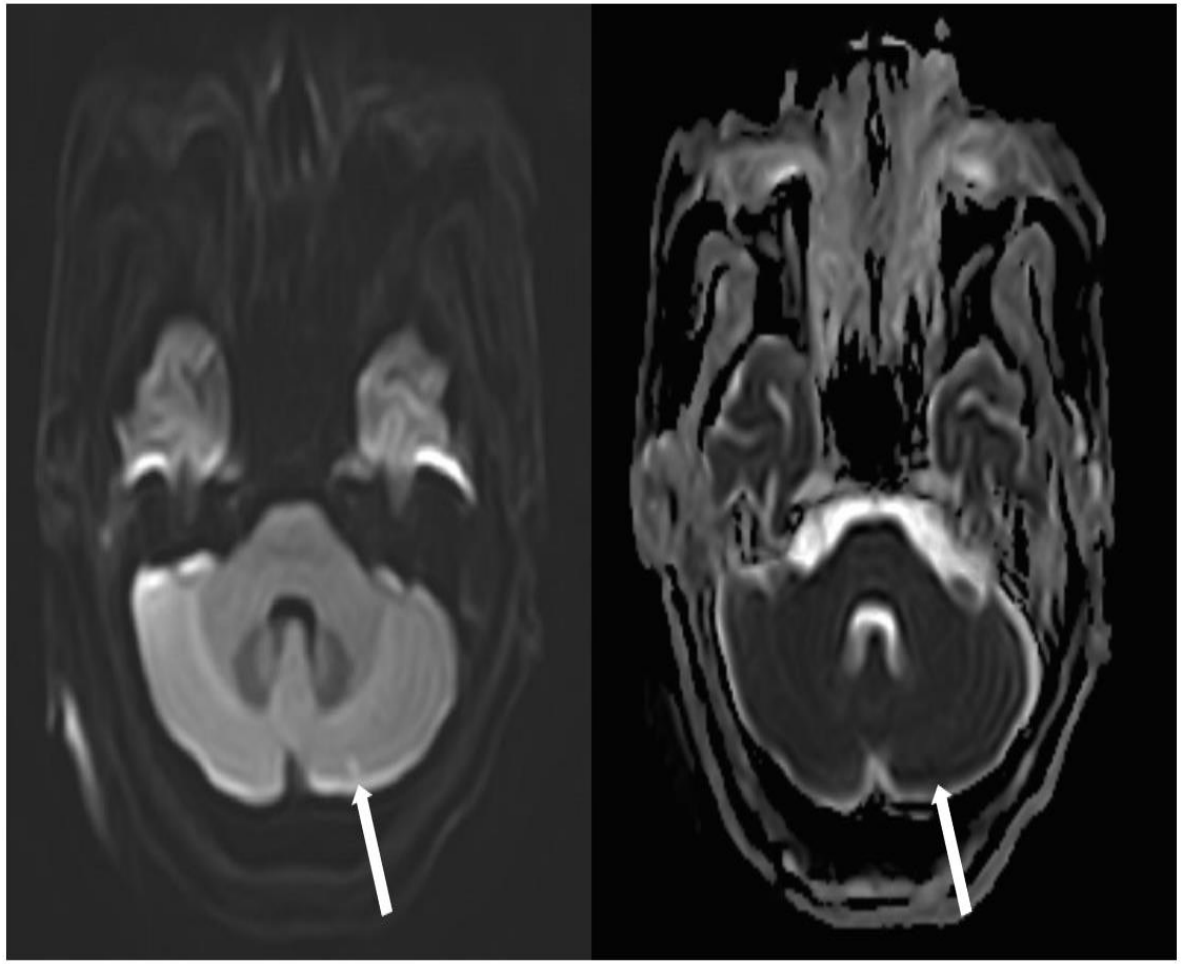


Figure 3. Diffusion-weighted imaging and apparent diffusion coefficient mapping performed after hyperbaric oxygen therapy show acute cytotoxic edema lesions at the left inferolateral aspect of the cerebellum

A Case of Decompression Sickness in a Surface-supplied Air Dive Caused by Rapid Ascent after Facial Blunt Trauma Struck by Weight of Ascent Line

Se-Hyun Oh, Hui-Dong Kang, Sang-Koo Jung, Won-Seok Yang, You-Jin Lee

Hyperbaric oxygen treatment center, Department of Emergency Medicine, Gangneung Asan Hospital, Gangneung, Korea

Introduction

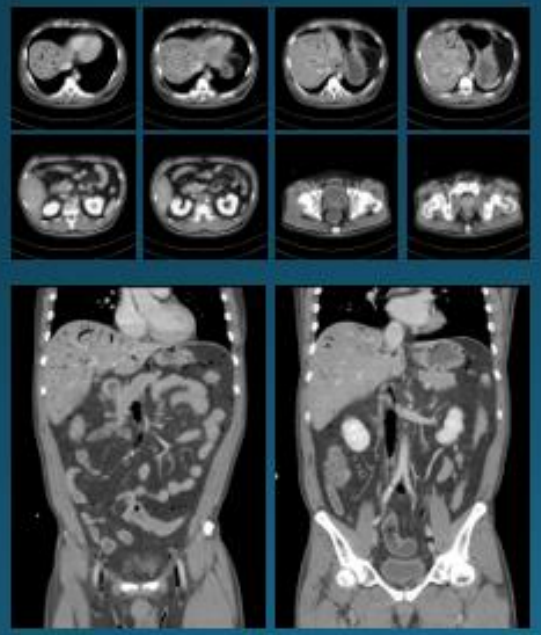
Case Presentation

Conclusions

References

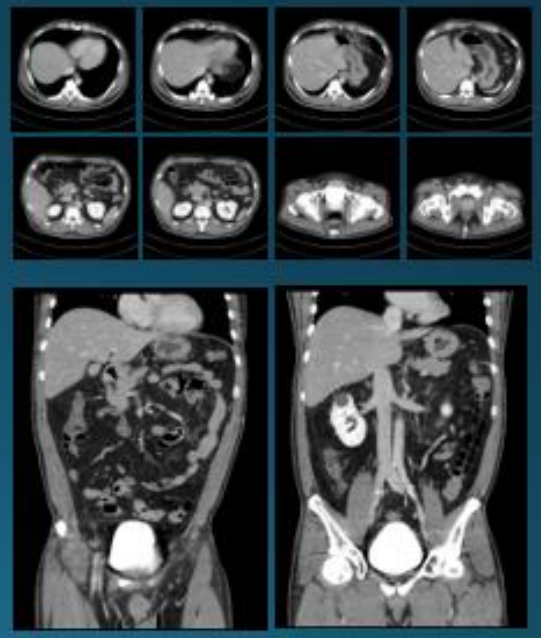
CLINICAL COURSE

- Hyperbaric oxygen therapy(HBOT) was given
- No change in hepatic enzyme
- 4 consecutive sessions of HBOT were given
- He returned his work after 3 weeks later



Pre-treatment abdominopelvic CT scan shows multiple intravascular gas collections along the course of venous systems in the peritoneal cavity

Skin lesion disappeared after one session of hyperbaric oxygen therapy



Follow up CT scan revealed no abnormal gas shadows

Template provided by ePosterBoards

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Conclusions

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CONCLUSIONS

- Rapid ascent is the major cause of decompression sickness(DCS)
- Delayed expression of DCS symptoms should be considered
- This is a rare case of DCS developed from rapid ascent after trauma struck by the weight of ascent line

References

- Trout, B. M., et al. (2015). DAN Annual Diving Report 2012-2015 Edition: A report on 2010-2013 data on diving fatalities, injuries, and incidents. P. Buzzacott. Durham (NC), Divers Alert Network
- Cummings, B. (2015). "The world as it is. British Sub-Aqua Club (BSAC) diving incidents report 2014." Diving Hyperb Med **45**(4): 259-260.
- Bird, N. (2007). "CT finding of VGE in the portal veins and IVC in a diver with abdominal pain: a case report." Undersea Hyperb Med **34**(6): 393-397.
- Vann, R. D., et al. (2011). "Decompression illness." Lancet **377**(9760): 153-164.

Acknowledges

- Thanks to my colleges in hyperbaric oxygen treatment center gathering PHOTOs and VIDEO

Template provided by aPosterBoard

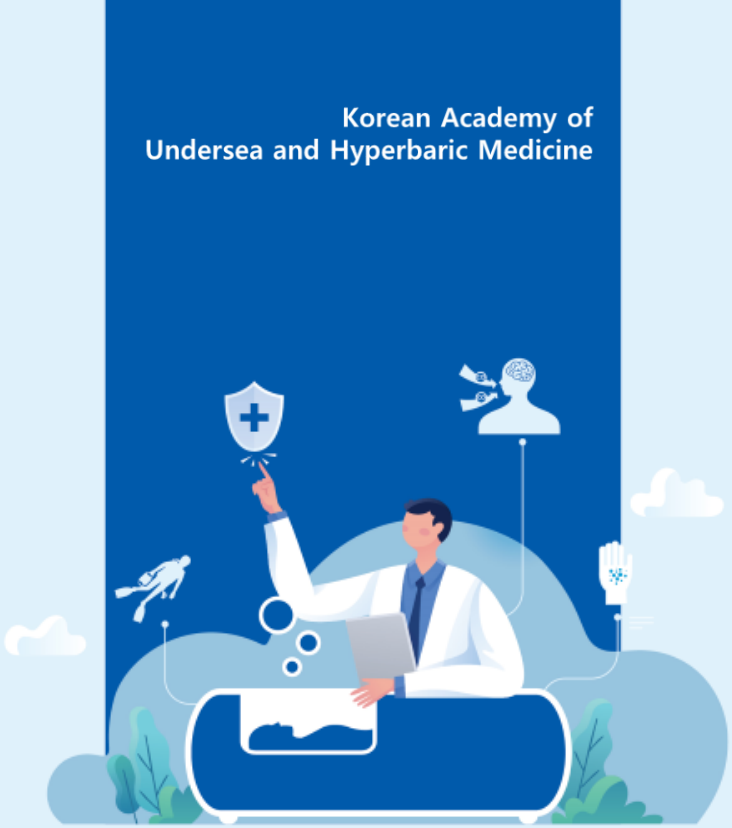
Differential diagnosis of DCI

- Inner-ear barotrauma
- Middle-ear or maxillary sinus over-inflation
- Contaminated diving gas and oxygen toxic effects
- Musculoskeletal strains or trauma sustained before, during, or after diving
- Seafood toxin ingestion (ciguatera, puffer fish, paralytic shellfish poisoning)
- Immersion pulmonary edema
- Water aspiration
- Co-incidental, unrelated acute neurological disorder

