comex

MEDICAL BOOK

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MEDICAL BOOK

Revised Edition 1986

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DIAGNOSIS

GENERAL PRINCIPLES FOR GUIDANCE IN TREATMENT OF DECOMPRESSION ACCIDENTS

— COMEX procedures recognize only two decompression accidents :

TYPE I corresponds to **simple** accidents such as joint pain and skin rash.

TYPE II corresponds to **serious** accidents (the rest of them).

It is not important to distinguish between burst lung with embolism and serious decompression sickness : the treatment is the same.

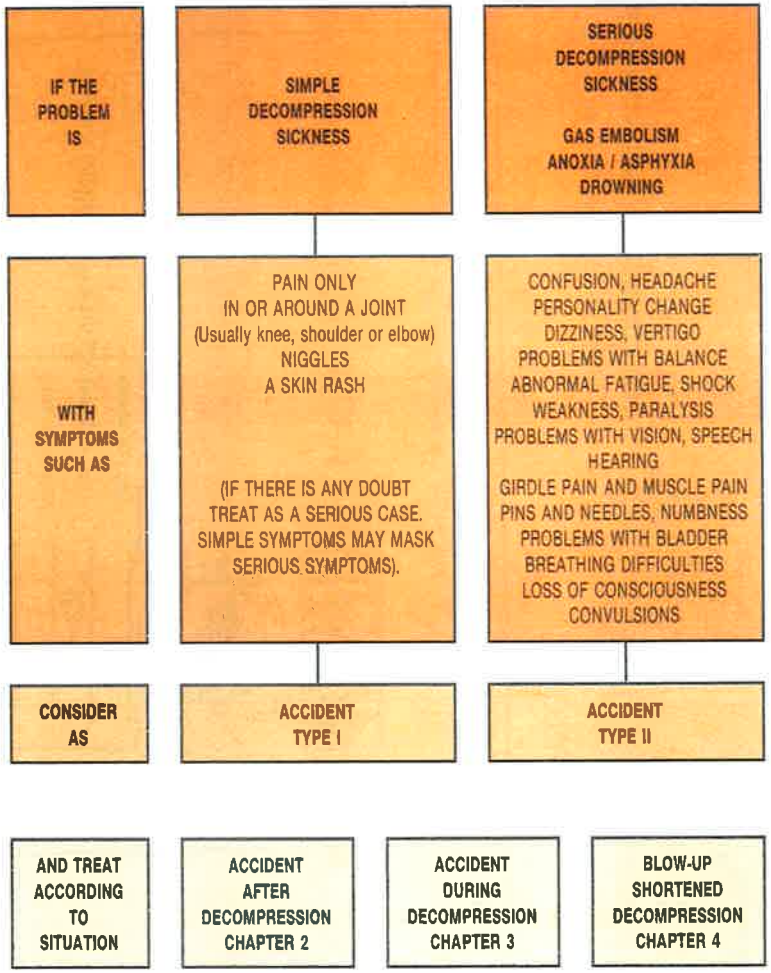
— Simple and spectacular symptoms may mask serious symptoms. If there is ANY DOUBT treat as a serious case.

— The more serious symptoms require greater recompression.

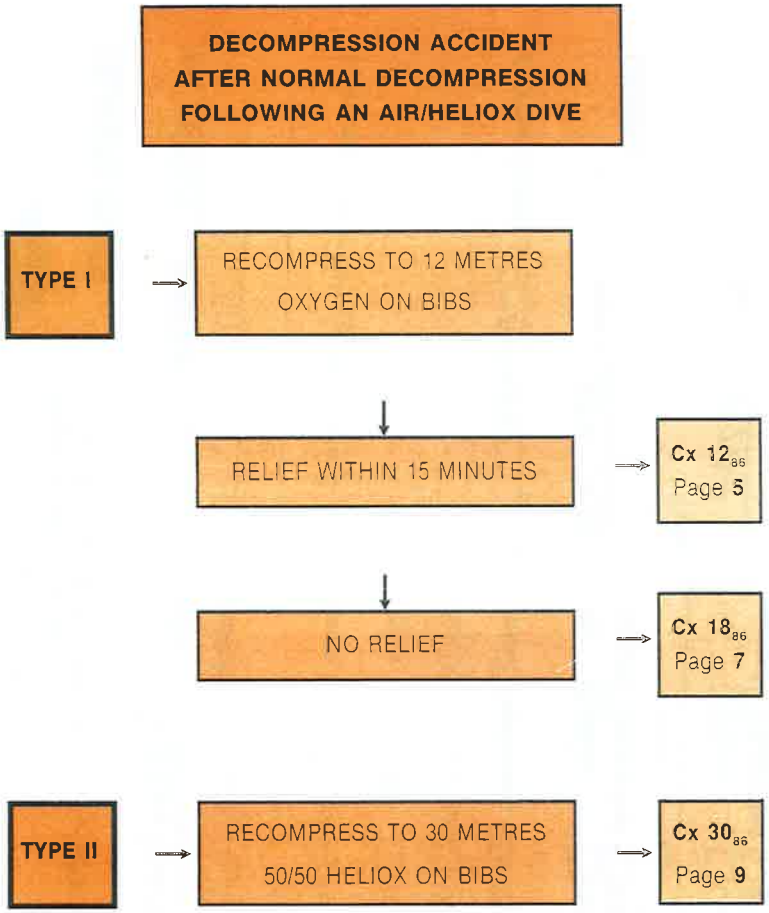
— The earlier the treatment, the better the result.

— Inadequate treatment may lead to a recurrence.

