In-water recompression

Does it have a role in managing DCI?

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THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

AUCKLAND DISTRICT HEALTH BOARD
Te Toka Tumai

Consensus guideline

Pre-hospital management of decompression illness: expert review of key principles and controversies

Simon J Mitchell[1], Michael H Bennett[2], Phillip Bryson[3], Frank K Butler[4], David J Doolette[5], James R Holm[6], Jacek Kot[7], Pierre Lafère[8]

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[2] *University of New South Wales, Sydney, Australia*
[3] *International SOS, Aberdeen, United Kingdom*
[4] *Joint Trauma System, Defence Center of Excellence for Trauma, San Antonio, USA*
[5] *University of Auckland, Auckland*
[6] *Virginia Mason Medical Centre, Seattle, USA.*
[7] *National Centre for Hyperbaric Medicine, Institute of Maritime and Tropical Medicine in Gdynia, Medical University of Gdansk, Poland*
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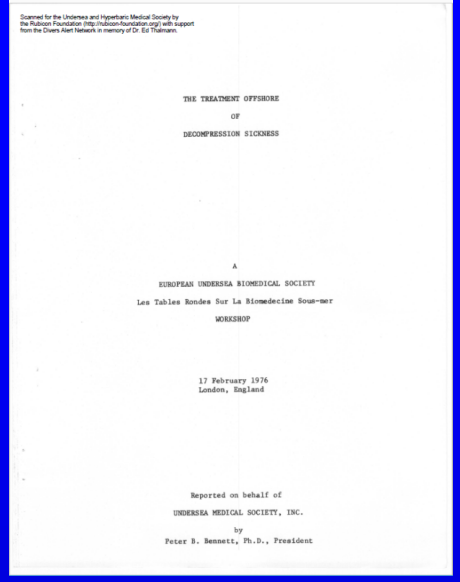
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6467826/

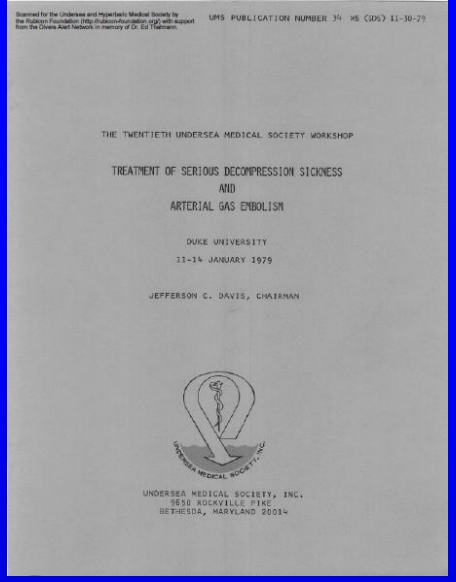
2. FIRST AID PROCEDURES	
A. Normobaric oxygen (surface oxygen administered as close to 100% as possible) is beneficial in the treatment of DCI. Normobaric oxygen should be administered as soon as possible after onset of symptoms.	Observational human studies[13,14] *In vivo* studies of bubble and symptom resolution[15–21]
B. Training of divers in oxygen administration is highly recommended.	
C. A system capable of administering a high percentage of inspired oxygen (close to 100%) and an oxygen supply sufficient to cover the duration of the most plausible evacuation scenario is highly recommended for all diving activities.	

An issue we were asked to focus on….

- Whether it was time for diving medical experts to endorse in water recompression
  - If so, under what circumstances?

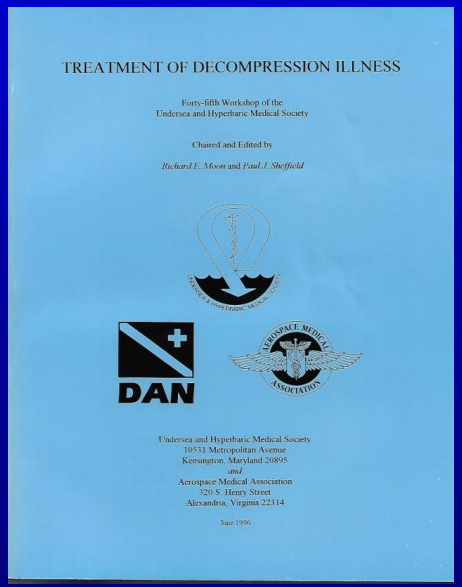


"[IWR] has no place in commercial or sports diving" (1976)

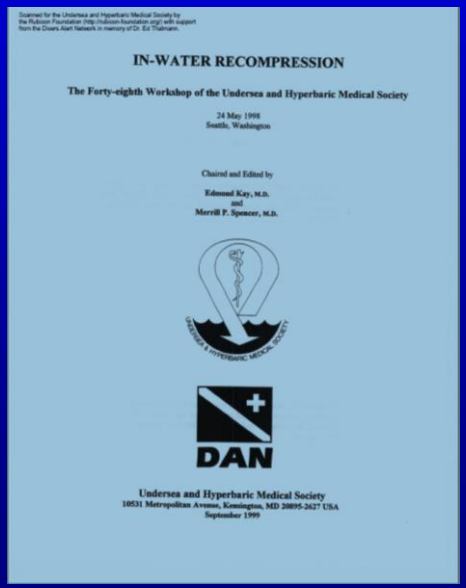


"[IWR] has value…however…the workshop could not recommend its widespread use" (1979)

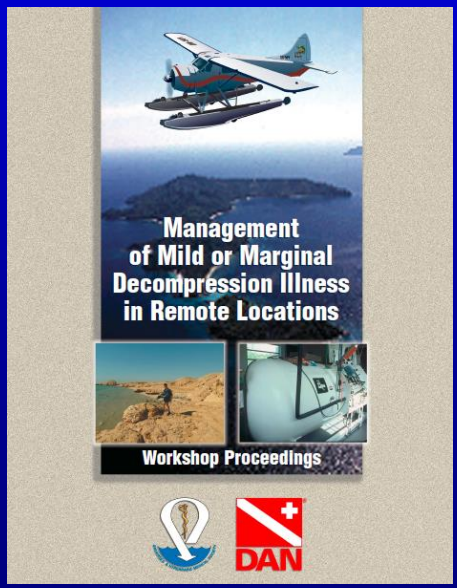
No consensus (1990)



"can be both safe and effective….IWR is not recommended in areas where …chambers are available" (1995)



No consensus (1998)



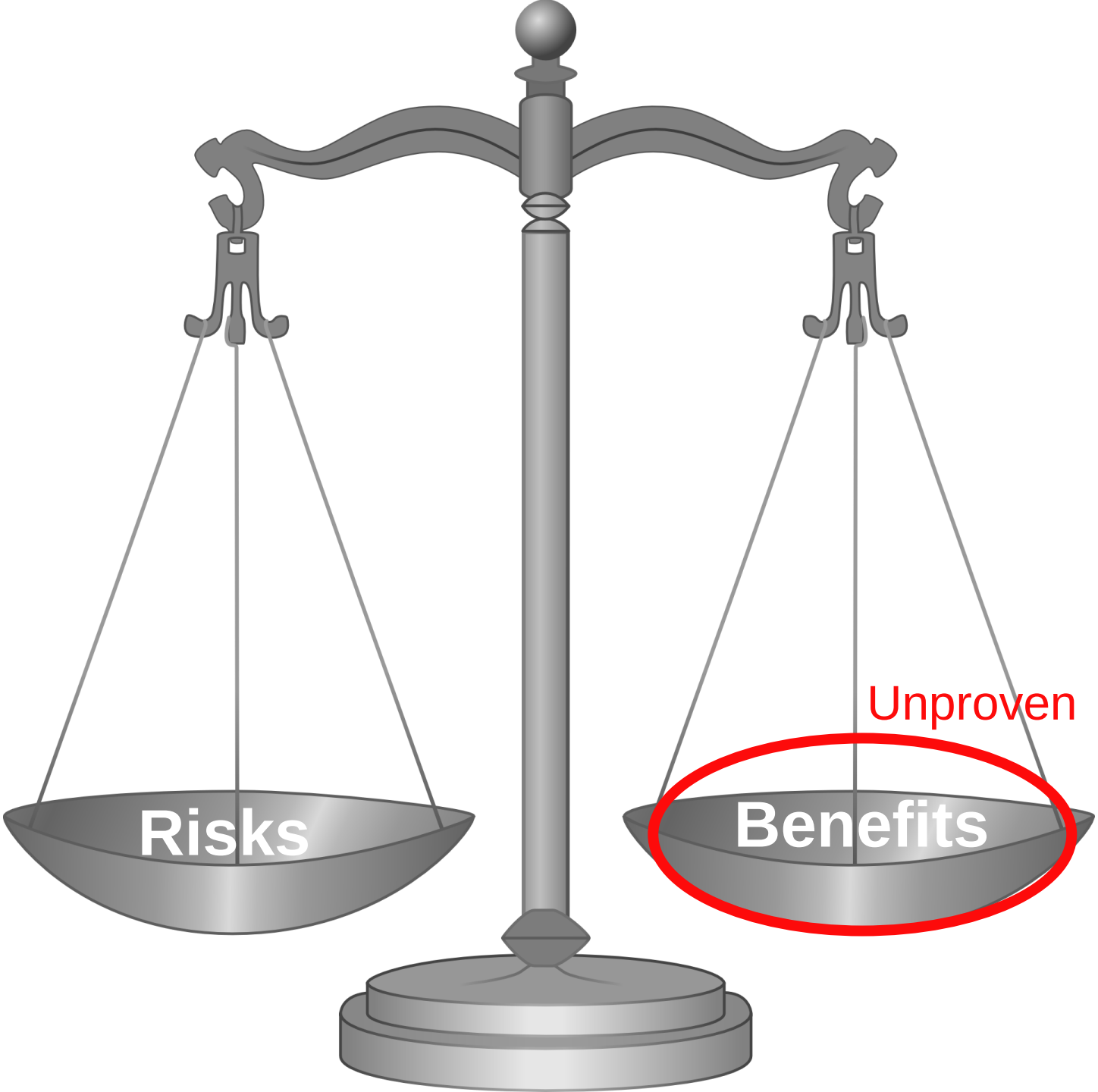
Some support but no policy (2004)


Why does the medical profession have such a big problem with IWR?