Ⅳ

잠수병의 치료

Treatment of DCS



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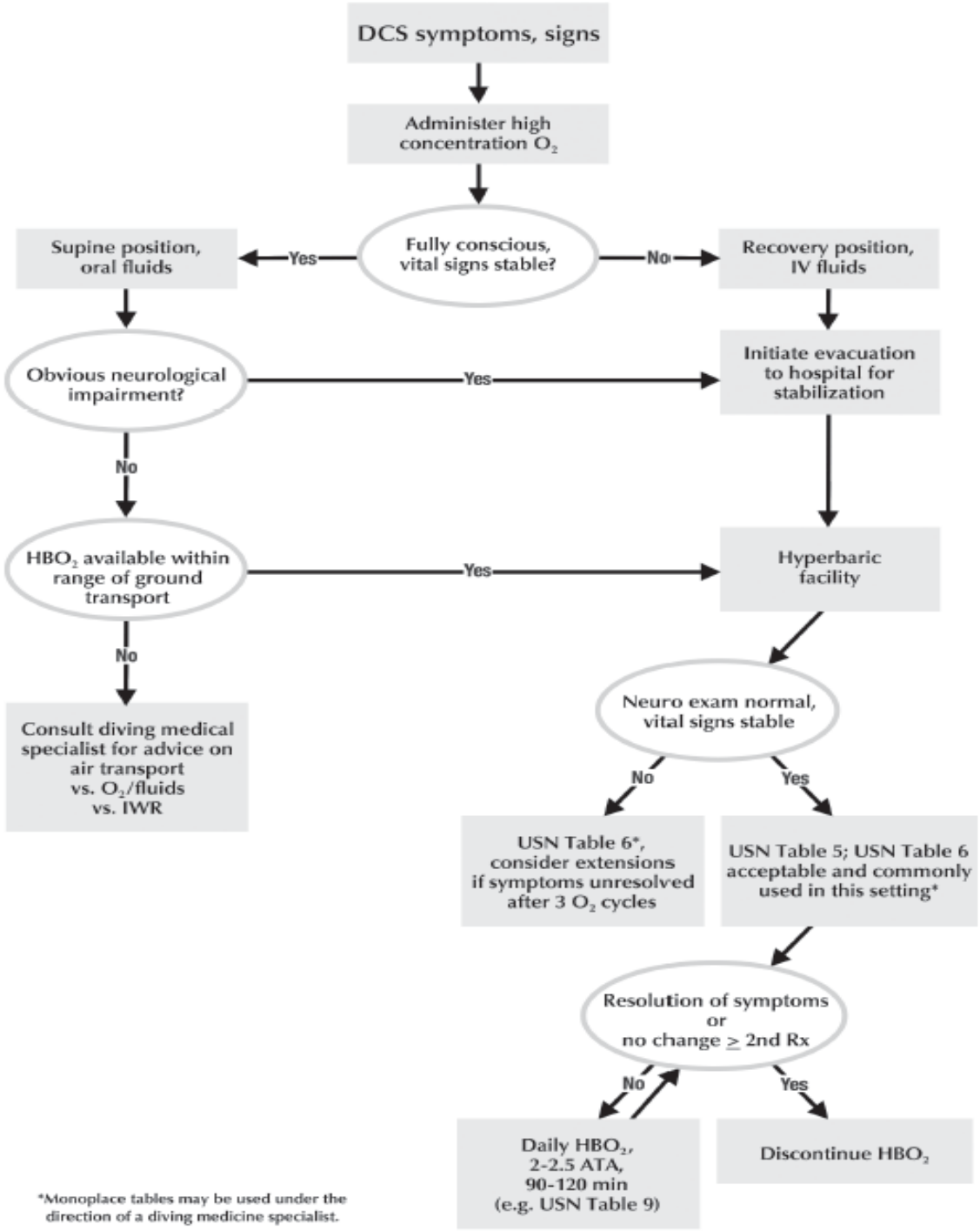
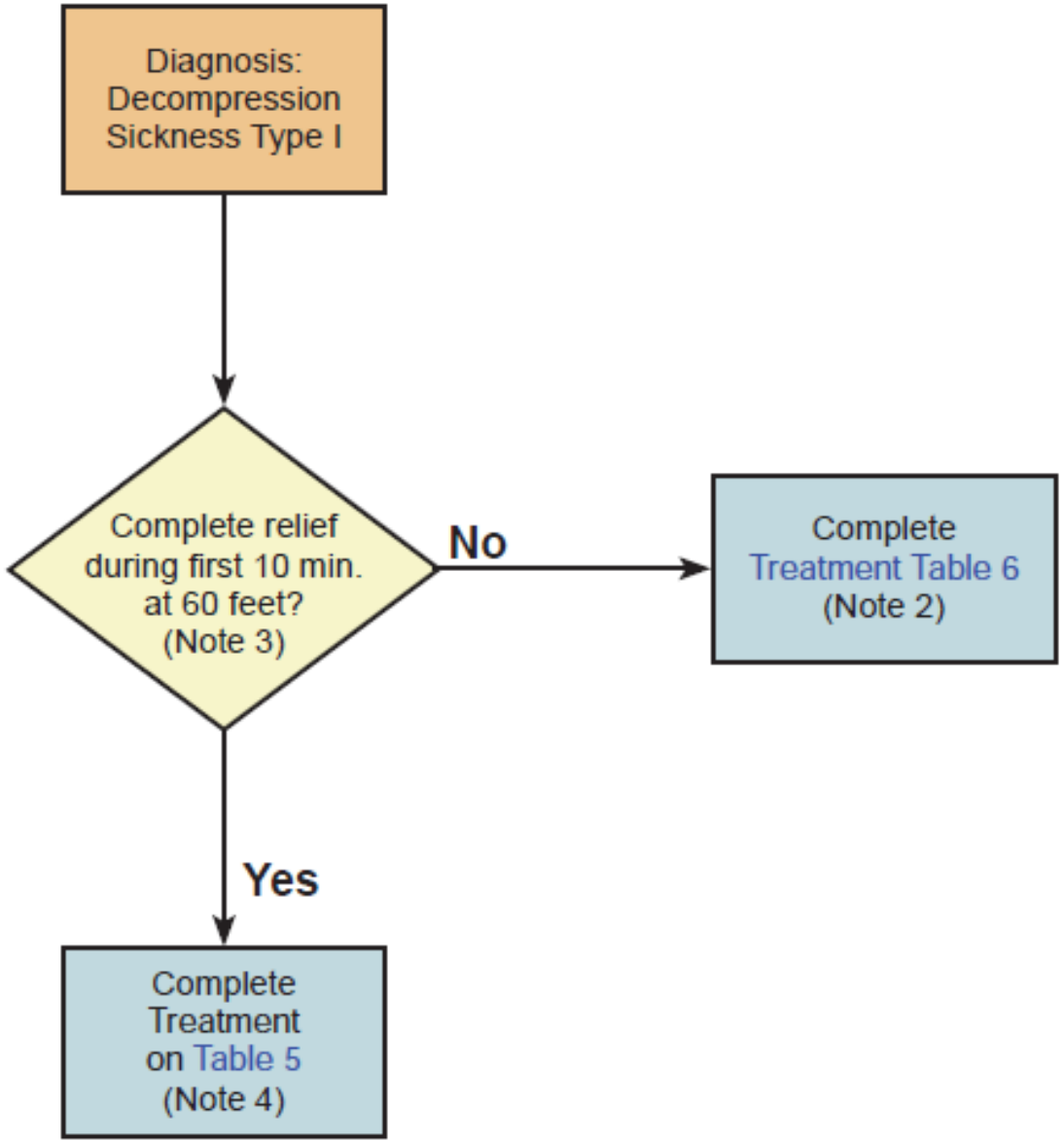
Flowchart for DCS symptoms



Rationale for HBOT

- Immediate reduction in bubble volume
- Increasing the diffusion gradient for inert gas from the bubble into the surrounding tissue
- oxygenation of ischemic tissue
- reduction of CNS edema
- reduction in neutrophil adhesion to the capillary endothelium