CHAPTER 1 - DIAGNOSIS AND ACTIONS FOR ACCIDENT RELATED TO DECOMPRESSION



CHAPTER 2



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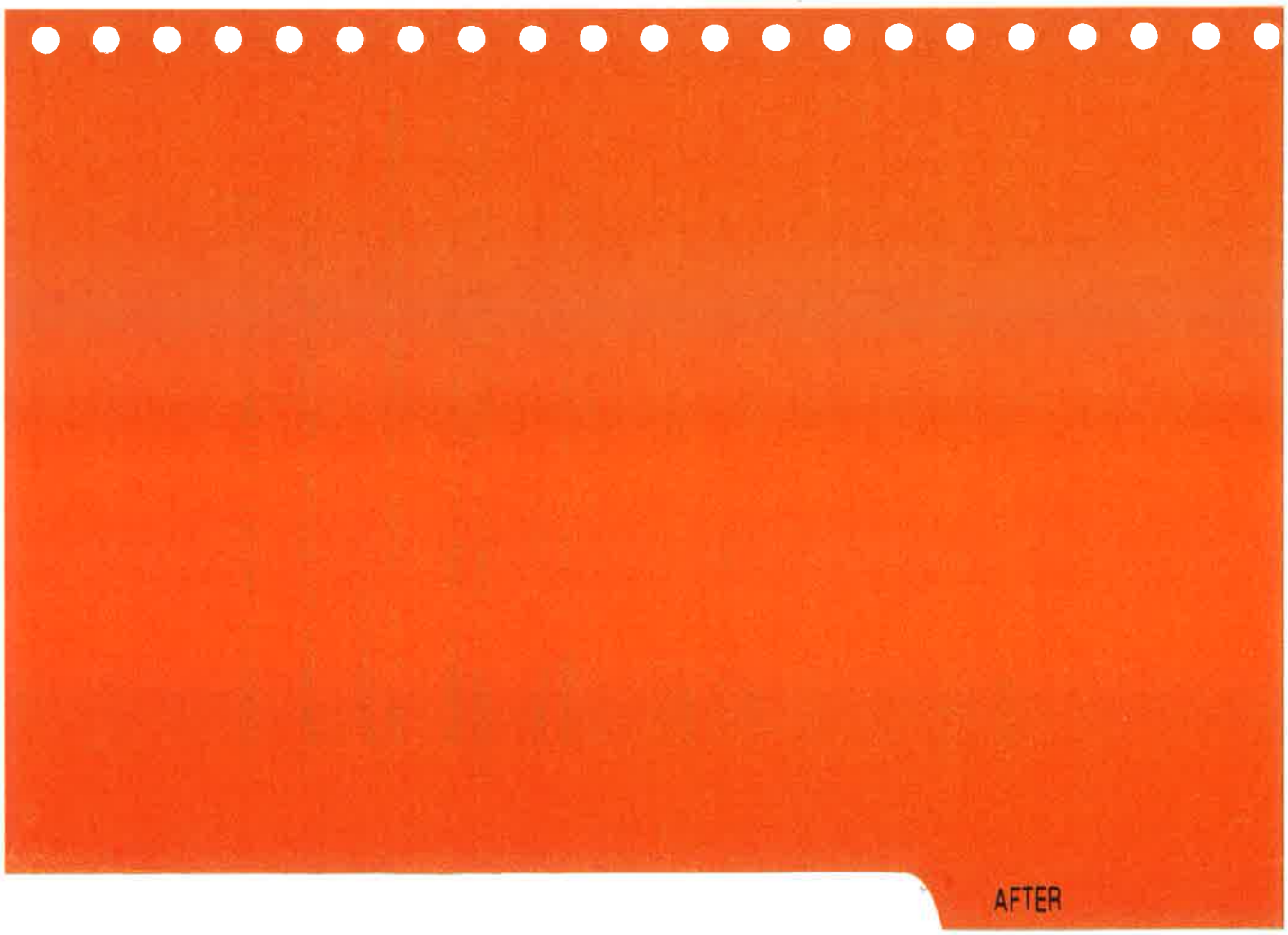

AFTER

2.1 TREATMENT TABLE Cx 12_{86}

Use for treatment of TYPE I accident AFTER NORMAL DECOMPRESSION of an AIR/NITROX/HELIOX dive.

RECOMPRESSION TO 12 METRES

— Pressurize chamber on Heliox 20/80 or Air to 12 metres as fast as possible.
— Put patient on Oxygen on BIBS asap.
— Note depth of relief (if relevant).

TREATMENT AT 12 METRES

— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n° 1 page 91.
— Put the patient on BIBS as per Table **Cx 12** opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval, thus he cannot be the second diver.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS during the ascent from 12 metres to surface.
— Attendant's surface interval after a Table **Cx 12** is 8 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— No relief within 15 minutes at 12m..... : apply Table **Cx 18** page 7
— Recurrence between 12m and surface.. : apply a second **Cx 12**
— Worsening of symptoms during treatment : apply Table **Cx 30** page 9

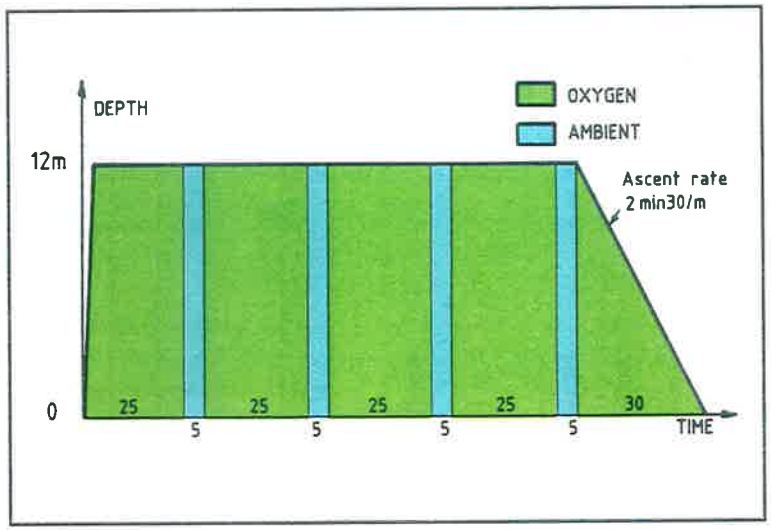
FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx 12_{86}

RECOMPRESS CHAMBER TO 12 METRES ON HELIOX 20/80 or AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
12 m	120 min	OXYGEN 4 BIBS sessions 25 min ON + 5 min OFF	AMBIENT	02h.00
12 - 0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	02h.30



2.2 TREATMENT TABLE Cx 18_{86}

Use for treatment of TYPE I accident AFTER NO RELIEF OR WORSENING of symptoms in a Table **Cx 12**.

RECOMPRESSION TO 18 METRES

— Pressurize chamber on Heliox 20/80 or Air from 12 to 18 metres as fast as possible.
— Keep patient on Oxygen on BIBS.
— Note depth of relief (if relevant).

TREATMENT AT 18 METRES

— Continue the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n°1, page 91 (if not already given at 12 m).
— Put the patient on BIBS as per Table **Cx 18** opposite. The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval, thus he cannot be the second diver.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS at 12 m (after the first 90 min Ambient) and during the ascent from 12 m to surface.
— Attendant's surface interval after a **Cx 18** is 12 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Contact immediately Medical/Safety Network.
— Change attendant using Air or Heliox decompression Table (**COMPULSORY**).
— No relief within 15 min at 18 m..... : apply Table **Cx 30** page 9
— Recurrence between 18 m and 12 m.... : apply a second **Cx 18**
— Recurrence between 12 m and surface. : apply Table **Cx 12** page 5
— Worsening of symptoms during treatment : apply Table **Cx 30** page 9

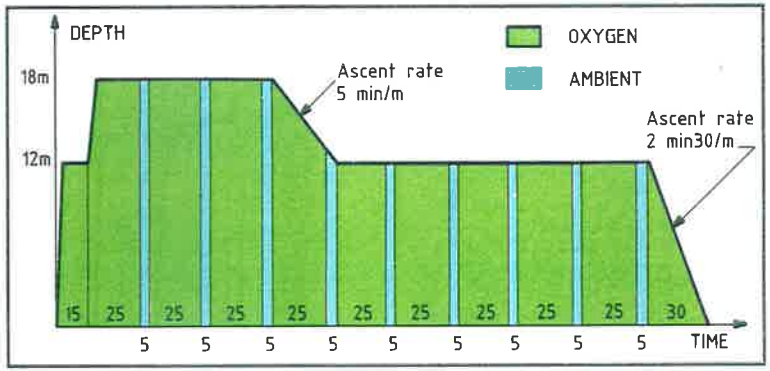
FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx 18_{86}

RECOMPRESS CHAMBER TO 18 METRES ON HELIOX 20/80 or AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
18 m	90 min	OXYGEN 3 BIBS sessions 25 min ON + 5 min OFF	AMBIENT	01h.30
18-12 m	30 min	OXYGEN 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	02h.00
12 m	150 min	OXYGEN 5 BIBS sessions 25 min ON + 5 min OFF	90 min AMBIENT Then OXYGEN 2 BIBS sessions 25 min ON + 5 min OFF	04h.30
12 - 0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	05h.00



2.3 TREATMENT TABLE Cx 30_{86}

Use for treatment of TYPE II accident AFTER NORMAL DECOMPRESSION of an AIR/NITROX/HELIOX dive.