Risks
Benefits

In-water Recompression

- Risks:
  - Oxygen toxicity
    - Convulsion can result in drowning
  - Environmental hazards e.g., cold
  - Deterioration in the water
  - Delay getting to a chamber
  - Occurs in settings without medical support
- Benefits:
  - Very early recompression
  - Recompression when a chamber is not available
    - But less pressure and duration than a chamber


Risks
Unproven
Benefits

Consensus guideline

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In-water recompression

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https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6156824/

Two questions:

1. Does **very** early recompression improve outcome?

2. Is a shallower shorter recompression effective?

In-water recompression

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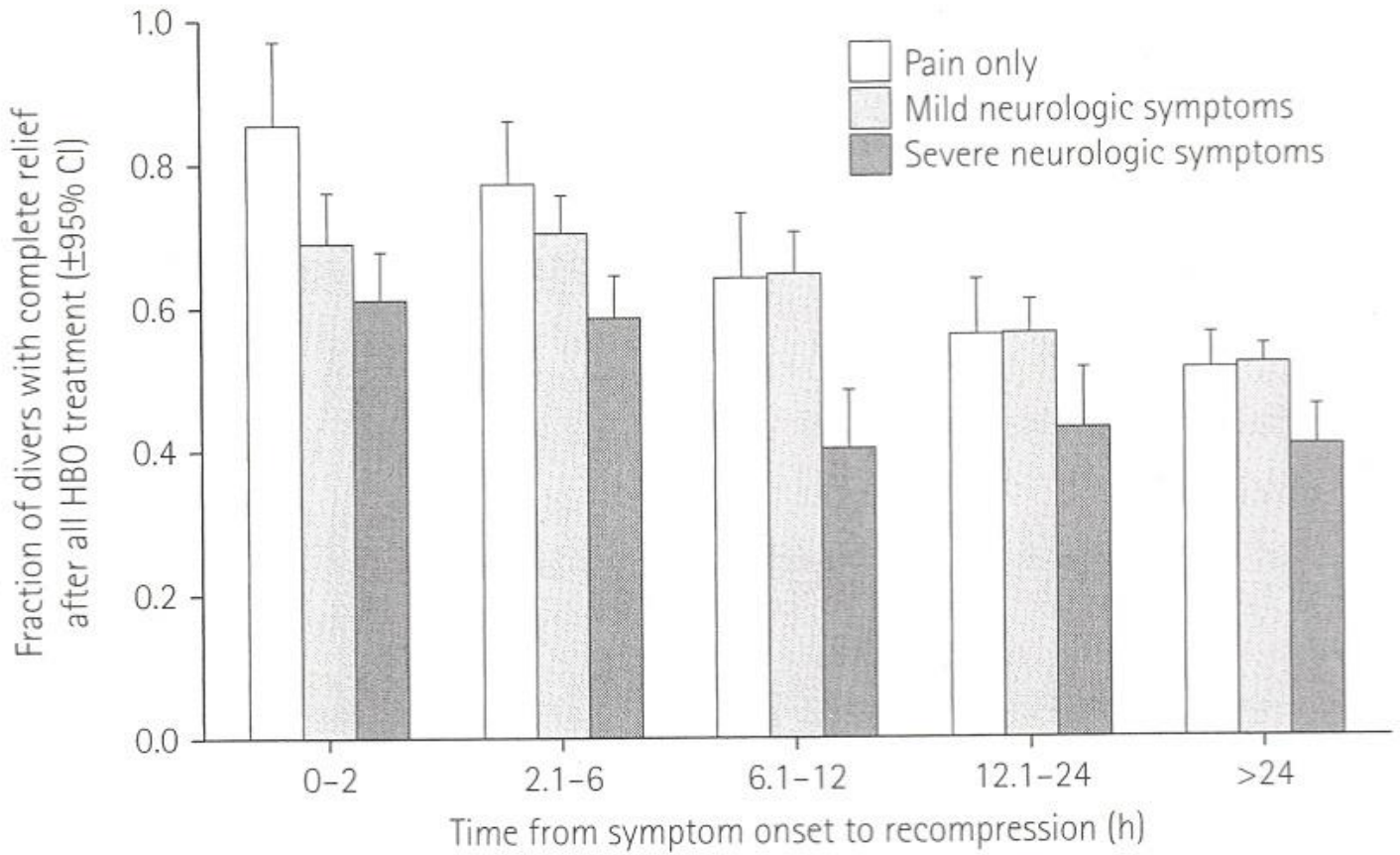
We went looking for relevant evidence that had not been previously reported….


1. Does very early recompression improve outcome ?

DAN data: effect of time to recompression on outcome in recreational divers stratified for severity of DCI



DAN data in Moon and Gorman. Bennett and Elliott 2003

neurocritical care society Neurocrit Care (2011) 15:120–127
DOI 10.1007/s12028-010-9370-1

ORIGINAL ARTICLE

Prognostic Factors of Spinal Cord Decompression Sickness in Recreational Diving: Retrospective and Multicentric Analysis of 279 Cases

Jean-Eric Blatteau · E. Gempp · O. Simon · M. Coulange · B. Delafosse ·

What about
< 1 hour
or < 30 min?

Delay to recompression (hours)	Full recovery: % of cases
< 3	76%
3 - 6	82%
> 6	63%

In-water recompression

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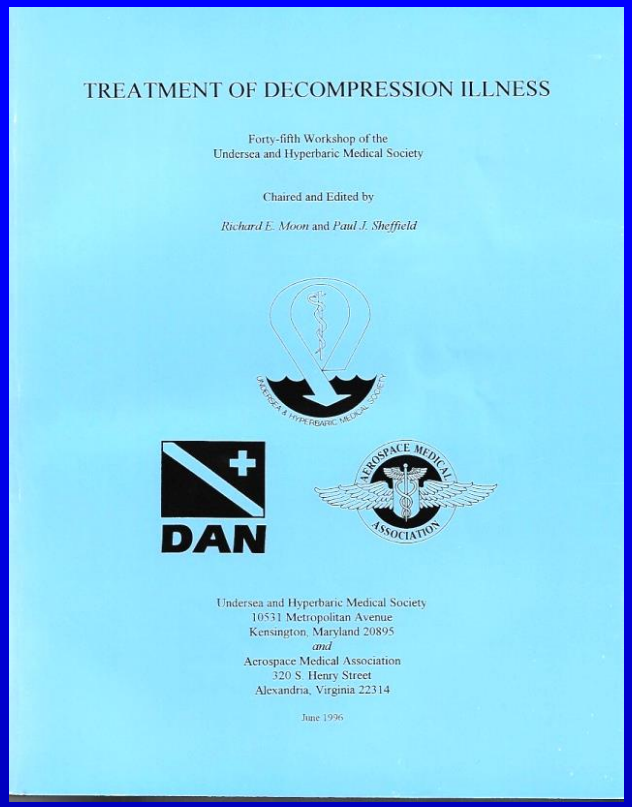
What did we find to help answer the question?



DCS arising during US Navy experimental dives. "Little or no delay between symptom occurrence and treatment"

166 cases

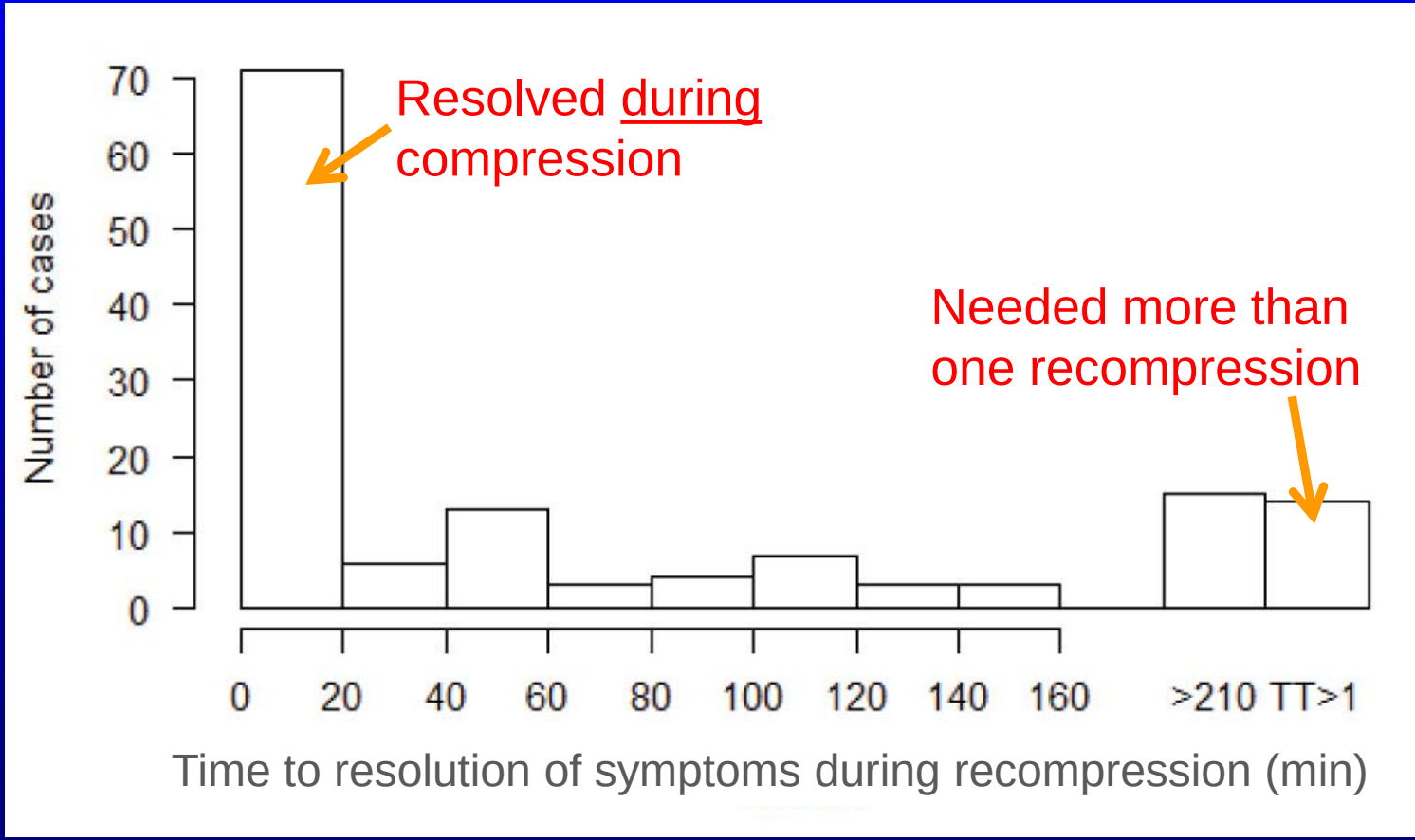
119 (72%) resolved during recompression or within 10 min