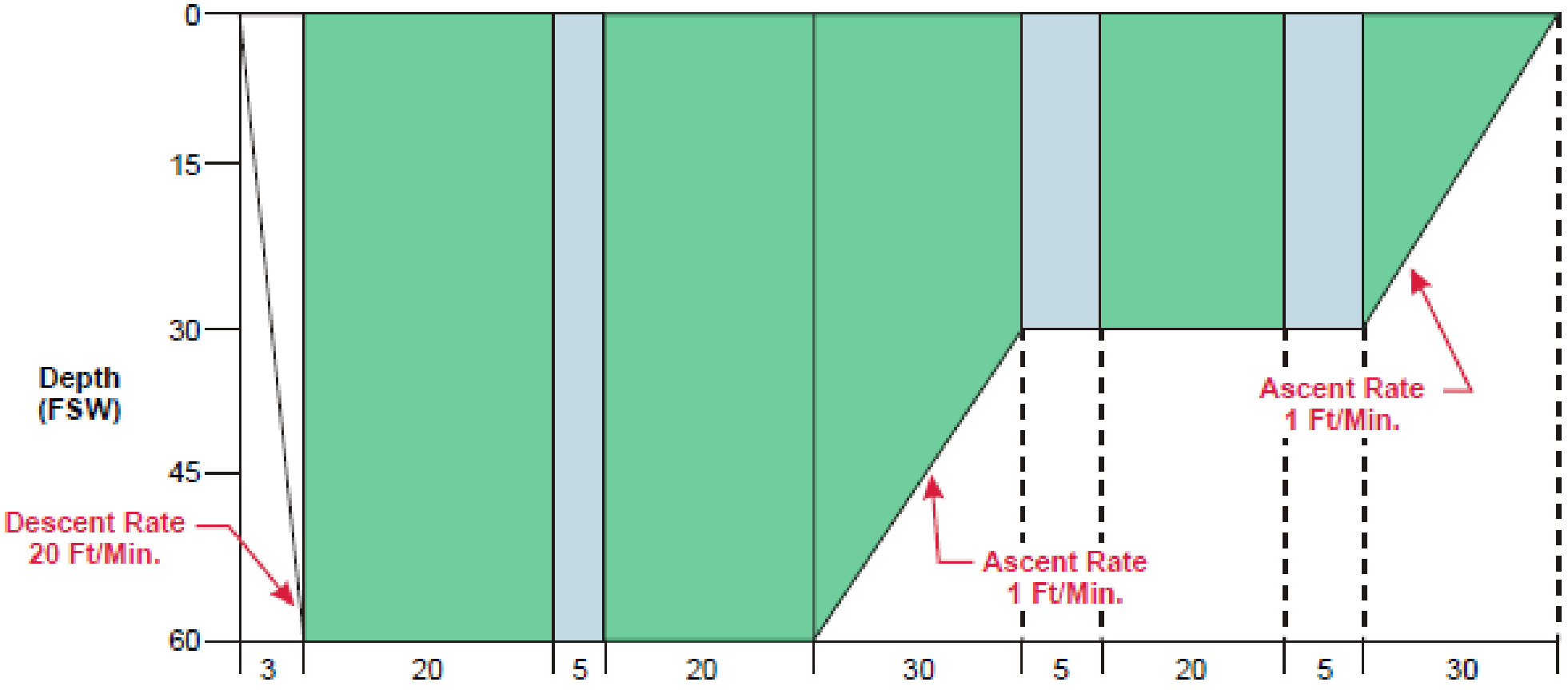
Type I DCS 의 치료



Notes;

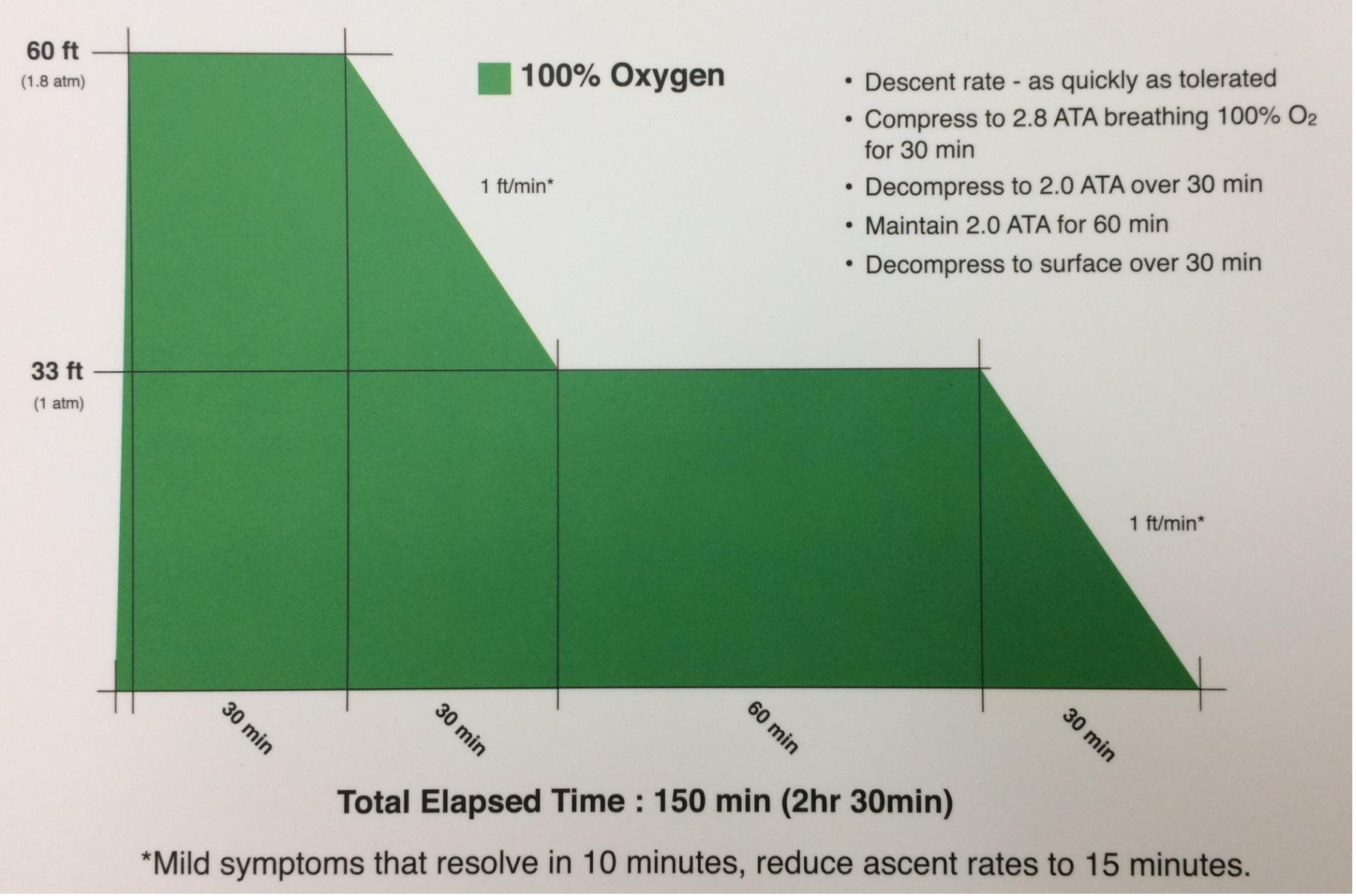
1. If a complete neurological exam was not completed before recompression, treat as a Type II symptom.
2. Treatment Table 6 may be extended up to four additional oxygen-breathing periods, two at 30 feet and/or two at 60 feet.
3. Diving Supervisor may elect to treat on Treatment Table 6.
4. Treatment Table 5 may be extended two oxygen-breathing periods at 30 feet.

US Navy Treatment Table 5



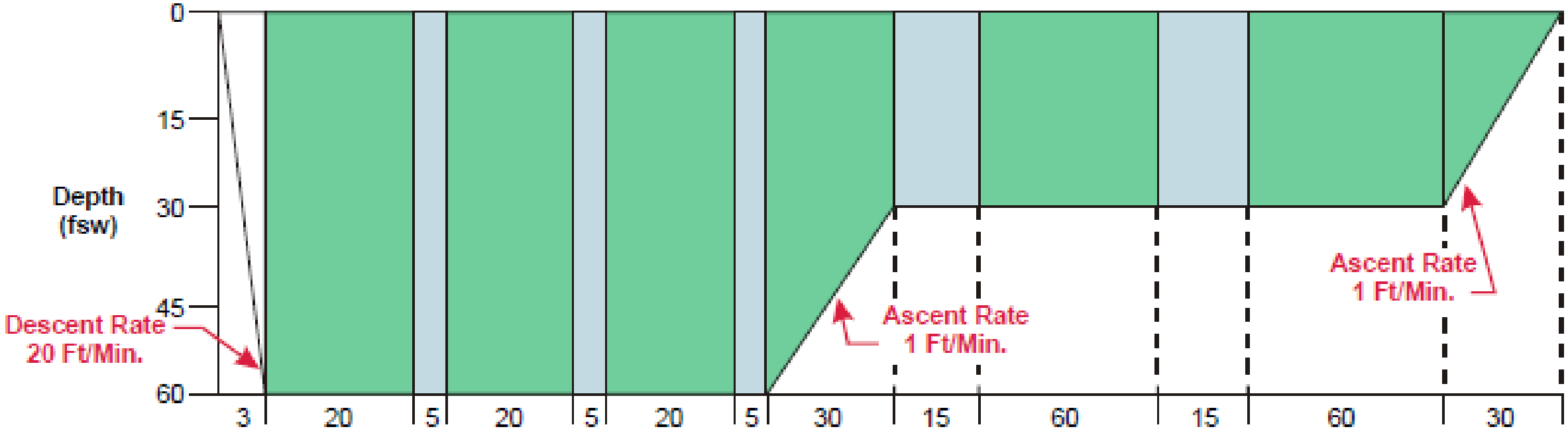
Total Elapsed Time:
135 Minutes
2 Hours 15 Minutes
(Not Including Descent Time)

Hart/Kindwall Treatment Table



- Descent rate - as quickly as tolerated
- Compress to 2.8 ATA breathing 100% O_2 for 30 min
- Decompress to 2.0 ATA over 30 min
- Maintain 2.0 ATA for 60 min
- Decompress to surface over 30 min