RECOMPRESSION TO 30 METRES

— Pressurize chamber on Heliox 20/80 or Air to 30 metres as fast as possible.
— Put patient on BIBS on Heliox 50/50 asap.

TREATMENT AT 30 METRES

— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n°2A, page 93.
— Put the patient on BIBS as per Table **Cx 30** opposite.
The patient breathes 60 min on BIBS continuously at 30m.
Then he breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— Contact Medical/Safety Network who will inform a doctor.
— If attendant is a qualified paramedic, he applies Treatment n°3, page 93.
If not, he applies Treatment n° 2B, page 93 and waits for doctor to come.
— For decompression of the doctor refer to page 142- 143.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval, thus he cannot be the second diver.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS at 12 metres and during the ascent from 12 m to surface.
— Attendant's surface interval after a **Cx 30** is 24 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— If bottom time permits, change the attendant using Air or Heliox Decompression Table.
— Recompress to 30 m.
— Keep Patient on BIBS on Heliox 50/50 for 25min/5min sessions during a period not exceeding 3 hours and wait for instructions.

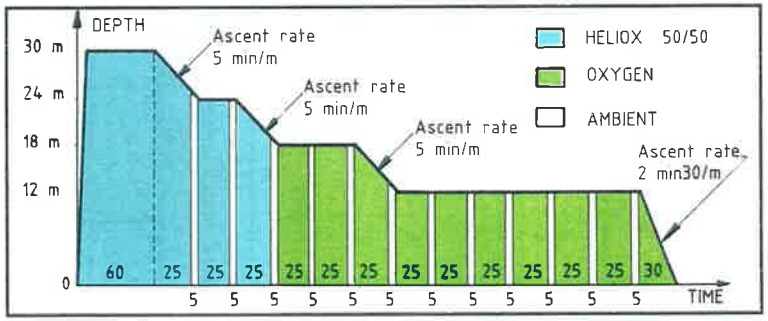
FOLLOW-UP

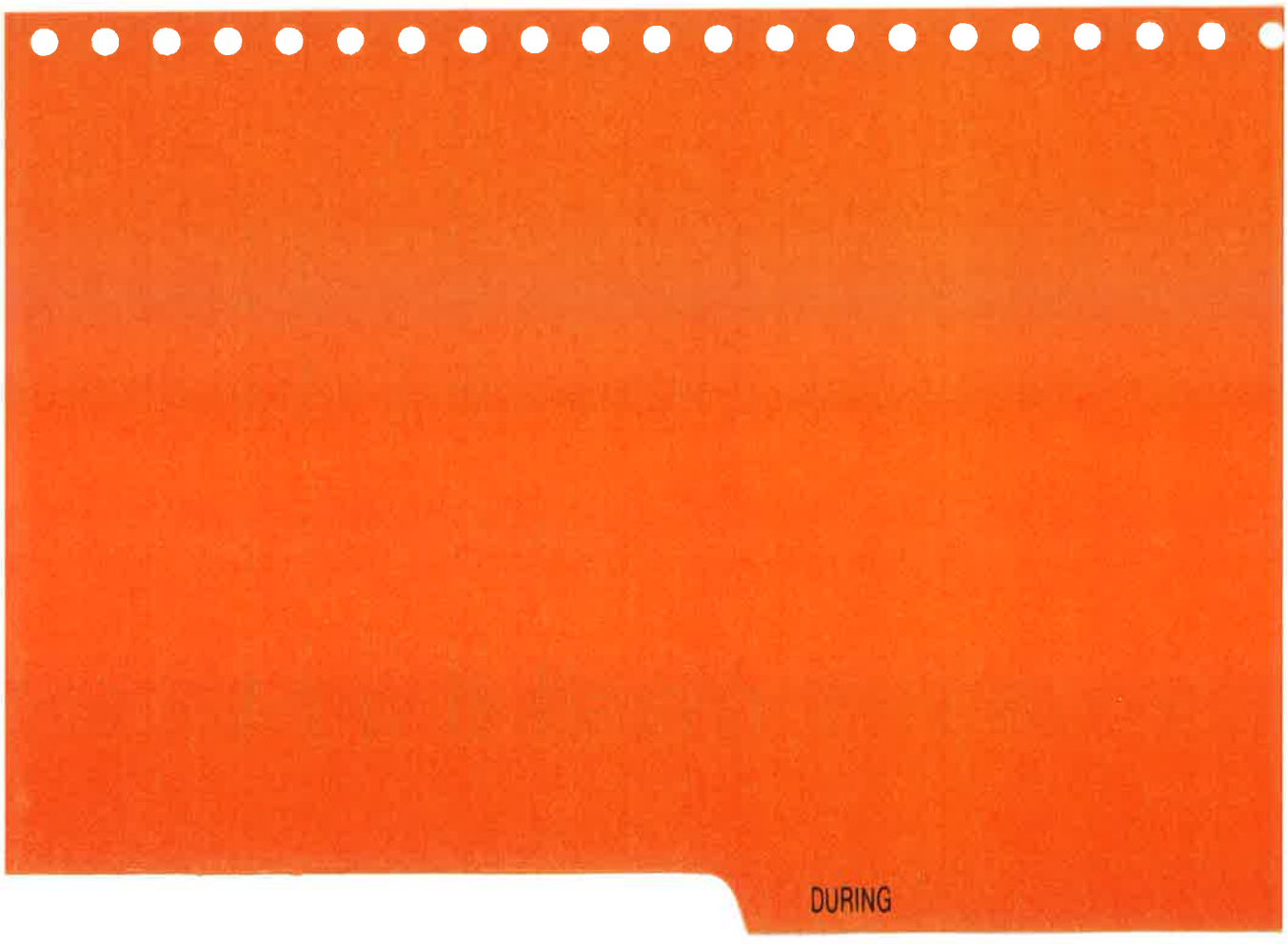
— Paperwork..... : see pages 118-119
— Flying after an accident..... : see page 135
— Diving after an accident..... : see page 134

Cx 30_{86}

RECOMPRESS CHAMBER TO 30 METRES ON HELIOX 20/80 or AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
30 m	60 min	HELIOX 50/50 60 min ON BIBS	AMBIENT	01h.00
30-24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	01h.30
24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	02h.00
24-18 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	02h.30
18 m	60 min	OXYGEN : 2 BIBS sessions 25 min ON + 5 min OFF	AMBIENT	03h.30
18-12 m	30 min	OXYGEN : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	04h.00
12 m	180 min	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	07h.00
12-0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	07h.30