161 (97%) resolved during first recompression

166 (100%) cases resolved eventually

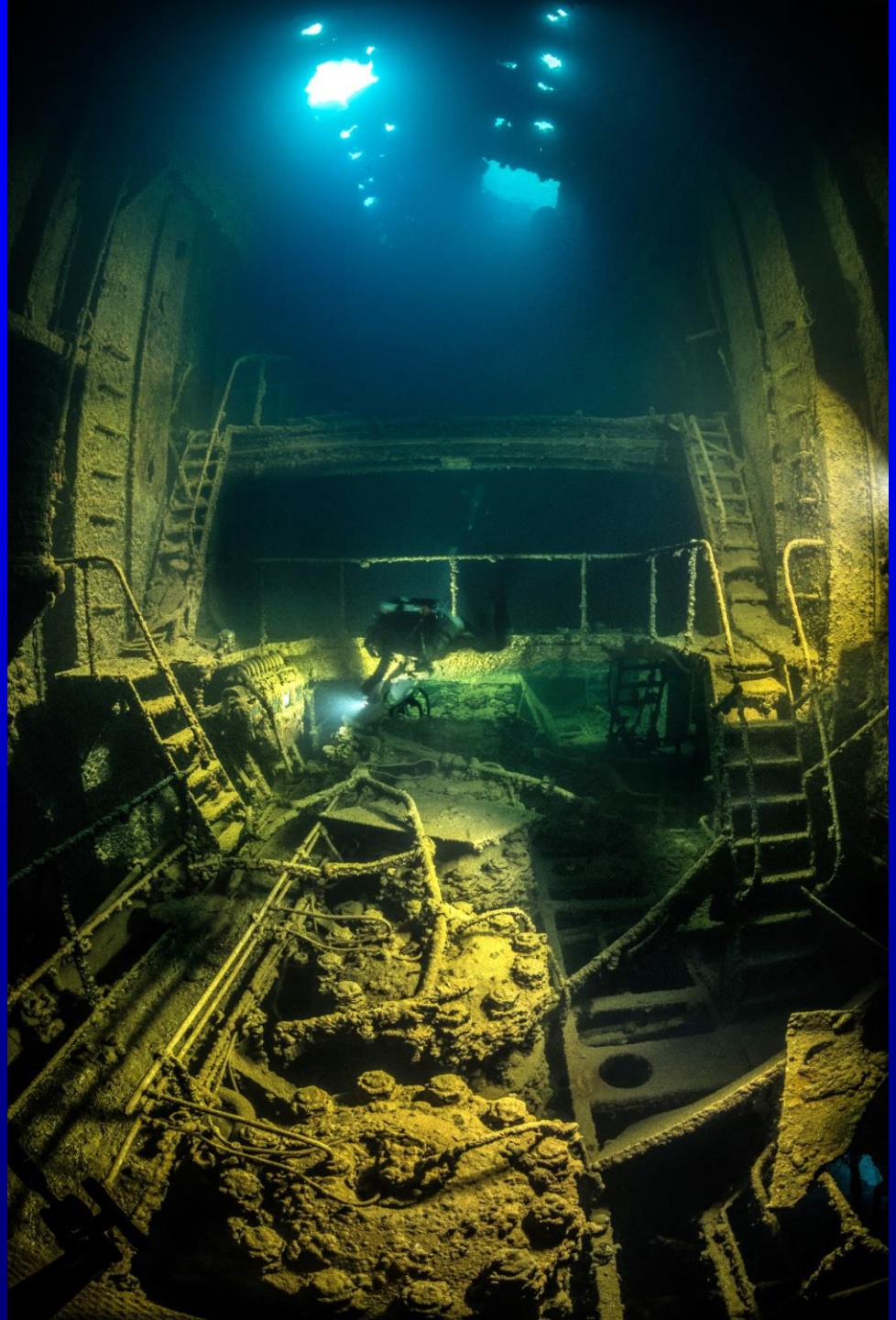
USN experimental diving 1988 – 2006: 140 cases of DCS

Median delay to recompression = 60 minutes



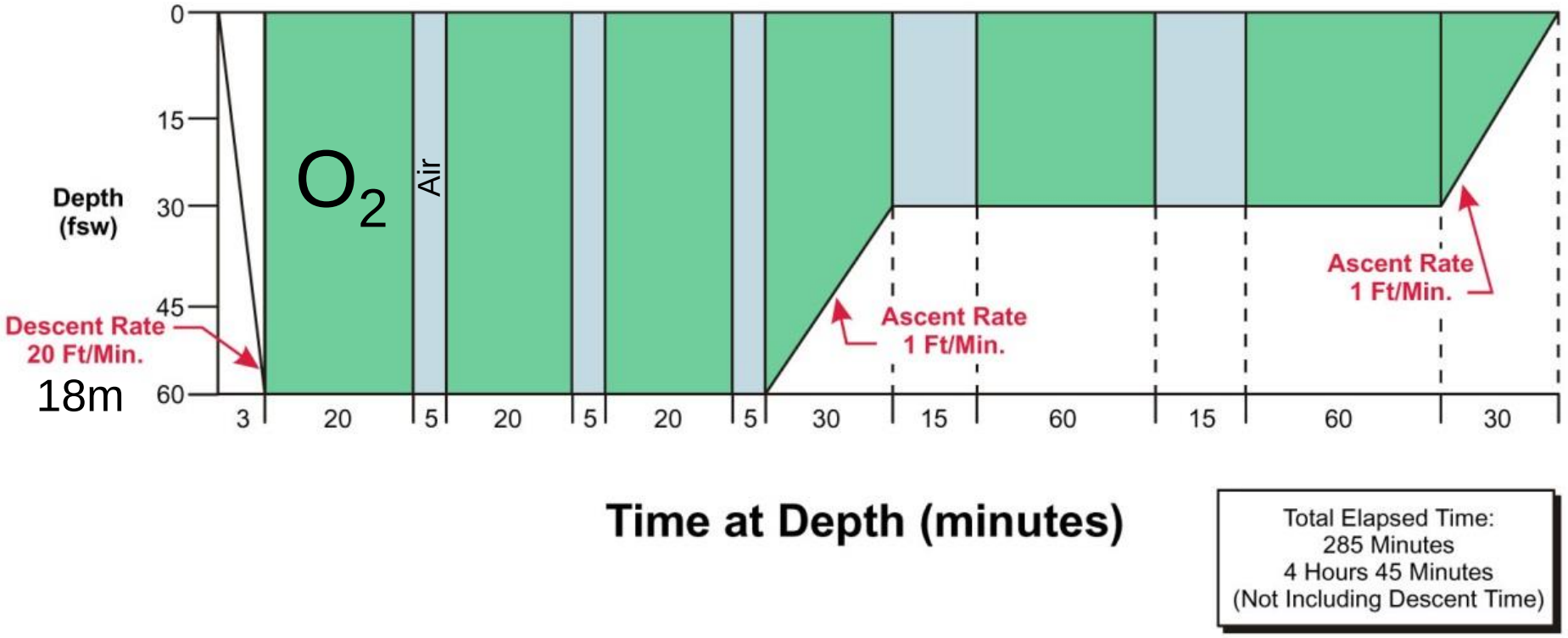
1. Does (very) early recompression improve outcome ?

Yes



2. Does a shorter shallow recompression work: especially if started early?

Most common chamber recompression is USN Table 6



You can't do this underwater (risk of oxygen toxicity)!

So, would a shallower, shorter recompression work?


Development of Table 6
included testing of shorter
shallower protocols!

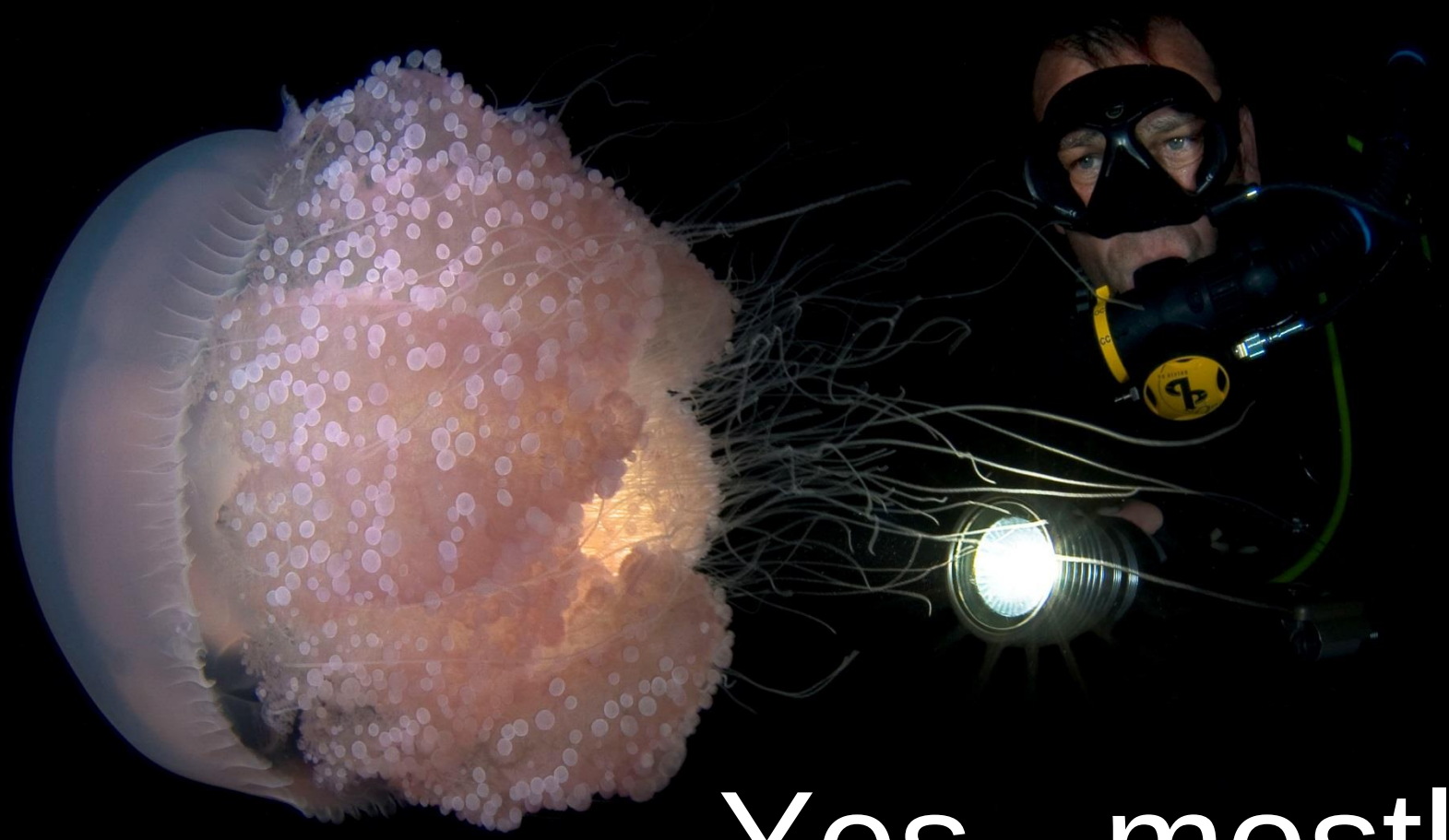
Shallow Recompression
Development of USN T 6

33’ (10m) for 30 min, with deco over 30 min

60’ (18m) for 30 min, with deco over 30 min

- 31 x 33’ (10m) treatments
  - 25 complete resolution
  - 2 substantial resolution
- 56 x 60’ (18m) treatments
  - 53 complete resolution
    (vs shallow, p=0.065, Fisher)