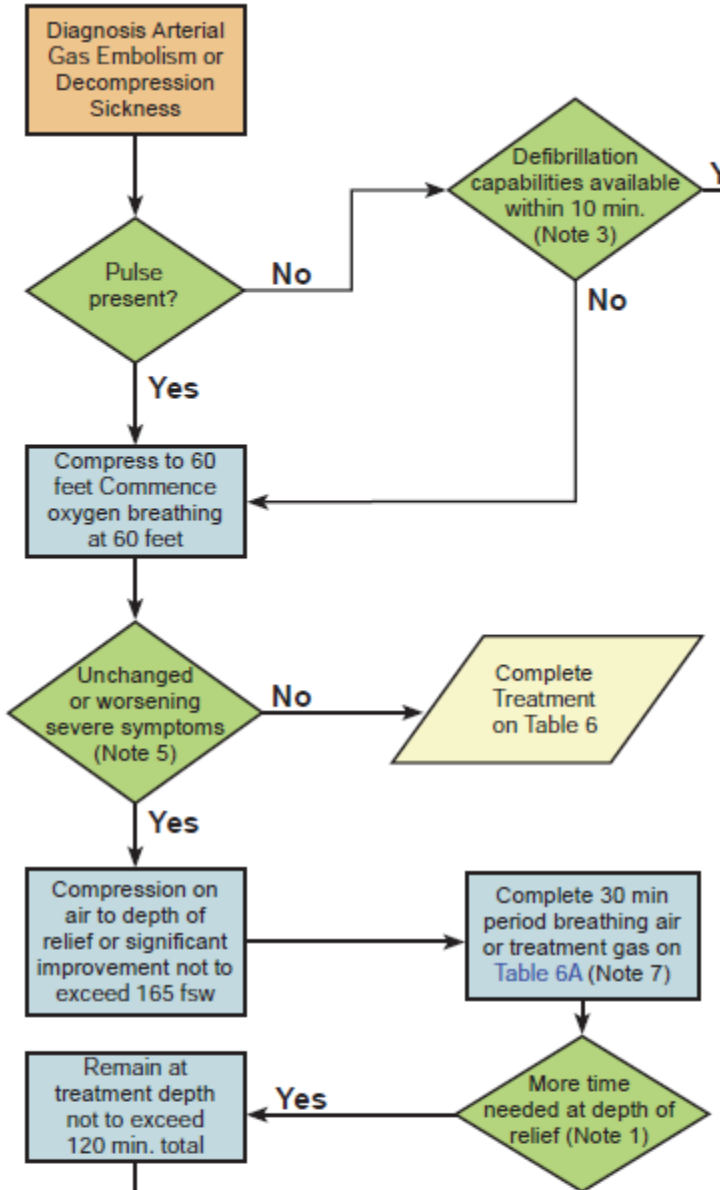
US Navy Treatment Table 6



Time at Depth (minutes)

Total Elapsed Time:
285 Minutes
4 Hours 45 Minutes
(Not Including Descent Time)

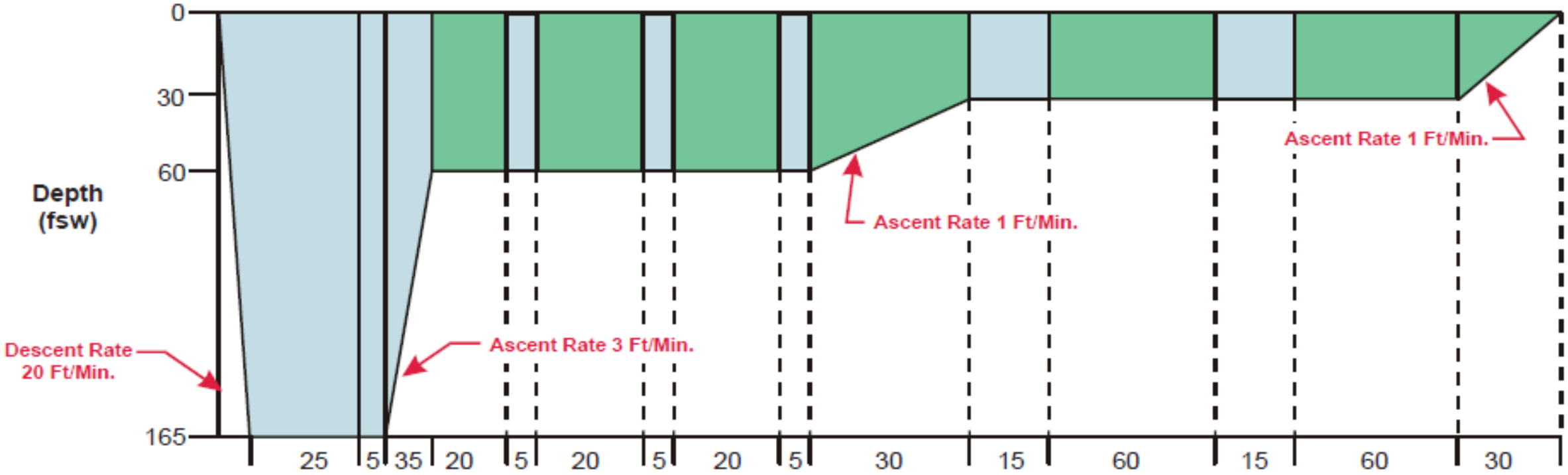
Treatment of AGE or serious DCS



NOTES:

1. A Diving Medical Officer shall be consulted before committing to a Treatment Table 4 or 7.
2. Treatment Table 6A may be extended if necessary at 60 and/or 30 feet.
3. Cardiac arrest requires early defibrillation. For the greatest chance of resuscitation consultation with a Diving Medical Officer is required as soon as possible (see paragraph 20-2.3).
4. Recompression chamber must be surfaced to perform defibrillation.
5. Assessment of patient must be made within 20 minutes. If the stricken diver remains pulseless after 20 minutes, termination of resuscitation may be considered.
6. Additional time may be required according to paragraph 20-5.6.
7. Enter Treatment Table 6A at depth

US Navy Treatment Table 6A



Time at Depth (minutes)

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

Adjunctive therapies for DCS, UHMS guideline

	Condition							
	AGE (no significant inert gas load)		DCS: pain only/mild		DCS: neurological		DCS: chokes (cardiorespiratory)	
	Class	Level	Class	Level	Class	Level	Class	Level
Surface O_2 (1 ATA)	I	C	I	C	I	C	I	C
Intravenous Fluid Therapy	D5W† III LR/crystalloid‡ IIb Colloid‖ IIb	C	D5W† III LR/crystalloid‡ I Colloid‖ I	C	D5W† III LR/crystalloid‡ I Colloid‖ I	C	D5W† III LR/crystalloid‡ IIb Colloid‖ IIb	C
Aspirin	IIb	C	IIb	C	IIb	C	IIb	C
NSAIDs	IIb	C	IIb	B	IIb	B	IIb	C
Anti-coagulants*	IIb	C	III	C	IIb§	C	IIb	C
Cortico-steroids	III	C	III	C	III	C	III	C
Lidocaine	IIa	B	III	C	IIb	C	III	C

If no chamber?

- Transport to nearest chamber vs in-water recompression
- 100% O_2, hydration, supine (not Trendelenberg)
- Unpressurized aircraft < 1000ft

Timing of treatment

- The sooner the treatment initiated, the better the outcome
- Cases of improvement have occurred even after about a week following the pressure exposure

No Flight After Diving

- Patients treated for DCS or AGE: 72 hours
- Tenders on Treatment Table 5,6,6A: 24 hours

Returning to Diving after Accident

- Type I DCS:
  - 7 days after successful completion of HBOT
- AGE or type II DCS:
  - 30 days after initial diagnosis and treatment

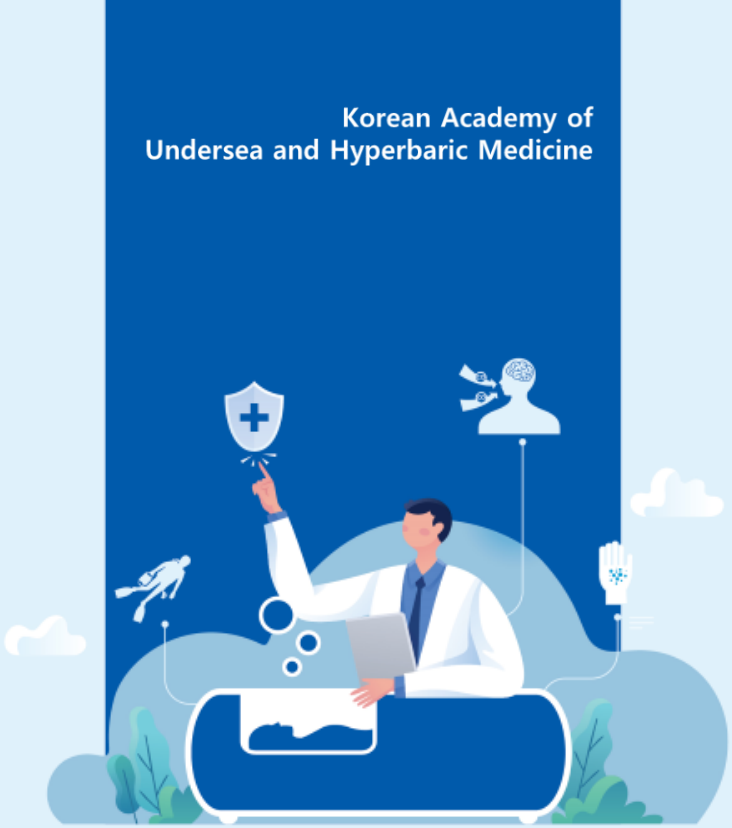
Returning to Diving after Accident

- Limb pain, cutaneous(skin rash with severe itching), lymphatic(swelling of tissues) or non-specific(persistent headache, excessive fatigue, loss of appetite, nausea) manifestations only;
  - With uncomplicated recovery: 24 hours
  - Where there has been a recurrence or relapse requiring further recompression: 7 days
- Neurological or pulmonary manifestations:
  - Altered sensation involving the limbs only: 7 days
  - Other neurological(including audiovestibular) or pulmonary manifestations: 28 days