DURING

GENERAL PRINCIPLES FOR GUIDANCE IN TREATMENT OF DECOMPRESSION ACCIDENTS

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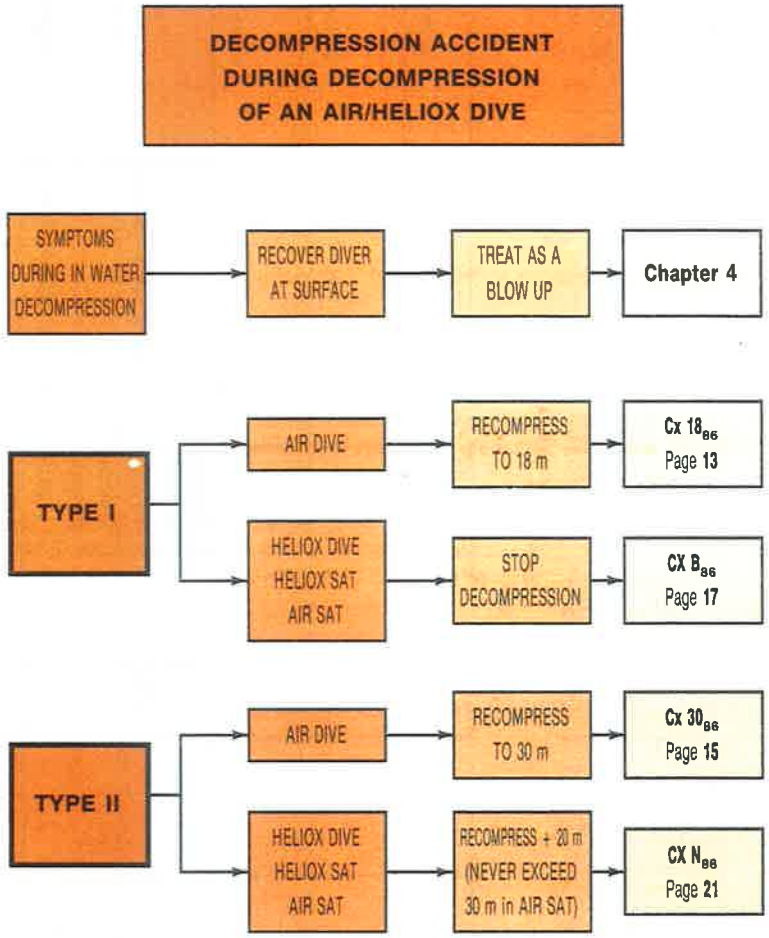
CHAPTER 3



3.1 TREATMENT TABLE Cx 18_{86}

Use for treatment of TYPE I accident DURING NORMAL DECOMPRESSION of an AIR/NITROX BOUNCE dive.

RECOMPRESSION TO 18 METRES

— Pressurize chamber on Air to 18 metres as fast as possible.
— Put patient on Oxygen on BIBS asap.
— Note depth of relief (if relevant).

TREATMENT AT 18 METRES

— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n°1, page 91.
— Put the patient on BIBS as per Table **Cx 18** opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval, thus he cannot be the second diver.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS at 12 m (after the first 90 min on Air) and during the ascent from 12 m to surface.
— Attendant's surface interval after a Table **Cx 18** is 12 hours.

SECOND DIVER

— He is on the same recompression Table as the patient.
— He breathes therapeutic gas on BIBS as the patient.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Contact immediately Medical/Safety Network.
— Change attendant using Air Decompression Table (**COMPULSORY**).
— No relief within 15 min at 18 m..... : apply Table **Cx 30** page 15
— Recurrence between 18 m and 12 m.... : apply a second **Cx 18**
— Recurrence between 12 m and surface. : apply Table **Cx 12** page 5
— Worsening of symptoms during treatment : apply Table **Cx 30** page 15

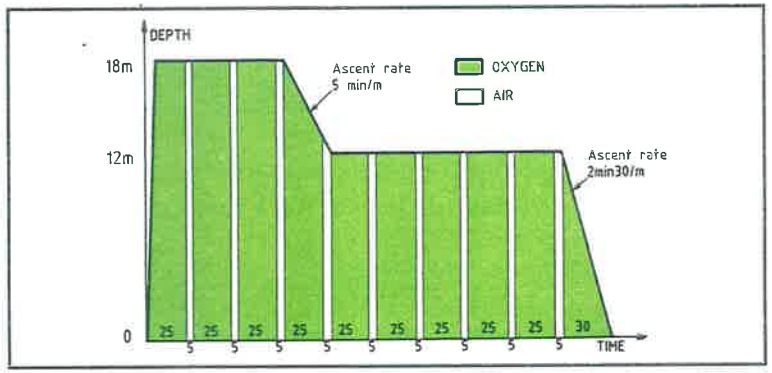
FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx 18_{86}

RECOMPRESS CHAMBER TO 18 METRES ON AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
18 m	90 min	OXYGEN 3 BIBS sessions 25 min ON + 5 min OFF	AIR	01h.30
18-12 m	30 min	OXYGEN 1 BIBS session 25 min ON + 5 min OFF	AIR	02h.00
12 m	150 min	OXYGEN 5 BIBS sessions 25 min ON + 5 min OFF	90 min AIR Then OXYGEN 2 BIBS sessions 25 min ON + 5 min OFF	04h.30
12 - 0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	05h.00



3.2 TREATMENT TABLE Cx 30_{86}

Use for treatment of TYPE II accident DURING NORMAL DECOMPRESSION of an AIR/NITROX BOUNCE dive.

RECOMPRESSION TO 30 METRES
— Pressurize chamber on Air to 30 metres as fast as possible.
— Put patient on BIBS on Heliox 50/50 asap.

TREATMENT AT 30 METRES
— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n°2A, page 93.
— Put the patient on BIBS as per Table **Cx 30** opposite.
The patient breathes 60 min on BIBS continuously at 30 m.
Then he breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— Contact Medical/Safety Network who will inform a doctor.
— If attendant is a qualified paramedic, he applies Treatment n°3, page 93.
If not, he applies Treatment n° 2B, page 93 and waits for doctor to come.
— For decompression of the doctor refer to pages 142- 143.

ATTENDANT
— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval, thus he cannot be the second diver.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS at 12 metres and during the ascent from 12 m to surface.
— Attendant's surface interval after a Table **Cx 30** is 24 hours.

SECOND DIVER
— He is on the same recompression Table as the patient.
— He breathes therapeutic gas on BIBS as the patient.

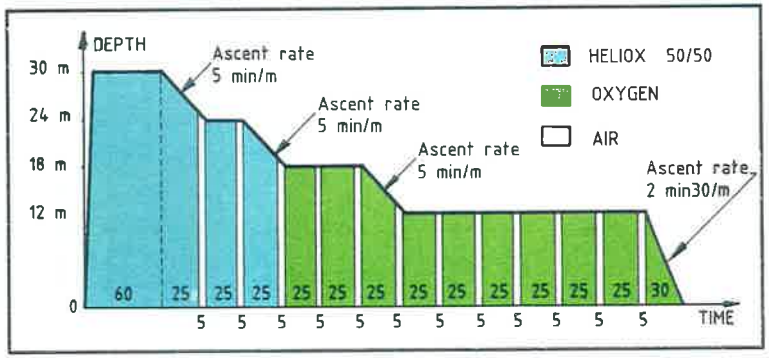
NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS
— If bottom time permits, change the attendant using Air Decompression Table.
— Recompress to 30 m.
— Keep the patient on BIBS on Heliox 50/50 for 25min/5min sessions during a period not exceeding 3 hours and wait for instructions.