2. Does a shorter shallow recompression work: especially if started early?



Yes - mostly

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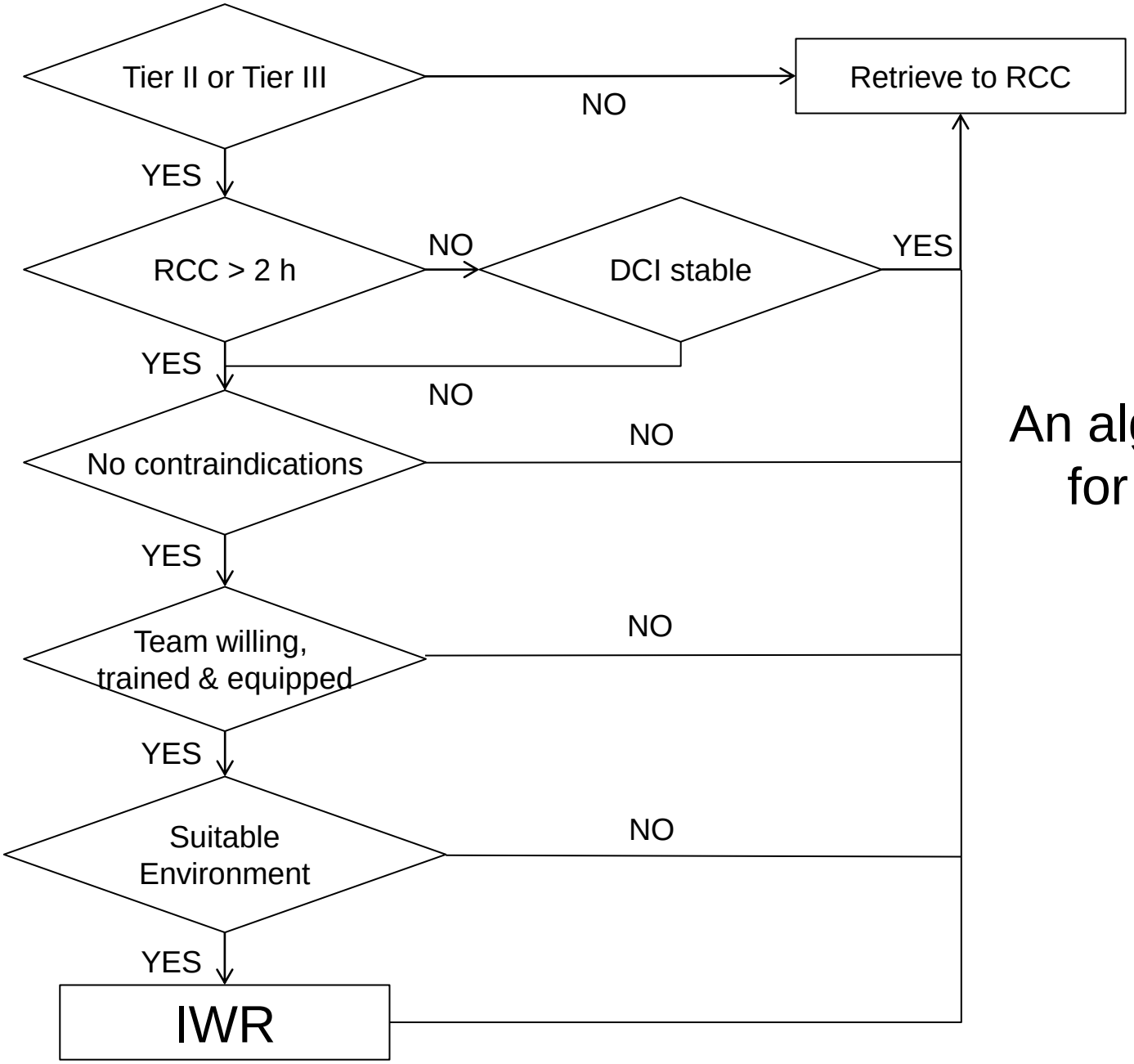
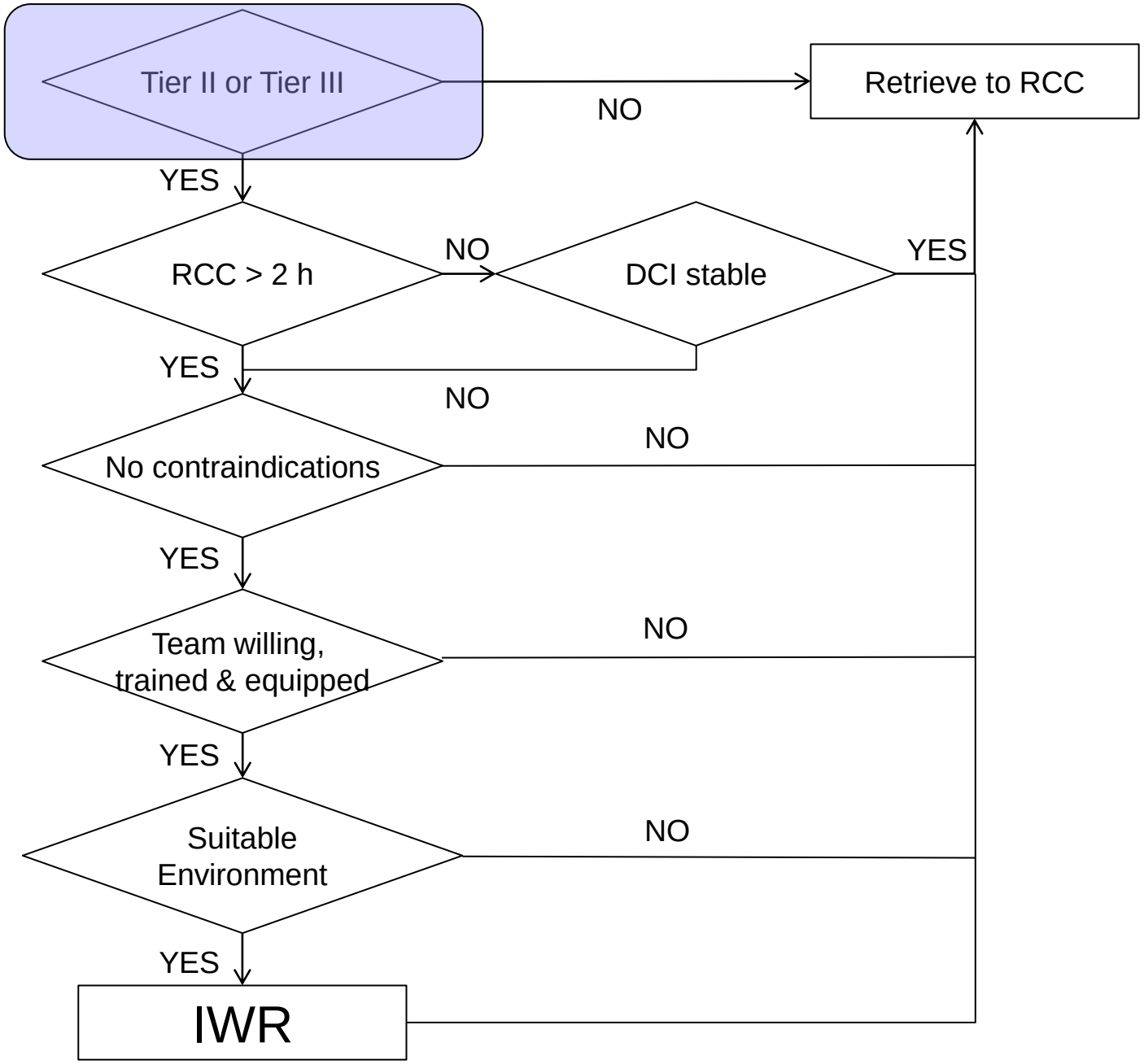
6. IN-WATER RECOMPRESSION (IWR)

A. Recompression and hyperbaric oxygen administered in a recompression chamber is acknowledged as the gold standard of care for DCI. However, in locations without ready access to a suitable hyperbaric chamber facility, and if symptoms are significant or progressing, in-water recompression using oxygen is an option. This is only appropriate where groups of divers (including the 'patient') have prior relevant training (see below) that imparts an understanding of related risks and facilitates a collective acceptance of responsibility for the decision to proceed.	Observational human evidence that very early recompression results in good outcomes,[36,39–46] or better outcomes compared to longer delays[37]
E. IWR should be accomplished with the patient breathing 100% oxygen, and at a maximum depth of 9 msw (30 fsw), according to a recognized protocol. The use of breathing gases other than oxygen for IWR is not recommended.	Published regimens for IWR,[8,48–50] with some observational human evidence of efficacy[8,49]



An algorithm for IWR


Who?


Tier II or Tier III
NO
Retrieve to RCC
YES
RCC > 2 h
NO
DCI stable
YES
YES
NO
No contraindications
NO
YES
Team willing,
trained & equipped
NO
YES
Suitable
Environment
NO
YES
IWR

Consider IWR for…..

TIER 2 – “Mild”

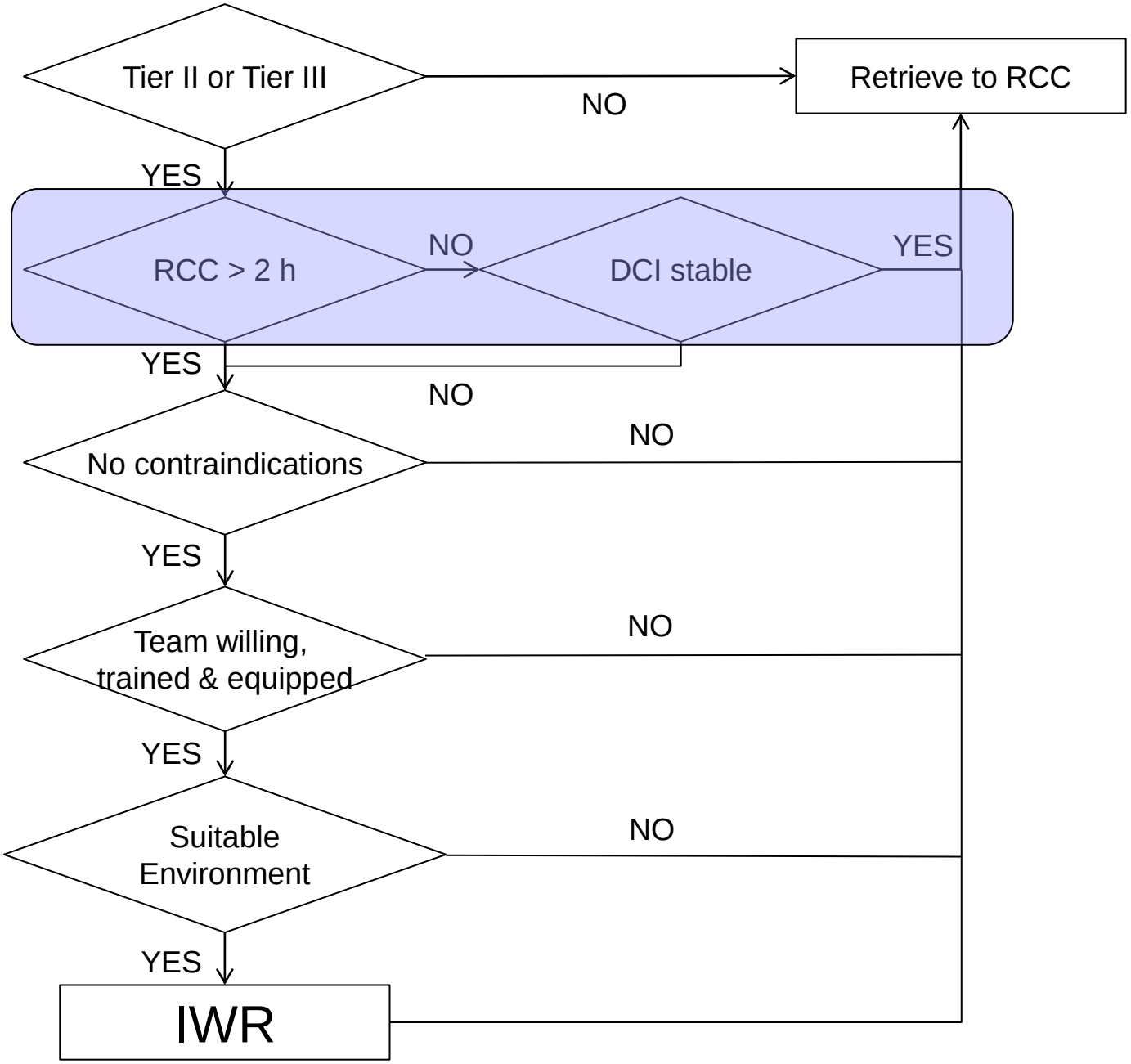
- Pain
- Rash
- Patchy tingling
- Swelling (lymphatic DCS)