V

감압표

Decompression Table



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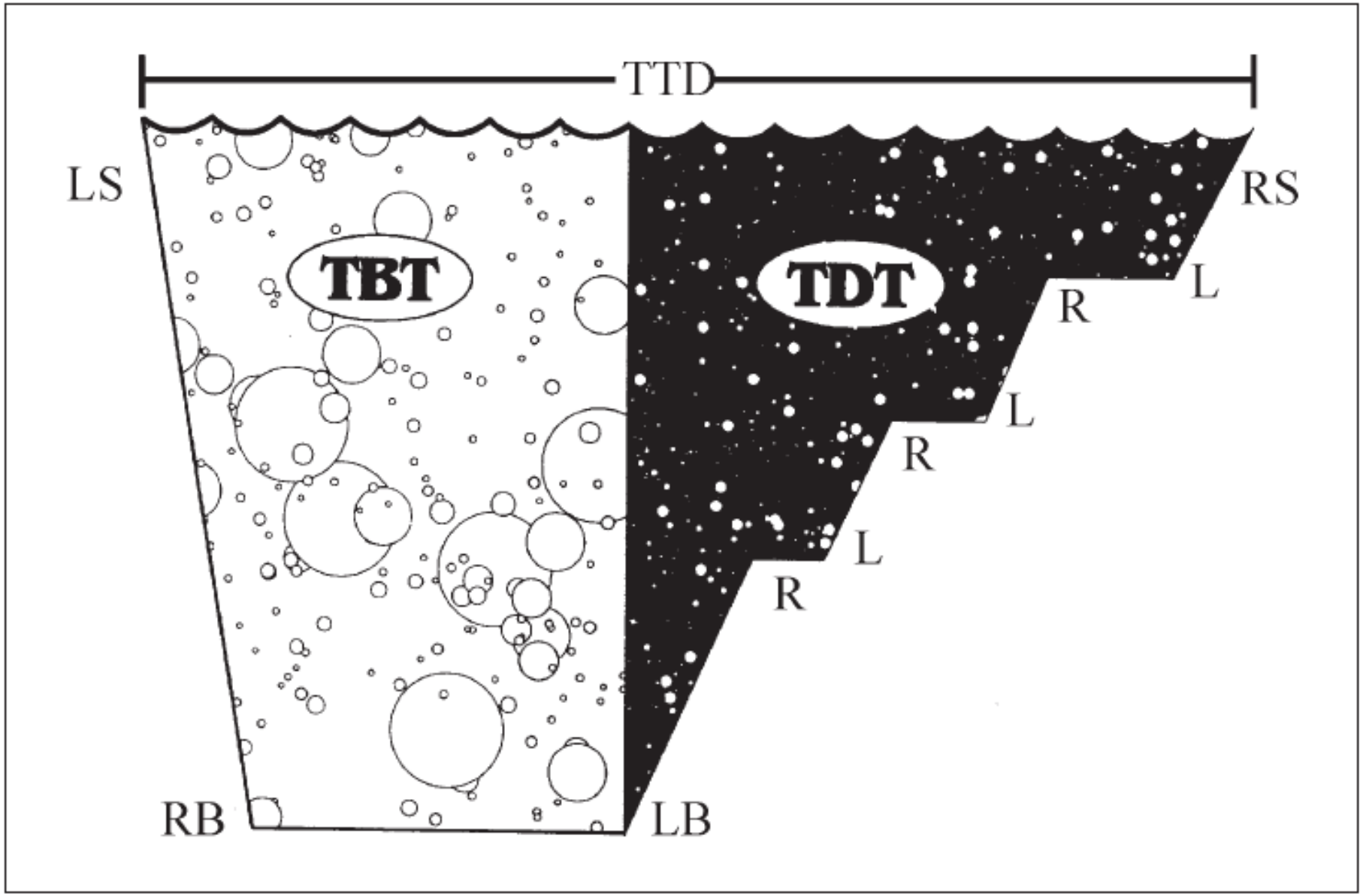
Dive profile



L: left
R: reached

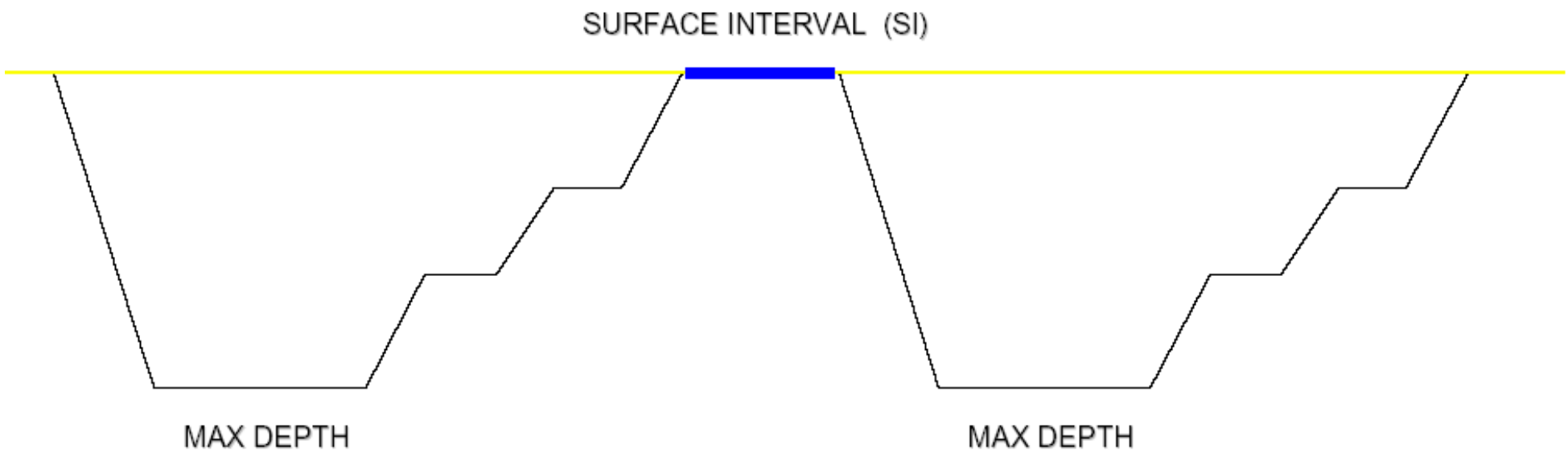
S: surface
B: bottom

TBT: total bottom time
TDT: total decom.time
TTD: total time of diving

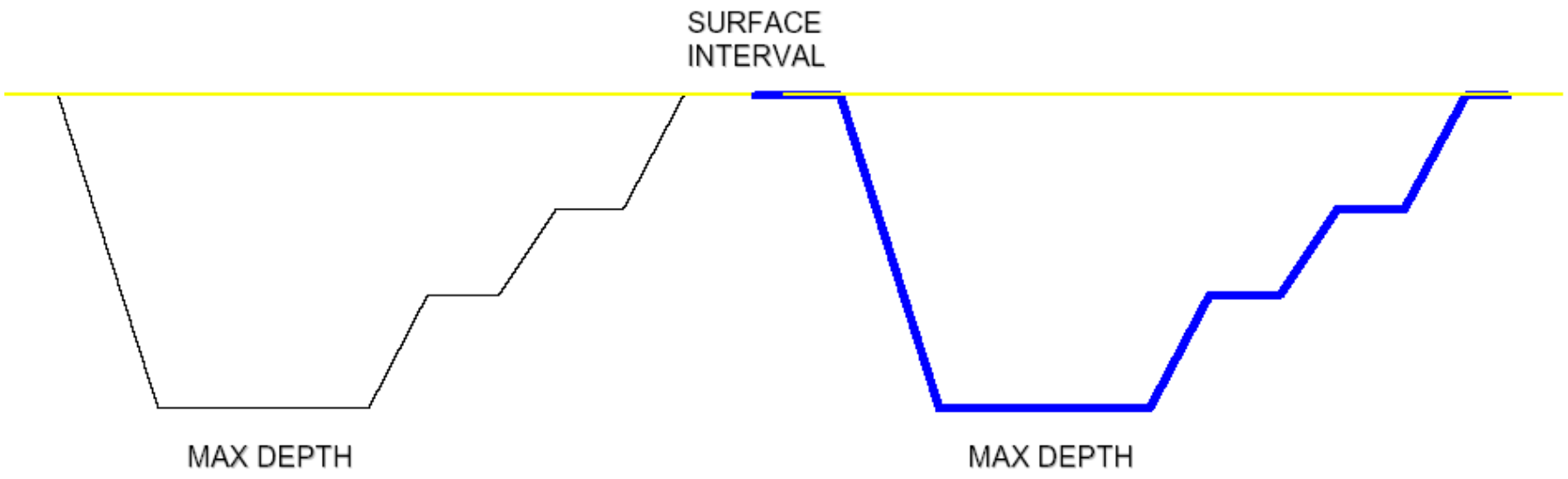
용어

- 일회잠수: 체내 잔여질소가 없는 상태에서의 잠수
- 반복잠수: 이전 잠수로 인하여 체내 잔여질소가 남아있는 상태에서의 잠수
- 표면간격(Surface Interval): 반복잠수 시 이전잠수와 다음잠수 사이 간격
- 비감압한계: 주어진 수심에서 감압정지가 필요없는 최대허용한계
- 잔여질소시간: 이전잠수로 체내에 남아있는 질소를 감안하여 반복잠수시 해저체류시간에 포함시키는 시간

표면간격(Surface Interval)



반복잠수(Repetitive Dive)

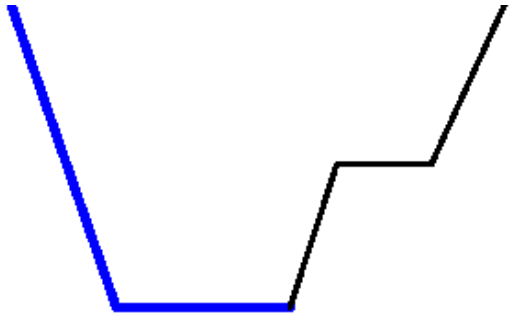


Equivalent Single Dive Time(ESDT)