FOLLOW-UP
— Paperwork..... : see pages 118-119
— Flying after an accident..... : see page 135
— Diving after an accident..... : see page 134

Cx 30_{86}

RECOMPRESS CHAMBER TO 30 METRES ON AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
30 m	60 min	HELIOX 50/50 60 min ON BIBS	AIR	01h.00
30-24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AIR	01h.30
24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AIR	02h.00
24-18 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AIR	02h.30
18 m	60 min	OXYGEN : 2 BIBS sessions 25 min ON + 5 min OFF	AIR	03h.30
18-12 m	30 min	OXYGEN : 1 BIBS session 25 min ON + 5 min OFF	AIR	04h.00
12 m	180 min	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	07h.00
12-0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	07h.30



3.3 TREATMENT TABLE Cx B_{86}

Use for treatment of TYPE I accident DURING NORMAL DECOMPRESSION of :
— HELIOX BELL BOUNCE dive
— AIR/HELIOX SATURATION.

TREATMENT

— Stop decompression. Start the Patient Check List : see page 141.
— Put the patient on BIBS as per Table **Cx B** opposite.
The 60 minutes period on BIBS should be taken without interruption.
— For the use of an Alternative Therapeutic Mix refer to page 136.
— A diver gives the patient the Medical Treatment n°1, page 91.
— A diver fills in the Patient Check List every hour.

DECOMPRESSION

After successful treatment resume decompression as follows :
— **Heliox Bell Bounce dive** : use the same Table (same depth, same bottom-time) and add 10 minutes to EACH stop of the initial decompression protocol.
— **Heliox Saturation** : apply Standard Heliox Saturation Decompression.
— **Air Saturation** : apply Standard Air Saturation Decompression.

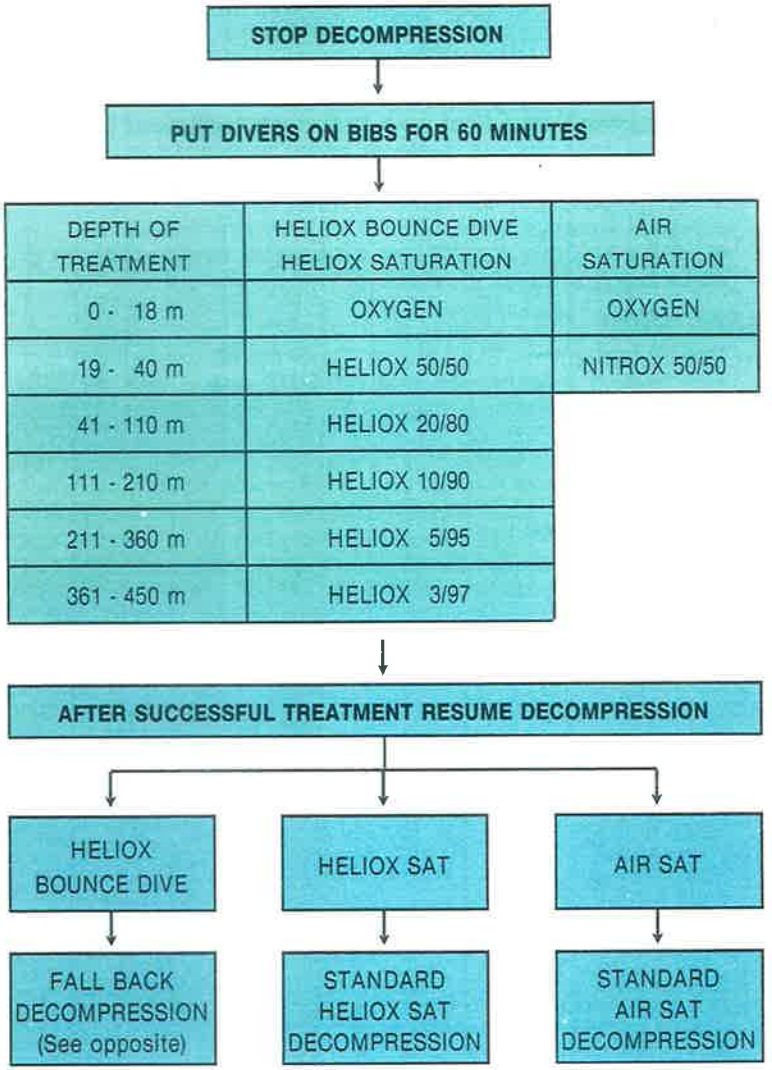
NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— No relief after 15 minutes..... : apply Table **Cx SB** page 19
— Recurrence later during decompression. : apply a second Table **Cx B**
— Worsening of symptoms during treatment : apply Table **Cx N** page 21

FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx B_{86}



3.4 TREATMENT TABLE Cx SB_{86}

Use in case of failure of a Table **Cx B** for the treatment of TYPE I accident DURING NORMAL DECOMPRESSION of :
— HELIOX BELL BOUNCE dive
— AIR/HELIOX SATURATION.

RECOMPRESSION

— Recompress the patient with the depth increment indicated opposite according to depth at which accident has occurred.
— Pressurize the chamber with :
  • Heliox Deep Mix for Heliox Bounce dive
  • Heliox Pressurization Mix for Heliox Saturation
  • Air for Air Saturation (**Never pressurize deeper than 30 m**).
— Note depth of relief (if relevant).

TREATMENT

— Put the patient on BIBS as per Table **Cx SB** opposite. The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— For the use of an Alternative Therapeutic Mix refer to page 136.
— A diver fills in the Patient Check List every hour.

DECOMPRESSION

After successful treatment resume decompression as follows :
— **Heliox Bounce dive** : Standard Air or Heliox Saturation Decompression Table depending on chamber atmosphere.
— **Heliox Saturation** : Standard Heliox Saturation Decompression.
— **Air Saturation** : Standard Air Saturation Decompression.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Recurrence of symptoms later in the decompression : apply Table **Cx B** page 17
— Worsening of symptoms during treatment : apply Table **Cx N** page 21

FOLLOW-UP

— Paperwork..... : see pages 118-119
— Flying after an accident..... : see page 135
— Diving after an accident..... : see page 134

Cx SB_{86}

RECOMPRESS DIVER

PUT DIVER ON BIBS (25 min ON + 5 min OFF)

DEPTH OF ACCIDENT	DEPTH OF TREATMENT	BIBS BREATHING DURATION	HELIOX BOUNCE DIVE HELIOX SAT	AIR SATURATION
0 - 12 m	PLUS 6 m	120 min	OXYGEN	OXYGEN
13 - 31 m	PLUS 9 m	120 min	HELIOX 50/50	NITROX 50/50
32 - 98 m	PLUS 12 m	120 min	HELIOX 20/80	
99 - 195 m	PLUS 15 m	120 min	HELIOX 10/90	
196 - 345 m	PLUS 15 m	120 min	HELIOX 5/95	
346 - 450 m	PLUS 15 m	120 min	HELIOX 3/97	

AFTER SUCCESSFUL TREATMENT RESUME DECOMPRESSION

HELIOX BOUNCE DIVE (WITH HELIOX CHAMBER ATMOSPHERE) HELIOX SAT → STANDARD HELIOX SAT DECOMPRESSION

HELIOX BOUNCE DIVE WITH AIR CHAMBER ATMOSPHERE → STANDARD AIR SAT DECOMPRESSION

AIR SAT → STANDARD AIR SAT DECOMPRESSION

3.5 TREATMENT TABLE Cx N_{86}

Use for treatment of TYPE II accident DURING NORMAL DECOMPRESSION of :
— HELIOX BELL BOUNCE dive
— AIR/HELIOX SATURATION.