TIER 3 – “Serious”

- Serious neurological
  - Paralysis
  - Numbness
  - Visual change
  - Bladder problems
  - Speech change

Diver Selection

- Would not use IWR for mild symptoms that may not be DCS – Tier 1.
- Tier 1 are very “non-specific” symptoms
- For example: lethargy, headache after diving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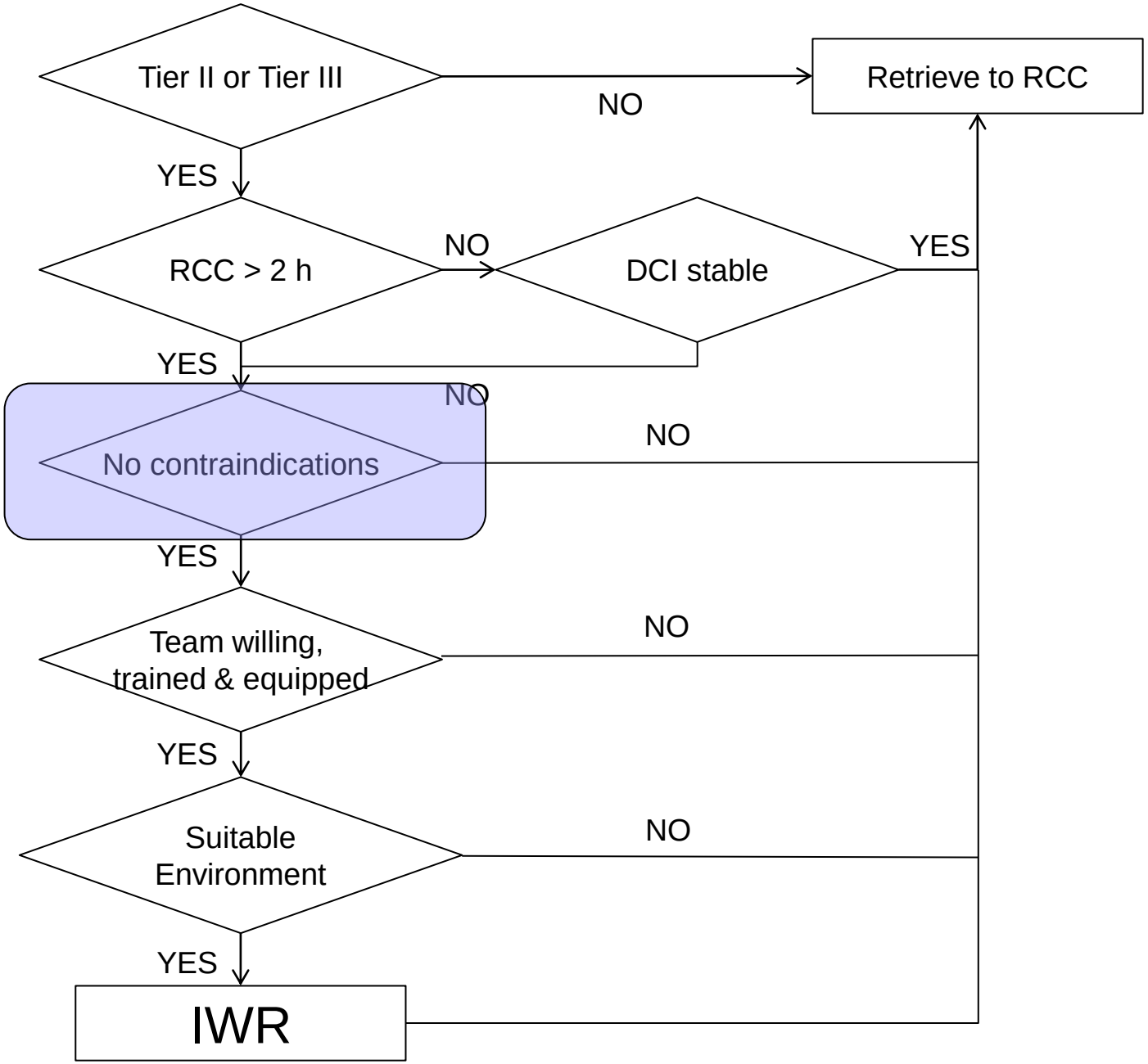
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Suitable
Environment
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IWR