이전 잠수의 잔여질소시간과 다음 잠수의 실제 해저체류시간의 합

Diver

Repeat Dive



	RNT	+	TBT	=	ESDT
i.e.	5 MIN	+	8 MIN	=	13 MIN ESDT

비감압한계표

Depth (fsw)	No-Stop Limit	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	Unlimited	57	101	158	245	426	*										
15	Unlimited	36	60	88	121	163	217	297	449	*							
20	Unlimited	26	43	61	82	106	133	165	205	256	330	461	*				
25	1102	20	33	47	62	78	97	117	140	166	198	236	285	354	469	992	1102
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			
55	74	8	14	19	25	31	37	43	50	56	63	71	74				
60	63	7	12	17	22	28	33	39	45	51	57	63					
70	48	6	10	14	19	23	28	32	37	42	47	48					
80	39	5	9	12	16	20	24	28	32	36	39						
90	33	4	7	11	14	17	21	24	28	31	33						
100	25	4	6	9	12	15	18	21	25								
110	20	3	6	8	11	14	16	19	20								
120	15	3	5	7	10	12	15										
130	12	2	4	6	9	11	12										
140	10	2	4	6	8	10											
150	8		3	5	7	8											
160	7		3	5	6	7											
170	6			4	6												
180	6			4	5	6											
190	5			3	5												

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval

A															:10	2:20 *
B														:10	1:16	1:17 / 3:36 *
C													:10 / :55	:56 / 2:11	2:12 / 4:31 *	
D												:10 / :52	:53 / 1:47	1:48 / 3:03	3:04 / 5:23 *	
E											:10 / :52	:53 / 1:44	1:45 / 2:39	2:40 / 3:55	3:56 / 6:15 *	
F										:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:31	3:32 / 4:48	4:49 / 7:08 *	
G									:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:23	4:24 / 5:40	5:41 / 8:00 *	
H								:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:16	5:17 / 6:32	6:33 / 8:52 *	
I							:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:08	6:09 / 7:24	7:25 / 9:44 *	
J						:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 7:00	7:01 / 8:16	8:17 / 10:36 *	
K					:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:52	7:53 / 9:09	9:10 / 11:29 *	
L					:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:50	7:51 / 8:44	8:45 / 10:01	10:02 / 12:21 *
M				:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:50	7:51 / 8:42	8:43 / 9:37	9:38 / 10:53	10:54 / 13:13 *
N			:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:50	7:51 / 8:42	8:43 / 9:34	9:35 / 10:29	10:30 / 11:45	11:46 / 14:05 *
O		:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:50	7:51 / 8:42	8:43 / 9:34	9:35 / 10:27	10:28 / 11:21	11:22 / 12:37	12:38 / 14:58 *
Z	:10 / :52	:53 / 1:44	1:45 / 2:37	2:38 / 3:29	3:30 / 4:21	4:22 / 5:13	5:14 / 6:06	6:07 / 6:58	6:59 / 7:50	7:51 / 8:42	8:43 / 9:34	9:35 / 10:27	10:28 / 11:19	11:20 / 12:13	12:14 / 13:30	13:31 / 15:50 *

Repetitive Group at the End of the Surface Interval

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
10	**	**	**	**	**	**	**	**	**	**	**	427	246	159	101	58
15	**	**	**	**	**	**	**	**	450	298	218	164	122	89	61	37
20	**	**	**	**	**	462	331	257	206	166	134	106	83	62	44	27
25	†	†	470	354	286	237	198	167	141	118	98	79	63	48	34	21
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11
55	114	105	96	88	80	72	65	58	51	44	38	32	26	20	15	10
60	101	93	86	79	72	65	58	52	46	40	35	29	24	19	14	9
70	83	77	71	65	59	54	49	44	39	34	29	25	20	16	12	8
80	70	65	60	55	51	46	42	38	33	29	25	22	18	14	10	7
90	61	57	52	48	44	41	37	33	29	26	22	19	16	12	9	6
100	54	50	47	43	40	36	33	30	26	23	20	17	14	11	8	5
110	48	45	42	39	36	33	30	27	24	21	18	16	13	10	8	5
120	44	41	38	35	32	30	27	24	22	19	17	14	12	9	7	5
130	40	37	35	32	30	27	25	22	20	18	15	13	11	9	6	4
140	37	34	32	30	27	25	23	21	19	16	14	12	10	8	6	4
150	34	32	30	28	26	23	21	19	17	15	13	11	9	8	6	4
160	32	30	28	26	24	22	20	18	16	14	13	11	9	7	5	4
170	30	28	26	24	22	21	19	17	15	14	12	10	8	7	5	3
180	28	26	25	23	21	19	18	16	14	13	11	10	8	6	5	3
190	26	25	23	22	20	18	17	15	14	12	11	9	8	6	5	3

Residual Nitrogen Times (Minutes)

NOAA AIR DIVING TABLE

WARNING: EVEN STRICT COMPLIANCE WITH THESE CHARTS WILL NOT GUARANTEE AVOIDANCE OF DECOMPRESSION SICKNESS. CONSERVATIVE USAGE IS STRONGLY RECOMMENDED.

RNT RESIDUAL NITROGEN TIME
+ ABT ACTUAL BOTTOM TIME
ESDT EQUIVALENT SINGLE DIVE TIME

(USE ESDT TO DETERMINE END-OF-DIVE LETTER GROUP)

THESE CHARTS ARE BASED ON THE U.S. NAVY AIR DECOMPRESSION TABLES 7, 8, & 9 REV. 6

CHART 1 — DIVE TIMES WITH END-OF-DIVE GROUP LETTER

00 MAXIMUM NO-STOP TIME

DIVE TIME REQUIRING DECOMPRESSION STOP MINUTES REQUIRED AT 20 fsw (6.1 msw) — 00 / 00

DEPTH msw	DEPTH fsw	00															
12.3	40	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	180 / 14
13.8	45	11	17	24	31	39	46	55	63	72	82	92	102	114	125	130 / 2	150 / 25
15.3	50	9	15	21	28	34	41	48	56	63	71	80	89	92	100 / 4	110 / 8	130 / 34
16.9	55	8	14	19	25	31	37	43	50	56	63	71	74	80 / 4	90 / 10	100 / 17	
18.4	60	7	12	17	22	28	33	39	45	51	57	60	65 / 2		80 / 14	90 / 23	
21.4	70	6	10	14	19	23	28	32	37	42	47	48	55 / 9	60 / 14	70 / 24		
24.5	80	5	9	12	16	20	24	28	32	36	39	45 / 10		50 / 17	60 / 30		
27.6	90	4	7	11	14	17	21	24	28	30	35 / 4		40 / 14	45 / 23			
30.6	100	4	6	9	12	15	18	21	25		30 / 3		35 / 15	40 / 26			
33.7	110	3	6	8	11	14	16	19	20	25 / 3		30 / 14		35 / 27			
36.8	120	3	5	7	10	12	15		20 / 2		25 / 8		30 / 24				
39.8	130	2	4	6	9	10		15 / 1		20 / 4		25 / 17					

CHART 3 — REPETITIVE DIVE TIME

REPETITIVE DIVES SHALLOWER THAN 40 FSW (12.3 MSW) ARE TO USE THE 40 FSW (12.3 MSW) REPETITIVE SCHEDULE

fsw / msw	40 / 12.3	45 / 13.8	50 / 15.3	55 / 16.9	60 / 18.4	70 / 21.4	80 / 24.5	90 / 27.6	100 / 30.6	110 / 33.7	120 / 36.8	130 / 39.8	GROUP LETTER
	13 / 150	12 / 113	11 / 81	10 / 64	9 / 51	8 / 40	7 / 32	6 / 24	5 / 20	5 / 15	5 / 10	4 / 6	A
	21 / 142	18 / 107	17 / 75	15 / 59	14 / 46	12 / 36	10 / 29	9 / 21	8 / 17	8 / 12	7 / 8	6 / 4	B
	29 / 134	25 / 100	23 / 69	20 / 54	19 / 41	16 / 32	14 / 25	12 / 18	11 / 14	10 / 10	9 / 6	9 / 1	C
	37 / 126	32 / 93	29 / 63	26 / 48	24 / 36	20 / 28	18 / 21	16 / 14	14 / 11	13 / 7	12 / 3		D
	45 / 118	40 / 85	35 / 57	32 / 42	29 / 31	25 / 23	22 / 17	19 / 11	17 / 8	16 / 4	14 / 1		E
	55 / 108	48 / 77	42 / 50	38 / 36	35 / 25	29 / 19	25 / 14	22 / 8	20 / 5	18 / 2			F
	64 / 99	56 / 69	49 / 43	44 / 30	40 / 20	34 / 14	29 / 10	26 / 4	23 / 2				G
	74 / 89	64 / 61	57 / 35	51 / 23	46 / 14	39 / 9	33 / 6	29 / 1					H
	85 / 78	73 / 52	65 / 27	58 / 16	52 / 8	44 / 4	38 / 1						I
	97 / 66	83 / 42	73 / 19	65 / 9	58 / 2								J
	109 / 54	93 / 32	81 / 11	72 / 2									K
	122 / 41	104 / 21	90 / 2										L
	136 / 27	115 / 10											M
	152 / 11												N
													O
													Z

00 / 00 — RED NUMBERS (TOP) ARE RESIDUAL NITROGEN TIMES (RNT)
BLACK NUMBERS (BOTTOM) ARE ADJUSTED
NO-STOP REPETITIVE DIVE TIMES
ACTUAL DIVE TIME SHOULD NOT EXCEED THIS NUMBER