RECOMPRESSION
— Recompress the patient 20 metres deeper.
— Pressurize the chamber with :
  • Heliox Deep Mix for Heliox Bounce dive
  • Heliox Pressurization Mix for Heliox Saturation
  • Air for Air Saturation (**Never pressurize deeper than 30 m**).

TREATMENT
— Start the Patient Check List : see page 141.
— Put the patient on BIBS as per Table **Cx N** opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— For the use of an Alternative Therapeutic Mix refer to page 136.
— A diver gives the patient the Medical Treatment n°2A, page 93.
— Contact Medical/Safety Network who will inform a doctor.
— If attendant is a qualified paramedic he applies Treatment n°3, page 93.
If not, he applies Treatment n°2B, page 93 and waits for doctor to come.
— For decompression of the doctor refer to pages 142- 143
— One diver fills in the Patient Check List every hour.

DECOMPRESSION
After successful treatment resume decompression as follows :
— **Heliox Bounce dive or Heliox Saturation** :
  • 60 minutes/metre from 200m to 15m ; PO_2 = 600 to 630 mb
  • 80 minutes/metre from 15m to surface with O_2 percentage of 23 to 24 %.
— **Air Saturation** :
  • 120 minutes/metre from 30m to 15m ; PO_2 = 600 to 630 mb
  • 180 minutes/metre from 15m to surface with O_2 percentage of 23 to 24 %.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS
— Recurrence of symptoms later in decompression : apply a second Table **Cx N.**
— No relief of symptoms : keep patient on BIBS on 25min/5min sessions (for no more than 3 hours) and wait for instructions.

FOLLOW-UP

— Paperwork..... : see pages 118-119
— Flying after an accident..... : see page 135
— Diving after an accident..... : see page 134

Cx N_{86}

RECOMPRESS DIVER TO A DEPTH OF TREATMENT EQUAL TO DEPTH OF ACCIDENT + 20 METRES (DO NOT EXCEED 30 METRES IN AIR SAT)

↓

PUT DIVER ON BIBS (25 min ON + 5 min OFF)

↓

DEPTH OF TREATMENT AFTER RECOMPRESSION	BIBS BREATHING DURATION	HELIOX BOUNCE DIVE HELIOX SAT	AIR SAT
20 - 40 m	120 min	HELIOX 50/50	NITROX 50/50
41 - 110 m	180 min	HELIOX 20/80	
111 - 210 m	240 min	HELIOX 10/90	
211 - 360 m	300 min	HELIOX 5/95	
361 - 450 m	360 min	HELIOX 3/97	

↓

AFTER SUCCESSFUL TREATMENT RESUME DECOMPRESSION

↓

HELIOX BOUNCE DIVE HELIOX SAT → APPLY SPECIAL SAT HELIOX (See opposite)

AIR SAT → APPLY SPECIAL SAT AIR (See opposite)

BLOW-UP

GENERAL PRINCIPLES FOR GUIDANCE IN TREATMENT OF DECOMPRESSION ACCIDENTS

— COMEX procedures recognize only two decompression accidents

TYPE I corresponds to **simple** accidents such as joint pain and skin rash

TYPE II corresponds to **serious** accidents (the rest of them)

It is not important to distinguish between burst lung with embolism and serious decompression sickness the treatment is the same

— Simple and spectacular symptoms may mask serious symptoms. If there is ANY DOUBT treat as a serious case

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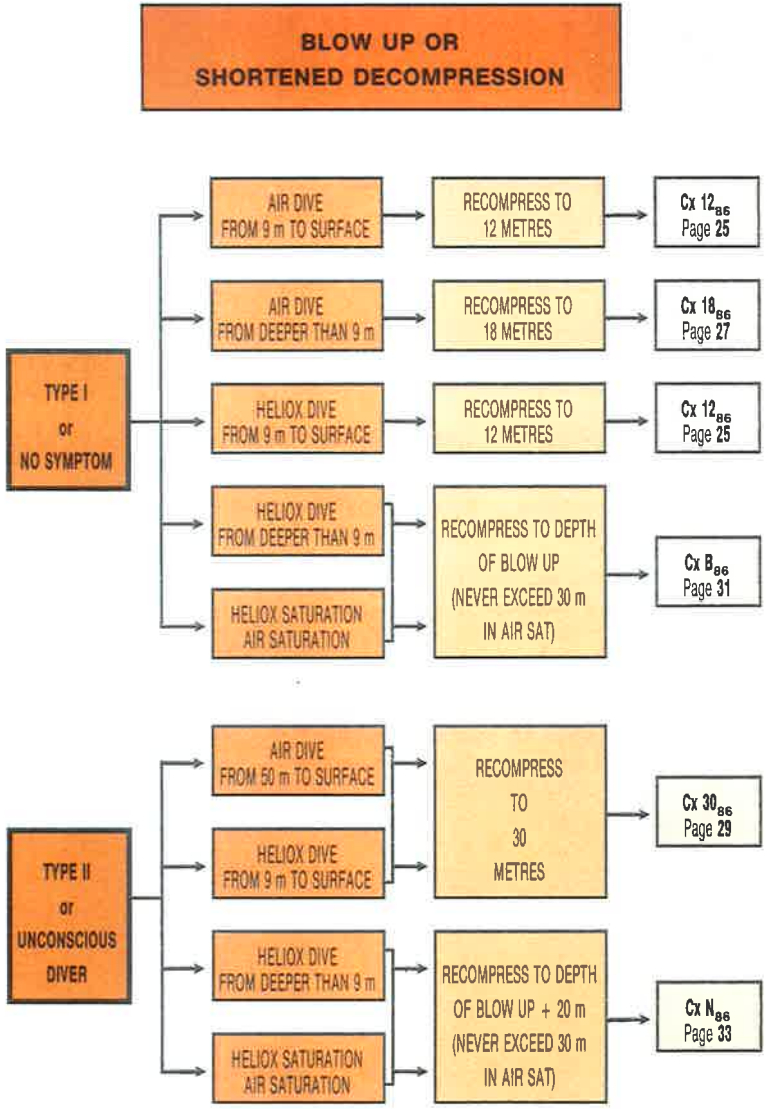
CHAPTER 4



4.1 TREATMENT TABLE Cx 12_{86}

Use for treatment of TYPE I accident after a BLOW-UP from 9 metres to surface in an AIR/NITROX/HELIOX BOUNCE dive.

RECOMPRESSION TO 12 METRES

— Pressurize chamber on Heliox 20/80 or Air to 12 metres as fast as possible
— Put patient on Oxygen on BIBS asap
— Note depth of relief (if relevant).