Contraindications to IWR

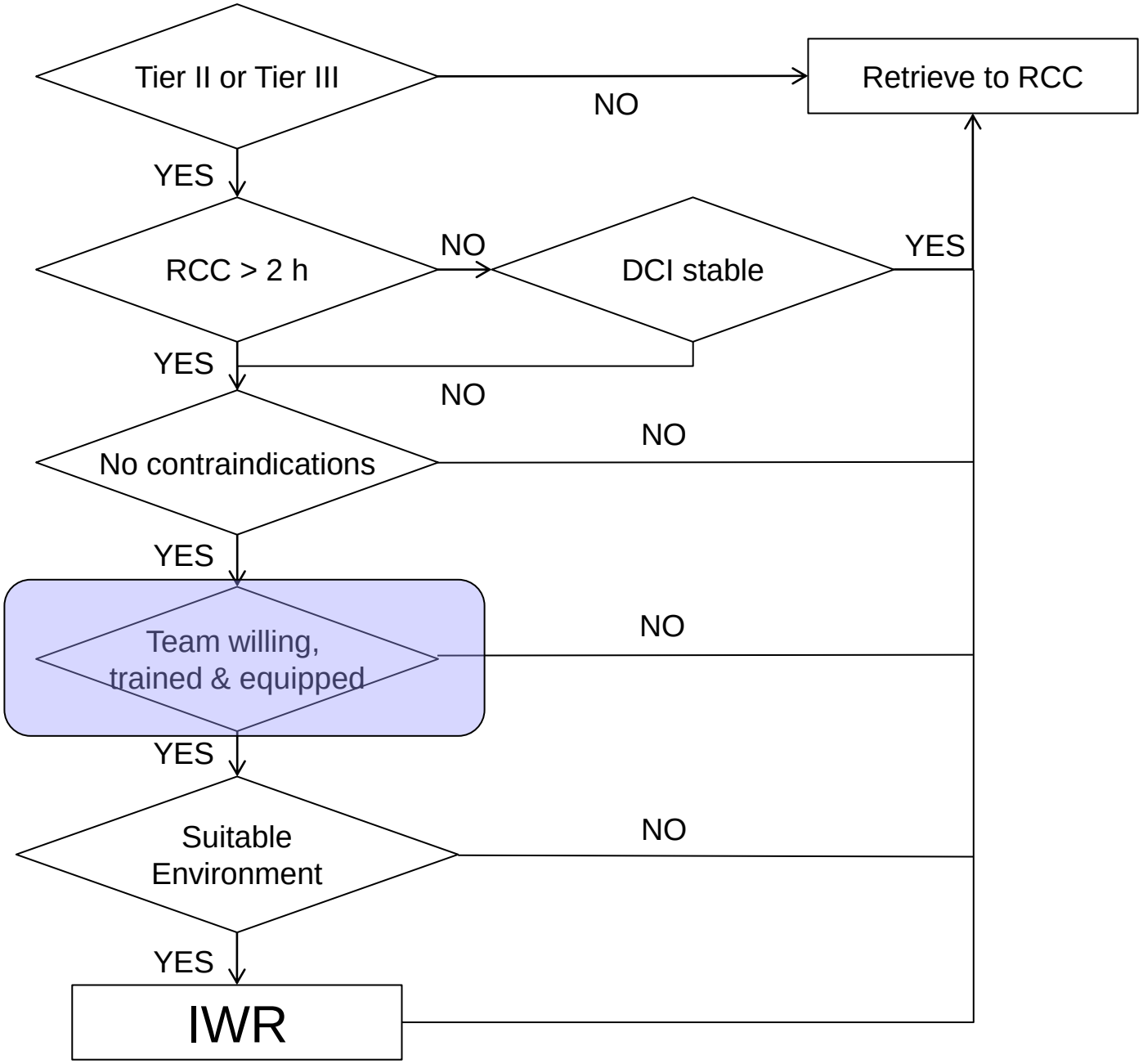
Severe vertigo

Unconsciousness or deteriorating level of consciousness

Oxygen toxicity as part of preceding events

Physical incapacitation rendering return to water unsafe

Unwilling patient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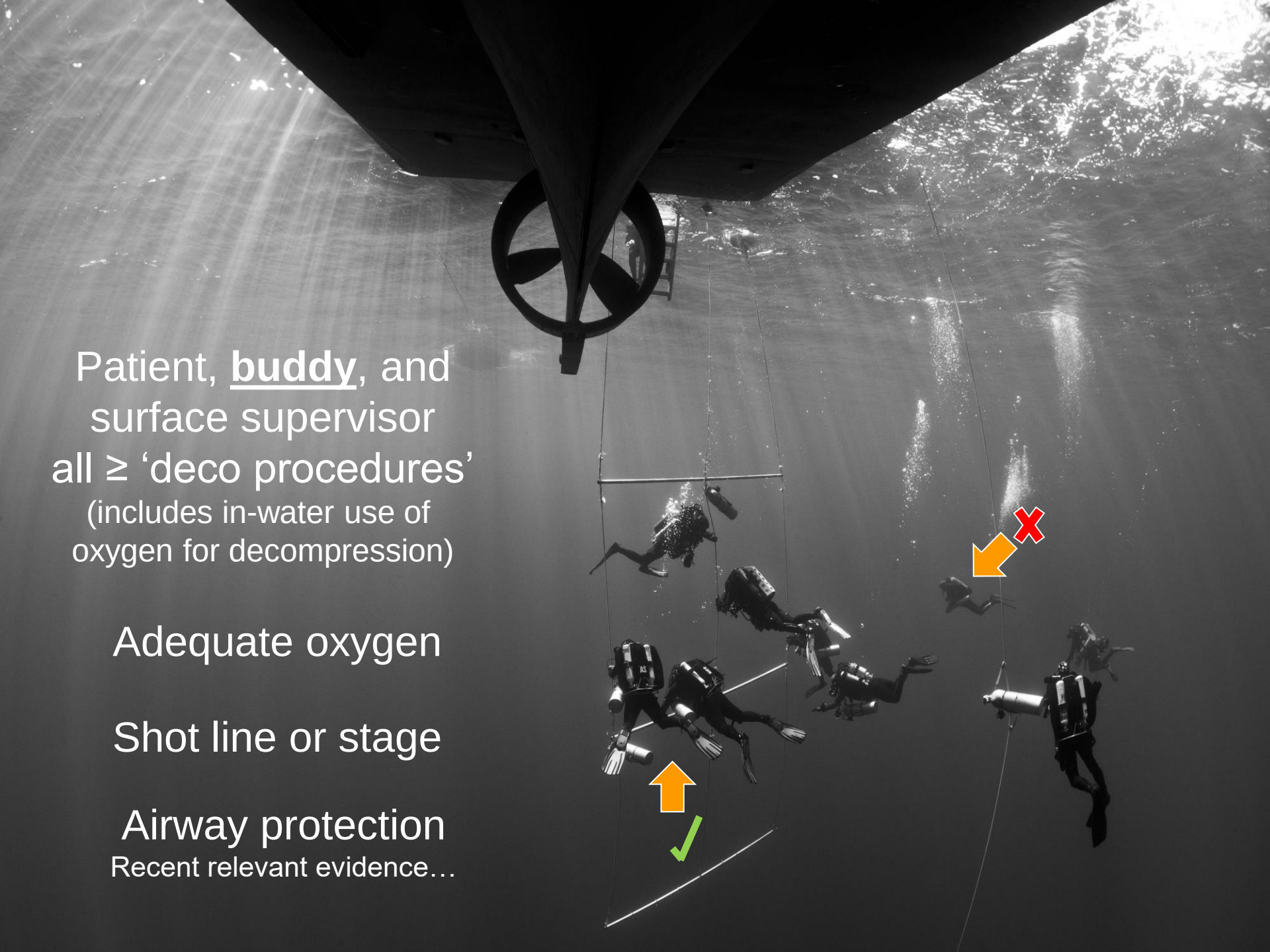
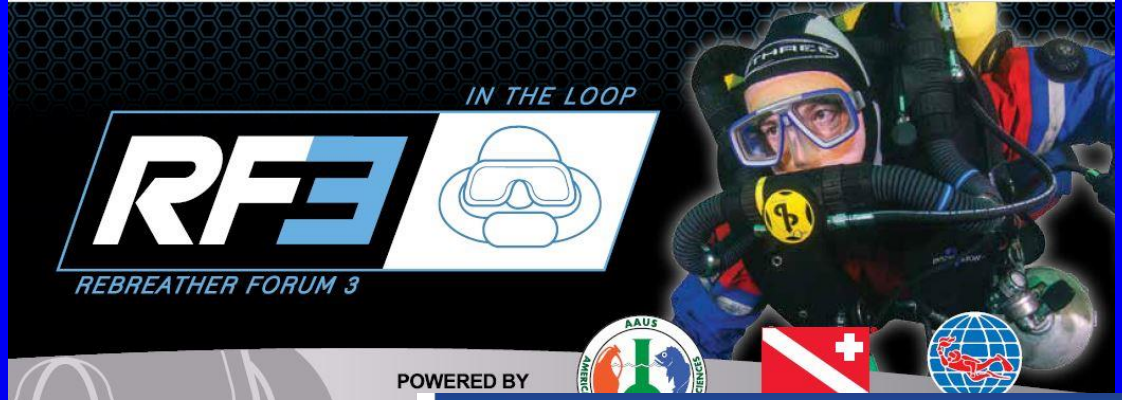


Patient, **buddy**, and surface supervisor all ≥ ‘deco procedures’
(includes in-water use of oxygen for decompression)

Adequate oxygen

Shot line or stage

Airway protection
Recent relevant evidence…



REBREA
PRO

Caribe Royal

Vann RD, Denoble PJ, Pollock NW, eds. Rebreather Forum 3. AAUS/DAN/PADI: Durham, NC; 2014.

REBREATHER FORUM 3 CONSENSUS

Simon J. Mitchell
Auckland, New Zealand
Session Moderator

Design and Testing 5. The forum identifies as a research question the issue of whether a mouthpiece-retaining strap would provide protection of the airway in an unconscious rebreather diver.

Design and Testing 6. The forum identifies as a research question the efficacy of a full-face masks for use with sport rebreathers.

www.rf30.org


Mouthpiece retainer
Photo by Pete Mesley

MILITARY MEDICINE, 176, 4:446, 2011

Descriptive Epidemiology of 153 Diving Injuries With Rebreathers Among French Military Divers From 1979 to 2009

LTC Emmanuel Gempp, French Armed Forces Health Service, MC;*
COL Pierre Louge, French Armed Forces Health Service, MC;*
COL Jean-Eric Blatteau, French Armed Forces Health Service, MC†;
*BG Michel Hugon, French Armed Forces Health Service, MC**

54 LOC events underwater, but only 3 drownings
All were wearing a mouthpiece retaining device

Deep anaesthesia: The Thailand cave rescue and its implications for management of the unconscious diver underwater

Hanna van Waart[1], Richard J Harris[2], Nicholas Gant[3], Xavier CE Vrijdag[1], Craig J Challen[4], Chanrit Lawthaweesawat[5], Simon J Mitchell[1,6,7]