CHART 2 — SURFACE INTERVAL TIME

Time Ranges in hours: minutes
Enter Chart 2 from the top,
move down to find surface interval time,
move left to find the next repetitive group letter.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
2:20 / :10	3:36 / 1:17	4:31 / 2:12	5:23 / 3:04	6:15 / 3:56	7:08 / 4:49	8:00 / 5:41	8:52 / 6:33	9:44 / 7:25	10:36 / 8:17	11:29 / 9:10	12:21 / 10:02	13:13 / 10:54	14:05 / 11:46	14:58 / 12:38	15:50 / 13:31
	1:16 / :10	2:11 / :56	3:03 / 1:48	3:55 / 2:40	4:48 / 3:32	5:40 / 4:24	6:32 / 5:17	7:24 / 6:09	8:16 / 7:01	9:09 / 7:53	10:01 / 8:45	10:53 / 9:38	11:45 / 10:30	12:37 / 11:22	13:30 / 12:14
		:55 / :10	1:47 / :53	2:39 / 1:45	3:31 / 2:38	4:23 / 3:30	5:16 / 4:22	6:08 / 5:14	7:00 / 6:07	7:52 / 6:59	8:44 / 7:51	9:37 / 8:43	10:29 / 9:35	11:21 / 10:28	12:13 / 11:20
			:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07	7:50 / 6:59	8:42 / 7:51	9:34 / 8:43	10:27 / 9:35	11:19 / 10:28
				:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07	7:50 / 6:59	8:42 / 7:51	9:34 / 8:43	10:27 / 9:35
					:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07	7:50 / 6:59	8:42 / 7:51	9:34 / 8:43
						:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07	7:50 / 6:59	8:42 / 7:51
							:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07	7:50 / 6:59
								:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14	6:58 / 6:07
									:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22	6:06 / 5:14
										:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30	5:13 / 4:22
											:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38	4:21 / 3:30
												:52 / :10	1:44 / :53	2:37 / 1:45	3:29 / 2:38
													:52 / :10	1:44 / :53	2:37 / 1:45
														:52 / :10	1:44 / :53
															:52 / :10

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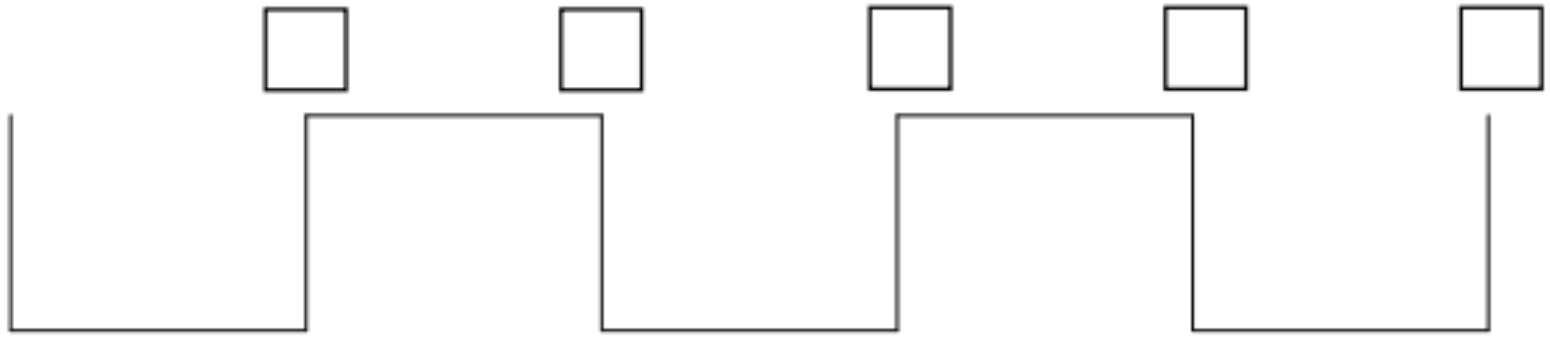
Example



_____ ABT

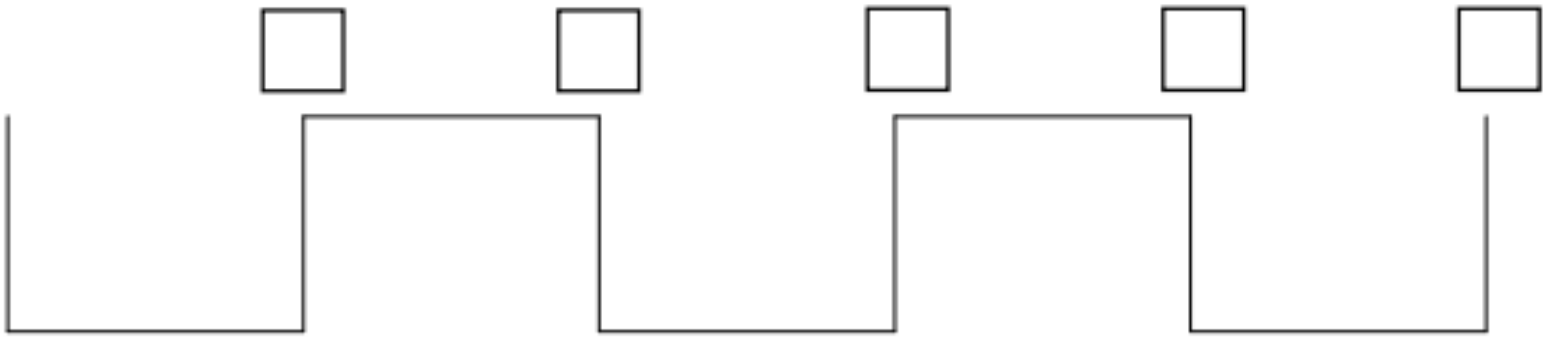
_____ RNT
+_____ ABT
_____ ESDT

_____ RNT
+_____ ABT
_____ ESDT

RNT: residual nitrogen time
ABT: actual bottom time
ESDT: equivalent single dive time

Example

74 fsw 깊이에서 10분간 잠수
1) 비감압한계 시간은?
2) 반복잠수군은?



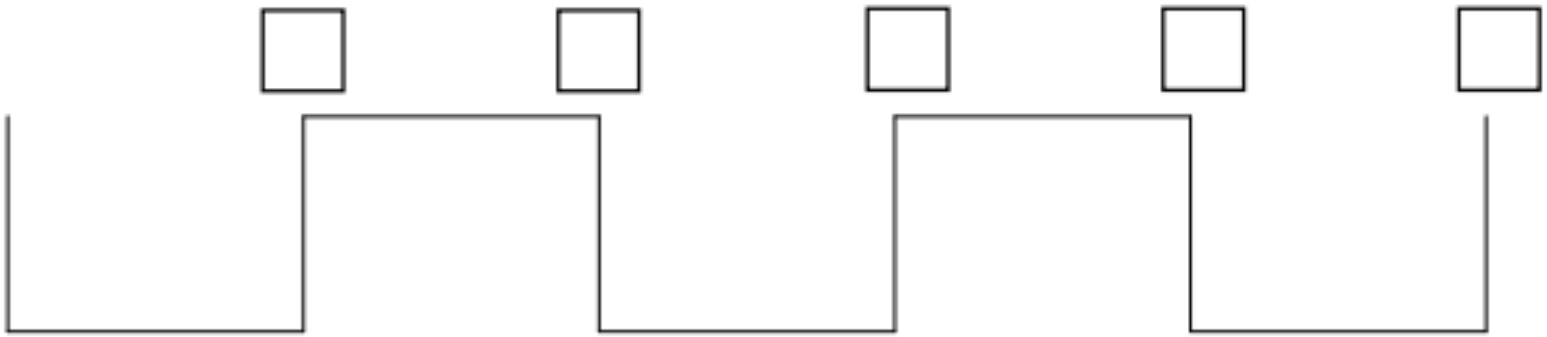
_____ ABT

_____ RNT
+_____ ABT
_____ ESDT

_____ RNT
+_____ ABT
_____ ESDT

Example

60 fsw 깊이에서 30분간 잠수 후 두번째 잠수를 50 fsw 에서 60분간 시행할 예정
두번째 잠수에서 감압하지 않고 상승하려면 수면에서의 최소 휴식시간은?



_____ ABT

_____ RNT
+_____ ABT
_____ ESDT

_____ RNT
+_____ ABT
_____ ESDT

VI

Fitness to Dive

대한고압의학회
Korean Academy of Undersea and Hyperbaric Medicine

Medical Examiner of Divers

- Must be able to determine whether or not a person is fit to undertake commercial offshore diving activities
- Able to assess a diver's fitness to return to diving after serious illness(including DCI) or accident
- Able to give advice to any commercial diver, or to his supervisor, who may have concerns about fitness to dive because of some individual's problem

R·S·T·C
RECREATIONAL SCUBA TRAINING COUNCIL

UNDERSEA & HYPERBARIC MEDICAL SOCIETY

MEDICAL STATEMENT

Participant Record (Confidential Information)

Please read carefully before signing.

This is a statement in which you are informed of some potential risks involved in scuba diving and of the conduct required of you during the scuba training program. Your signature on this statement is required for you to participate in the scuba training program offered

by_____and
Instructor

_____located in the
Facility

city of_____, state/province of _____.

Read this statement prior to signing it. You must complete this Medical Statement, which includes the medical questionnaire section, to enroll in the scuba training program. If you are a minor, you must have this Statement signed by a parent or guardian.

Diving is an exciting and demanding activity. When performed correctly, applying correct techniques, it is relatively safe. When established safety procedures are not followed, however, there are increased risks.

To scuba dive safely, you should not be extremely overweight or out of condition. Diving can be strenuous under certain conditions. Your respiratory and circulatory systems must be in good health. All body air spaces must be normal and healthy. A person with coronary disease, a current cold or congestion, epilepsy, a severe medical problem or who is under the influence of alcohol or drugs should not dive. If you have asthma, heart disease, other chronic medical conditions or you are taking medications on a regular basis, you should consult your doctor and the instructor before participating in this program, and on a regular basis thereafter upon completion. You will also learn from the instructor the important safety rules regarding breathing and equalization while scuba diving. Improper use of scuba equipment can result in serious injury. You must be thoroughly instructed in its use under direct supervision of a qualified instructor to use it safely.

If you have any additional questions regarding this Medical Statement or the Medical Questionnaire section, review them with your instructor before signing.

Divers Medical Questionnaire

To the Participant:

The purpose of this Medical Questionnaire is to find out if you should be examined by your doctor before participating in recreational diver training. A positive response to a question does not necessarily disqualify you from diving. A positive response means that there is a preexisting condition that may affect your safety while diving and you must seek the advice of your physician prior to engaging in dive activities.