TREATMENT AT 12 METRES

— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n°1, page 91.
— Put the patient on BIBS as per Table **Cx** 12 opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— Check for symptoms of a **TYPE II** accident.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS during the ascent from 12 m to surface.
— Attendant's surface interval after a Table **Cx 12** is 8 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— No relief within 15 minutes at 12m..... : apply Table **Cx 18** page 27
— Recurrence between 12m and surface.. : apply a second **Cx 12**
— Worsening of symptoms during treatment : apply Table **Cx 30** page 29

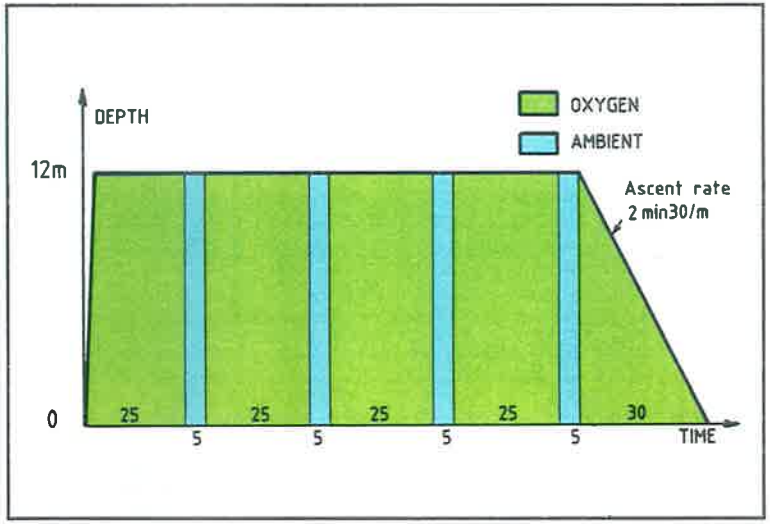
FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx 12_{86}

RECOMPRESS CHAMBER TO 12 METRES ON HELIOX 20/80 or AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
12 m	120 min	OXYGEN 4 BIBS sessions 25 min ON + 5 min OFF	AMBIENT	02h.00
12 - 0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	02h.30



4.2 TREATMENT TABLE Cx 18_{86}

Use for treatment of TYPE I accident after a BLOW-UP from deeper than 9 m in an AIR/NITROX BOUNCE dive.

RECOMPRESSION TO 18 METRES

— Pressurize chamber on Air to 18 metres as fast as possible
— Put patient on Oxygen on BIBS asap
— Note depth of relief (if relevant).

TREATMENT AT 18 METRES

— Start the Patient Check List : see page 141.
— The attendant gives the patient the Medical Treatment n° 1, page 91.
— Put the patient on BIBS as per Table **Cx 18** opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— Check for symptoms of a **TYPE II** accident.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval.
— He fills in the Patient Check List every hour.
— He breathes Oxygen on BIBS at 12 m (after the first 90 min on Air) and during the ascent from 12 m to surface.
— Attendant's surface interval after a **Cx 18** is 12 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Contact immediately Medical/Safety Network.
— Change attendant using air decompression Table (**COMPULSORY**).
— No relief within 15 min at 18 m..... : apply Table **Cx 30** page 29
— Recurrence between 18 m and 12 m.... : apply a second **Cx 18**
— Recurrence between 12 m and surface. : apply Table **Cx 12** page 25
— Worsening of symptoms during treatment : apply Table **Cx 30** page 29

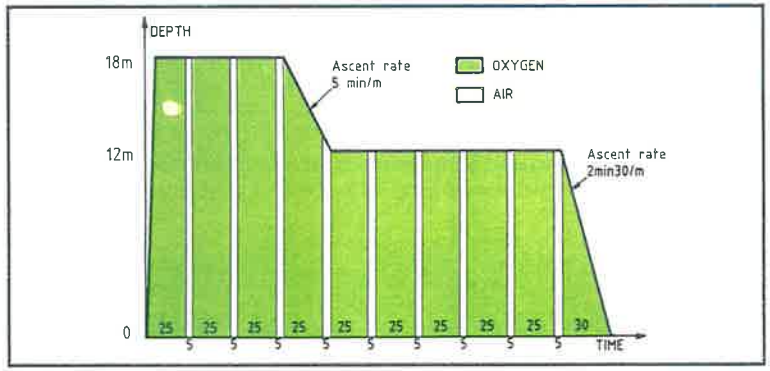
FOLLOW-UP

— Paperwork..... : see pages 118-119
— Diving after an accident..... : see page 135
— Flying after an accident..... : see page 134

Cx 18_{86}

RECOMPRESS CHAMBER TO 18 METRES ON AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
18 m	90 min	OXYGEN 3 BIBS sessions 25 min ON + 5 min OFF	AIR	01h.30
18-12 m	30 min	OXYGEN 1 BIBS session 25 min ON + 5 min OFF	AIR	02h.00
12 m	150 min	OXYGEN 5 BIBS sessions 25 min ON + 5 min OFF	90 min AIR Then OXYGEN 2 BIBS sessions 25 min ON + 5 min OFF	04h.30
12 - 0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	05h.00



4.3 TREATMENT TABLE Cx 30_{86}

Use for treatment of a TYPE II accident after a BLOW-UP from :
— 0 to 50 m in AIR/NITROX BOUNCE dive
— 0 to 9 m in HELIOX BOUNCE dive.

RECOMPRESSION TO 30 METRES

— Pressurize chamber on Heliox 20/80 or Air to 30 metres as fast as possible.
— Put patient on Heliox 50/50 on BIBS asap.

TREATMENT AT 30 METRES

— Start the Patient Check List : see page 141.
— Put the patient on BIBS as per Table **Cx 30** indicated opposite. The patient breathes 60 min on BIBS continuously at 30 m. Then he breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— The attendant gives the patient the Medical Treatment n°2A, page 93.
— Contact Medical/Safety Network who will inform a doctor.
— If attendant is a qualified paramedic, he applies Treatment n°3, page 93.
If not, he applies Treatment n°2B, page 93 and waits for doctor to come.
— For decompression of the doctor refer to pages 142 - 143.

ATTENDANT

— One attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval.
— He fills in the Patient Check List every hour.
— He must breathe Oxygen on BIBS at 12 metres and during the ascent from 12 m to surface.
— Attendant's surface interval after a Table **Cx 30** is 24 hours.

NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— If bottom time permits, change the attendant using Air Decompression Table.
— Recompress to 30 m.
— Put the patient on BIBS on Heliox 50/50 for 25min/5min sessions during a period not exceeding 3 hours and wait for instructions.

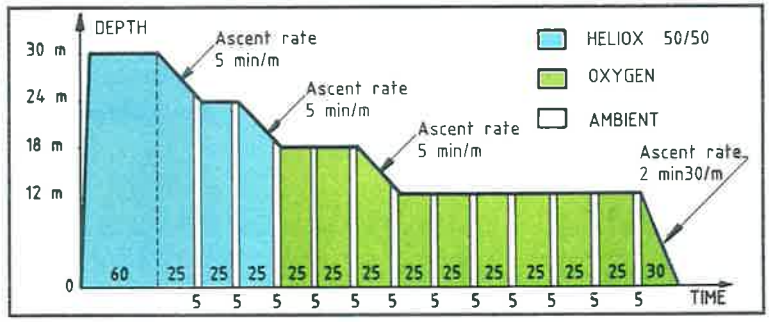
FOLLOW-UP

— Paperwork ..... : see pages 118-119
— Diving after an accident ..... : see page 135
— Flying after an accident ..... : see page 134

Cx 30_{86}

RECOMPRESS CHAMBER TO 30 METRES ON HELIOX 20/80 or AIR

DEPTH	DURATION	BREATHING MIX		ELAPSED TIME
		PATIENT	ATTENDANT	
30 m	60 min	HELIOX 50/50 60 min ON BIBS	AMBIENT	01h.00
30-24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	01h.30
24 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	02h.00
24-18 m	30 min	HELIOX 50/50 : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	02h.30
18 m	60 min	OXYGEN : 2 BIBS sessions 25 min ON + 5 min OFF	AMBIENT	03h.30
18-12 m	30 min	OXYGEN : 1 BIBS session 25 min ON + 5 min OFF	AMBIENT	04h.00
12 m	180 min	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	OXYGEN : 6 BIBS sessions 25 min ON + 5 min OFF	07h.00
12-0 m	30 min	OXYGEN 30 min ON BIBS	OXYGEN 30 min ON BIBS	07h.30



4.4 TREATMENT TABLE Cx B_{86}

Use for treatment of TYPE I accident after a BLOW-UP from :
— DEEPER THAN 9 m in an HELIOX BOUNCE dive
— AIR/HELIOX SATURATION.