[1] *Department of Anaesthesiology, University of Auckland, Auckland, New Zealand*
[2] *MedSTAR Emergency Medical Retrieval Service, Adelaide, Australia*
[3] *Department of Exercise Sciences, University of Auckland, Auckland, New Zealand*
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[5] *Medical Association of Thailand, Bangkok, Thailand*
[6] *Department of Anaesthesia, Auckland City Hospital, Auckland, New Zealand*
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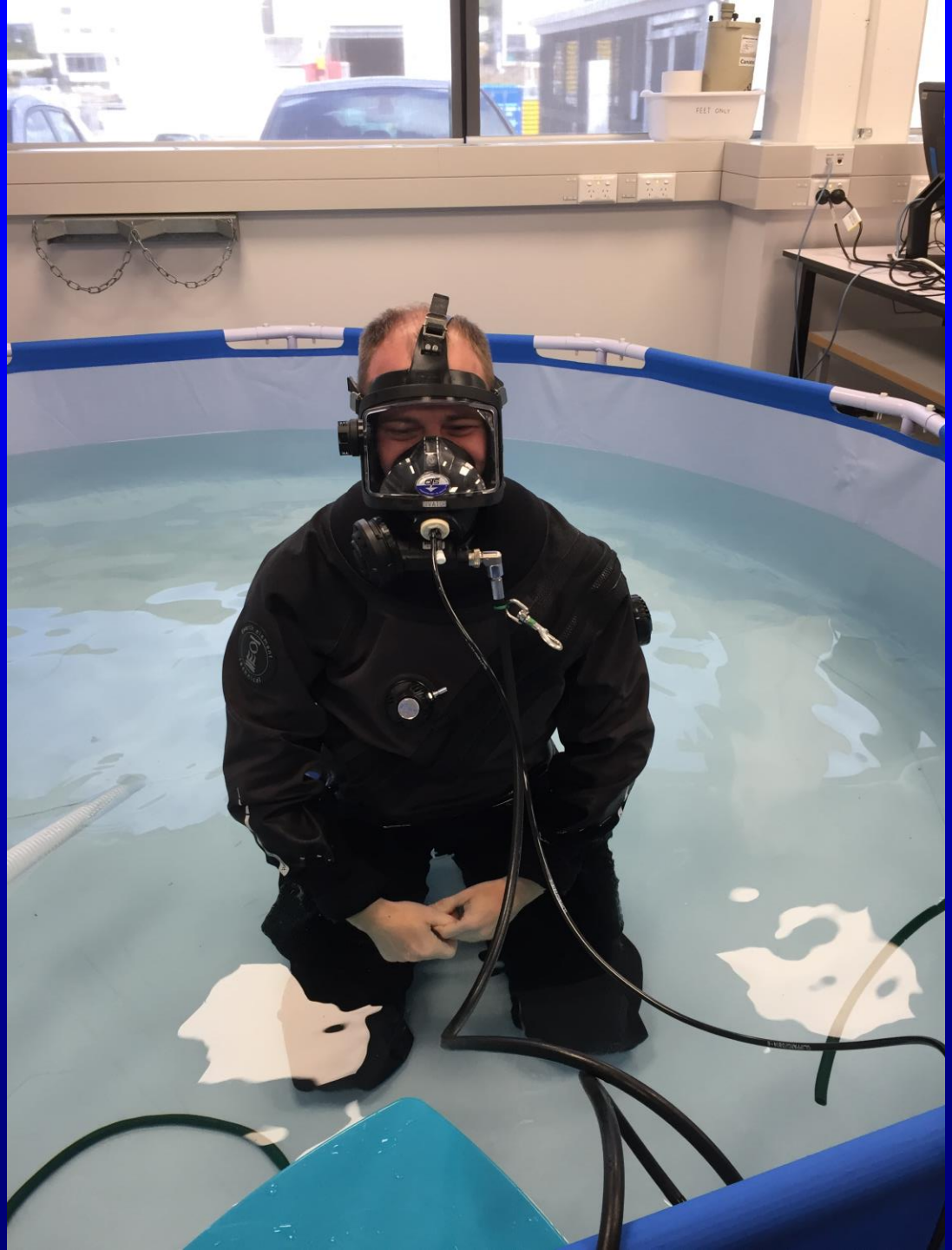
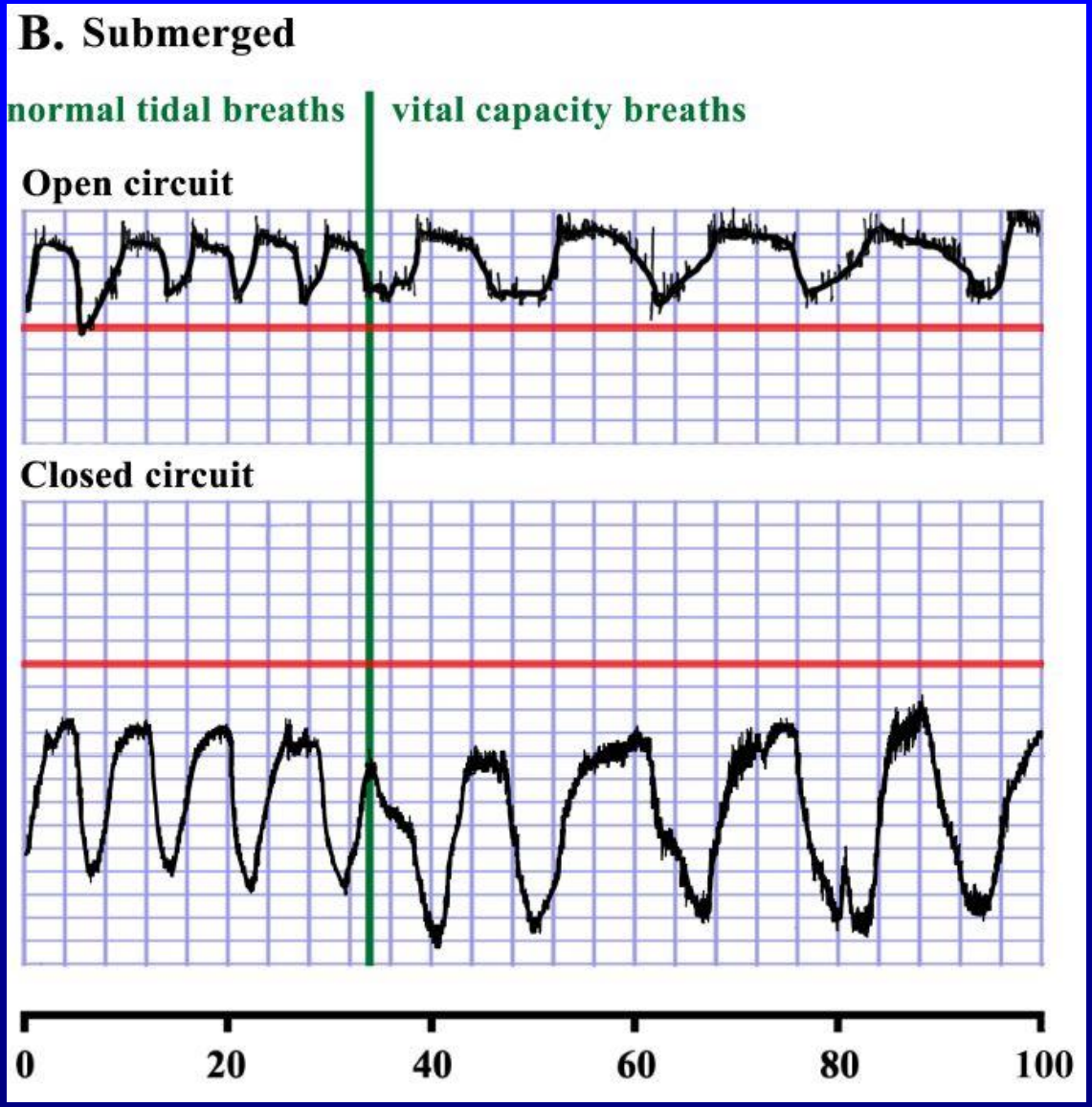
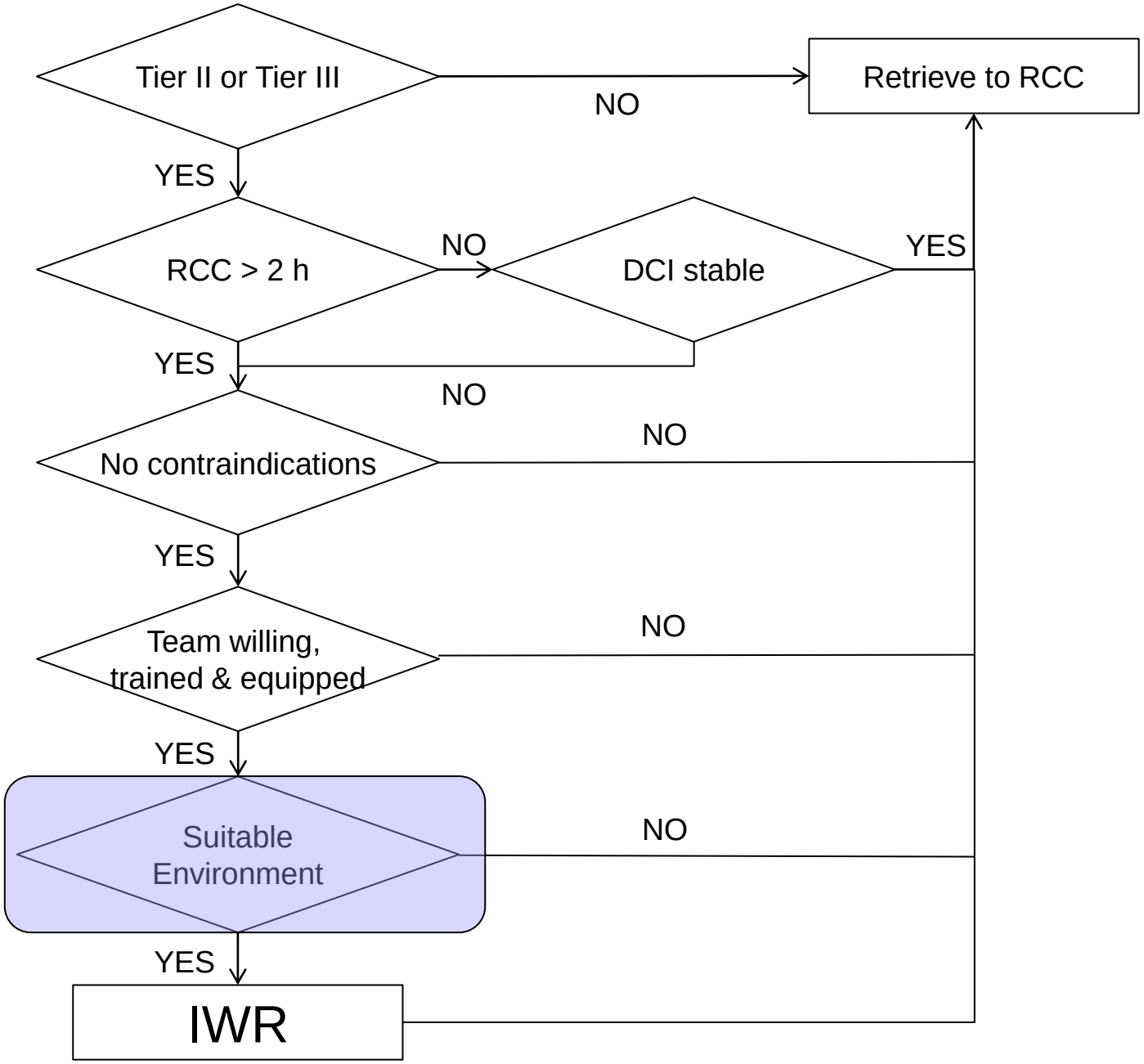