_____ Could you be pregnant, or are you attempting to become pregnant?

_____ Are you presently taking prescription medications? (with the exception of birth control or anti-malarial)

_____ Are you over 45 years of age and can answer YES to one or more of the following?
- currently smoke a pipe, cigars or cigarettes
- have a high cholesterol level
- have a family history of heart attack or stroke
- are currently receiving medical care
- high blood pressure
- diabetes mellitus, even if controlled by diet alone

Have you ever had or do you currently have...

_____ Asthma, or wheezing with breathing, or wheezing with exercise?

_____ Frequent or severe attacks of hayfever or allergy?

_____ Frequent colds, sinusitis or bronchitis?

_____ Any form of lung disease?

_____ Pneumothorax (collapsed lung)?

_____ Other chest disease or chest surgery?

_____ Behavioral health, mental or psychological problems (Panic attack, fear of closed or open spaces)?

_____ Epilepsy, seizures, convulsions or take medications to prevent them?

_____ Recurring complicated migraine headaches or take medications to prevent them?

_____ Blackouts or fainting (full/partial loss of consciousness)?

_____ Frequent or severe suffering from motion sickness (seasick, carsick, etc.)?

Please answer the following questions on your past or present medical history with a **YES** or **NO**. If you are not sure, answer **YES**. If any of these items apply to you, we must request that you consult with a physician prior to participating in scuba diving. Your instructor will supply you with an RSTC Medical Statement and Guidelines for Recreational Scuba Diver's Physical Examination to take to your physician.

_____ Dysentery or dehydration requiring medical intervention?

_____ Any dive accidents or decompression sickness?

_____ Inability to perform moderate exercise (example: walk 1.6 km/one mile within 12 mins.)?

_____ Head injury with loss of consciousness in the past five years?

_____ Recurrent back problems?

_____ Back or spinal surgery?

_____ Diabetes?

_____ Back, arm or leg problems following surgery, injury or fracture?

_____ High blood pressure or take medicine to control blood pressure?

_____ Heart disease?

_____ Heart attack?

_____ Angina, heart surgery or blood vessel surgery?

_____ Sinus surgery?

_____ Ear disease or surgery, hearing loss or problems with balance?

_____ Recurrent ear problems?

_____ Bleeding or other blood disorders?

_____ Hernia?

_____ Ulcers or ulcer surgery ?

_____ A colostomy or ileostomy?

_____ Recreational drug use or treatment for, or alcoholism in the past five years?

STUDENT

Please print legibly.

Name _____ Birth Date _____ Age _____
First Initial Last Day/Month/Year

Mailing Address _____

City _____ State/Province/Region _____

Country _____ Zip/Postal Code _____

Home Phone ( ) _____ Business Phone ( ) _____

Email _____ FAX _____

Name and address of your family physician

Physician _____ Clinic/Hospital _____

Address _____

Date of last physical examination _____

Name of examiner _____ Clinic/Hospital _____

Address _____

Phone ( ) _____ Email _____

Were you ever required to have a physical for diving? ☐ Yes ☐ No If so, when? _____

PHYSICIAN

This person applying for training or is presently certified to engage in scuba (self-contained underwater breathing apparatus) diving. Your opinion of the applicant's medical fitness for scuba diving is requested. There are guidelines attached for your information and reference.

Physician's Impression

☐ I find no medical conditions that I consider incompatible with diving.

☐ I am unable to recommend this individual for diving.

Remarks _____

_____

_____

_____ Date _____
Physician's Signature or Legal Representative of Medical Practitioner Day/Month/Year

Physician _____ Clinic/Hospital _____

Address _____

Phone ( ) _____ Email _____

Guidelines for
Recreational Scuba Diver's Physical Examination

1. Neurological
   - Relative risk conditions
     - Complicated migraine headaches whose symptoms or severity impair motor or cognitive function, neurologic manifestations
     - History of head injury with sequelae other than seizure
     - Herniated nucleus pulposus
     - Intracranial tumor or aneurysm
     - Peripheral neuropathy
     - Multiple sclerosis
     - Trigeminal neuralgia
     - History of spinal cord or brain injury

Guidelines for
Recreational Scuba Diver's Physical Examination

1. Neurological
   - Temporary risk conditions
     - History of cerebral gas embolism without residual where pulmonary air trapping has been excluded and for which there is a satisfactory explanation and some reason to believe that the probability of recurrence is low

Guidelines for
Recreational Scuba Diver's Physical Examination

1. Neurological
   - Severe risk conditions
     - History of seizures other than childhood febrile seizures
     - History of TIA or CVA
     - History of serious (CNS, cerebral or inner ear) decompression sickness with residual deficits

Guidelines for
Recreational Scuba Diver's Physical Examination

2. Cardiovascular systems

- Relative risk conditions
  - History of CABG
  - Percutaneous balloon angioplasty or coronary artery disease (CAD)
  - History of myocardial infarction
  - Congestive heart failure
  - History of dysrhythmias requiring medication for suppression
  - Valvular regurgitation

Guidelines for
Recreational Scuba Diver's Physical Examination

2. Cardiovascular systems
   - Severe risk conditions
     - Venous emboli, commonly produced during decompression, may cross major intracardiac right-to-left shunts and enter the cerebral or spinal cord circulations causing neurological decompression illness
     - Hypertrophic cardiomyopathy and valvular stenosis

Guidelines for
Recreational Scuba Diver's Physical Examination

3. Pulmonary systems

- Relative risk conditions
  - History of asthma or reactive airway disease(RAD)
  - History of exercise induced bronchospasm(EIB)
  - History of solid, cystic or cavitating lesion
  - Pneumothorax secondary to:
    - Thoracic surgery
    - Trauma or pleural penetration
    - Previous overinflation injury
  - Obesity
  - History of immersion pulmonary edema restrictive disease
  - Interstitial lung disease: may increase the risk of pneumothorax

Guidelines for
Recreational Scuba Diver's Physical Examination

3. Pulmonary systems
   - Severe risk conditions
     - History of spontaneous pneumothorax
     - Impaired exercise performance due to respiratory disease

Guidelines for
Recreational Scuba Diver's Physical Examination

4. Gastrointestinal
   - Temporary risk conditions
     - Peptic ulcer disease associated with pyloric obstruction or severe reflux
     - Unrepaired hernias of the abdominal wall large enough to contain bowel within the hernia sac could incarcerate

Guidelines for
Recreational Scuba Diver's Physical Examination

4. Gastrointestinal
   - Relative risk conditions
     - Inflammatory bowel disease
     - Functional bowel disorders

Guidelines for
Recreational Scuba Diver's Physical Examination

4. Gastrointestinal
   - Severe risk conditions
     - Gastric outlet obstruction of a degree sufficient to produce recurrent vomiting
     - Chronic or recurrent small bowel obstruction
     - Severe gastroesophageal reflux
     - Achalasia
     - Paraesophageal hernia

Guidelines for
Recreational Scuba Diver's Physical Examination

5. Orthopaedic
   - Relative risk conditions
     - Amputation
     - Scoliosis must also assess impact on respiratory function and exercise performance
     - Aseptic necrosis possible risk of progression due to effects of decompression (evaluate the underlying medical cause of decompression may accelerate/escalate the progression)
   - Temporary risk conditions
     - Back pain

Guidelines for
Recreational Scuba Diver's Physical Examination

6. Hematological

- Relative risk conditions
  - Sickle cell disease
  - Polycythemia vera
  - Leukemia
  - Hemophilia/impaired coagulation

Guidelines for
Recreational Scuba Diver's Physical Examination

7. Metabolic and endocrinological
   - Relative risk conditions
     - Hormonal excess of deficiency
     - Obesity
     - Renal insufficiency

Guidelines for
Recreational Scuba Diver's Physical Examination

7. Metabolic and endocrinological
   - Severe risk conditions
     - The potentially rapid change in level of consciousness associated with hypoglycemia in diabetes on insulin therapy or certain oral hypoglycemic medications can result in drowning
     - Pregnancy: diving is not recommended during and stage of pregnancy or for women actively seeking to become pregnant

Guidelines for
Recreational Scuba Diver's Physical Examination

8. Behavioral health
   - Relative risk conditions
     - Developmental delay
     - History of drug or alcohol abuse
     - History of previous psychotic episodes
     - Use of psychotropic medications

Guidelines for
Recreational Scuba Diver's Physical Examination

8. Behavioral health

- Severe risk conditions
  - Inappropriate motivation to dive – solely to please spouse, partner or family member, to prove oneself in the face of personal fears
  - Claustrophobia and agoraphobia
  - Active psychosis
  - History of untreated panic disorder
  - Drug or alcohol abuse

Guidelines for
Recreational Scuba Diver's Physical Examination

9. Otolaryngological

- Relative risk conditions
  - Recurrent otitis externa
  - Significant obstruction of external auditory canal
  - History of significant cold injury to pinna
  - Eustachian tube dysfunction
  - Recurrent otitis media or sinusitis
  - History of TM perforation/tympanoplasty
  - History of mastoidectomy
  - Significant conductive or sensorineural hearing impairment
  - Facial nerve paralysis not associated with barotrauma
  - Full prosthedontic devices
  - History of mid-face fracture/head and/or neck therapeutic radiation
  - Unhealed oral surgery sites
  - History of temperomandibular joint dysfunction
  - History of round window rupture

Guidelines for
Recreational Scuba Diver's Physical Examination

9. Otolaryngological

- Severe risk conditions
  - Monomeric TM
  - Open TM perforation
  - Tube myringotomy
  - History of stapedectomy/ossicular chain surgery
  - History of History of inner ear surgery
  - Facial nerve paralysis secondary to barotrauma
  - Inner ear disease other than presbycusis
  - Uncorrected upper airway obstruction
  - Laryngectomy or status post partial laryngectomy
  - Tracheostomy
  - Uncorrected laryngocele
  - History of vestibular decompression sickness

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Thank you

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