Full face mask


B. Submerged
normal tidal breaths
vital capacity breaths
Open circuit
Closed circuit
0
20
40
60
80
100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Environment
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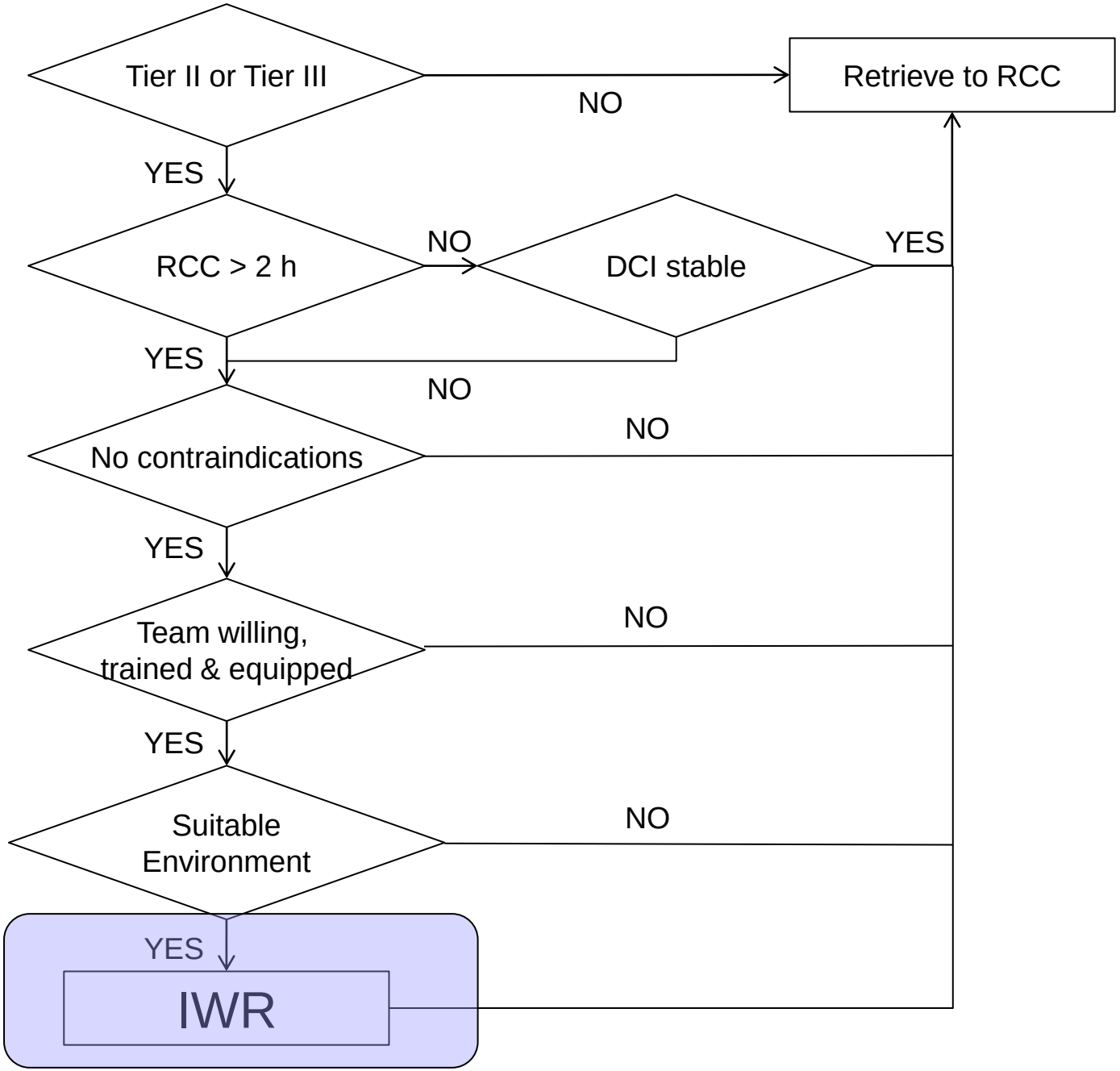
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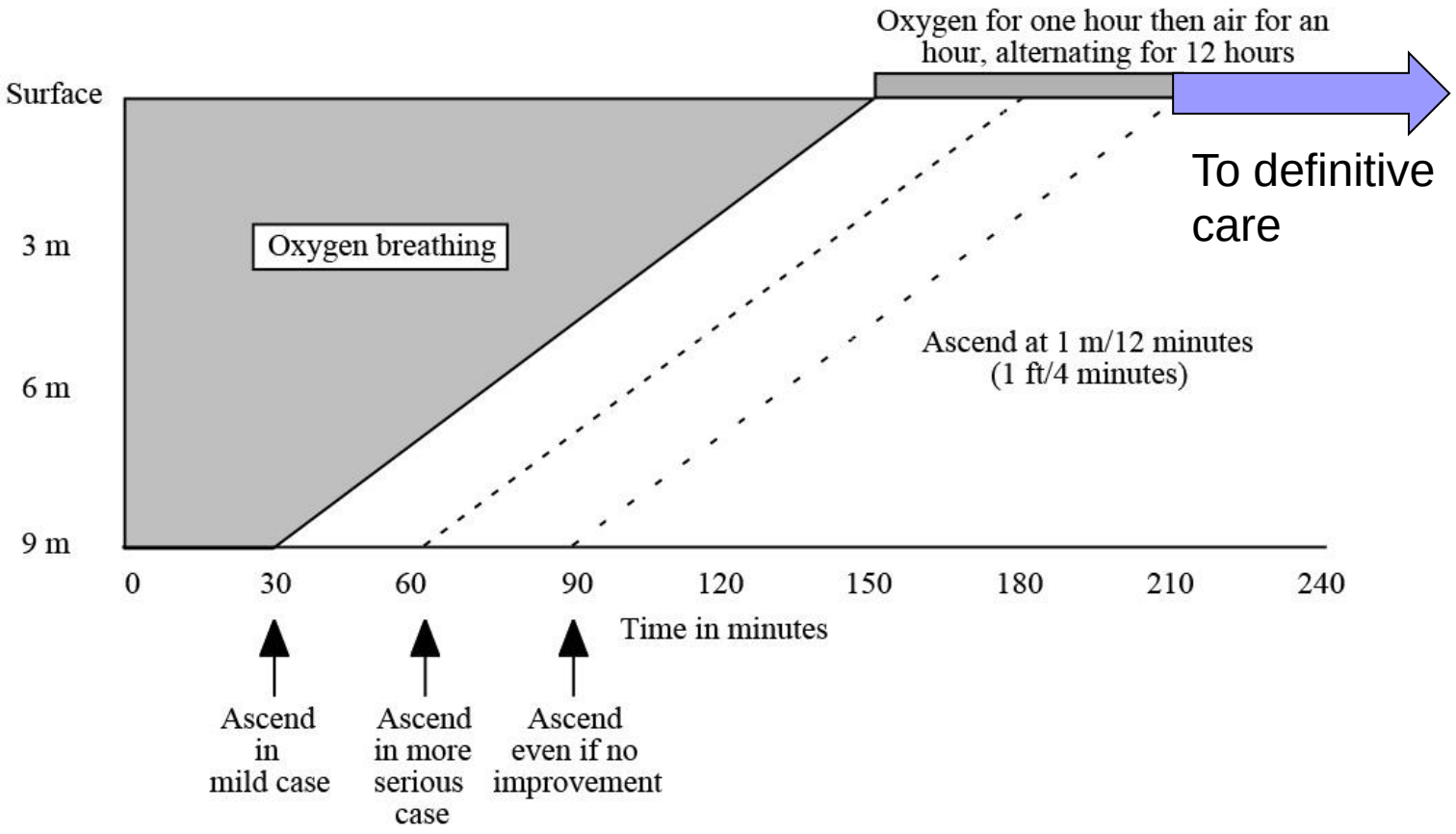
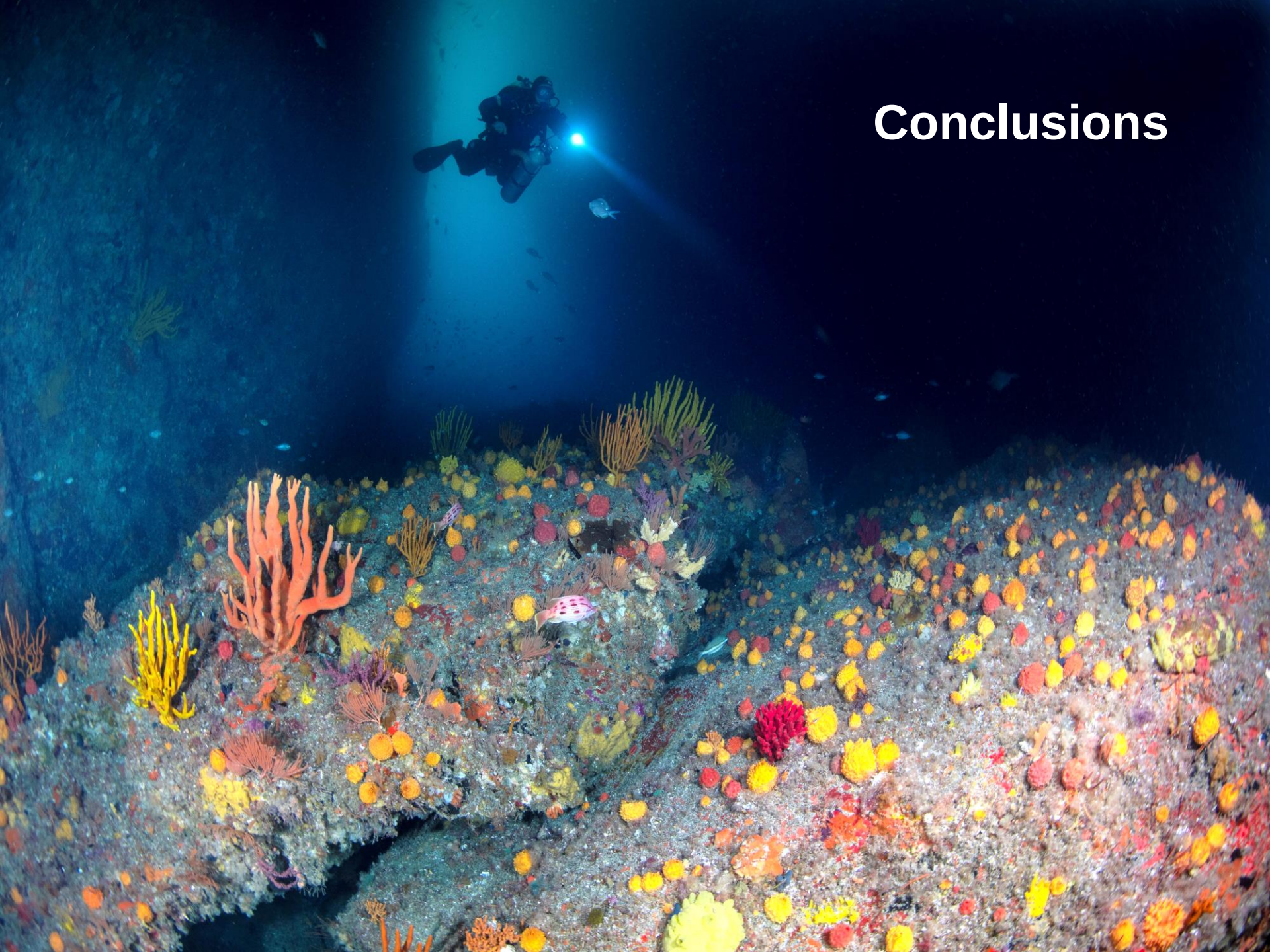
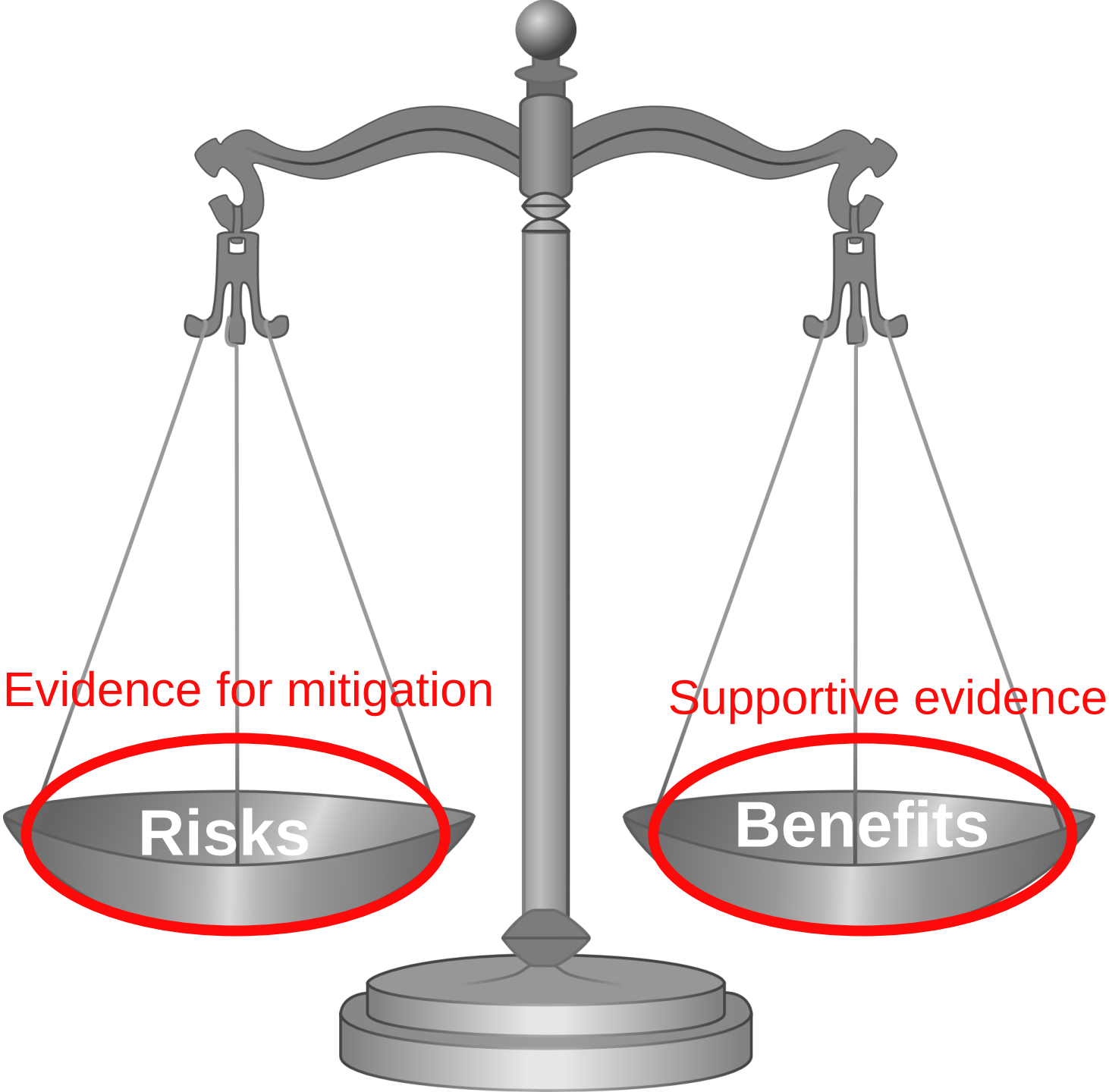
THE AUSTRALIAN METHOD OF EMERGENCY IN-WATER RECOMPRESSION



Accompanied at all times



Conclusions


Evidence for mitigation
Risks
Supportive evidence
Benefits

Conclusions

- Short delays to recompression seem associated with better outcomes
  - IWR facilitates very short delays
- Recompressions shallower and shorter than a Table 6 are effective
- IWR is endorsed for divers trained in oxygen use underwater, and equipped for IWR
  - Evidence that mouthpiece retainers and FFMs will reduce risk