RECOMPRESSION

— Recompress the patient to the depth of departure of the BLOW-UP.
— Pressurize the chamber with :
  • Heliox Bottom Mix for Heliox Bounce dive
  • Heliox Pressurization Mix for Heliox Saturation
  • Air for Air Saturation (**Never pressurize deeper than 30 m**)
— Put patient on BIBS asap.

TREATMENT

— Start the Patient Check List : see page 141.
— Put the patient on BIBS as per Table **Cx B** opposite.
The 60 min period on BIBS should be taken without interruption.
— For the use of an Alternative Therapeutic Mix refer to page 136.
— The attendant gives the patient the Medical Treatment n° 1, page 91.
— Check for symptoms of a TYPE II accident.

DECOMPRESSION

After successful treatment resume decompression as follows :
— **Heliox Bell Bounce dive** : use the same Table (same depth, same bottom-time) and add 10 minutes to EACH stop of the initial decompression protocol.
— **Heliox Saturation** : apply Standard Heliox Saturation Decompression.
— **Air Saturation** : apply Standard Air Saturation Decompression.

ATTENDANT

— An attendant (paramedic if possible) must enter the chamber. He must have cleared any previous decompression surface interval.
— He fills in the Patient Check List every hour.
— He is decompressed on the same Table as the divers.

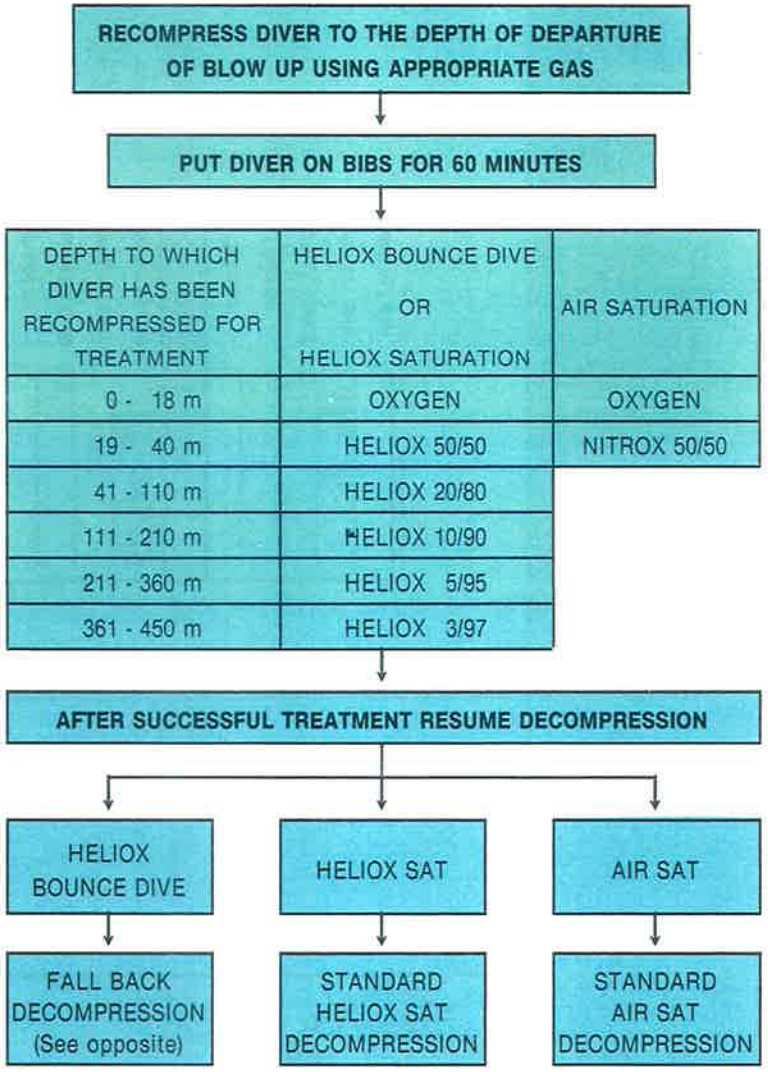
NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Immediately contact Medical/Safety Network.
— Apply Table **Cx N** page 33.

FOLLOW-UP

— Paperwork ..... : see pages 118-119
— Diving after an accident ..... : see page 135
— Flying after an accident ..... : see page 134

Cx B_{86}



4.5 TREATMENT TABLE Cx N_{86}

Use for treatment of TYPE II accident after a BLOW- UP from :
— DEEPER THAN 9 m in an HELIOX BOUNCE dive
— AIR/HELIOX SATURATION.

RECOMPRESSION

— Recompress to the depth of departure of the BLOW-UP **PLUS** 20 metres.
— Pressurize the chamber with :
  • Heliox Bottom Mix for Heliox Bounce dive.
  • Heliox Pressurization Mix for Heliox Saturation.
  • Air for Air Saturation dive (**Never pressurize deeper than 30 m**)
— Put patient on BIBS asap. Start the Patient Check List.

TREATMENT

— Put the patient on BIBS as per Table **Cx N** opposite.
The patient breathes 25 min on BIBS and 5 min off BIBS (chamber atmosphere) for each 30 min BIBS period indicated in the Table.
— If the patient is unable to breathe on BIBS raise the chamber PO_2
— For the use of an Alternative Therapeutic Mix refer to page 136.
— The attendant gives the patient the Medical Treatment n°2A, page 93.
— Contact Medical/Safety Network who will inform a doctor.
— If attendant is a qualified paramedic, he applies Treatment n°3, page 93.
If not, he applies Treatment n°2B, page 93 and waits for doctor to come.
— For decompression of the doctor refer to pages 142- 143.

DECOMPRESSION

After successful treatment resume decompression as follows :
— **Heliox Bounce dive or Heliox Saturation** :
  • 60 minutes/metre from 200m to 15m ; PO_2 = 600 to 630 mbar
  • 80 minutes/metre from 15m to surface ; O_2 percentage = 23 to 24 %
— **Air Saturation :**
  • 120 minutes/metre from 30m to 15m ; PO_2 = 600 to 630 mbar
  • 180 minutes/metre from 15m to surface with O_2 percentage of 23 to 24 %

ATTENDANT

— An attendant (paramedic if possible) must enter the chamber.
— He fills in the Patient Check List every hour.
— He is decompressed on the same Table as the divers.

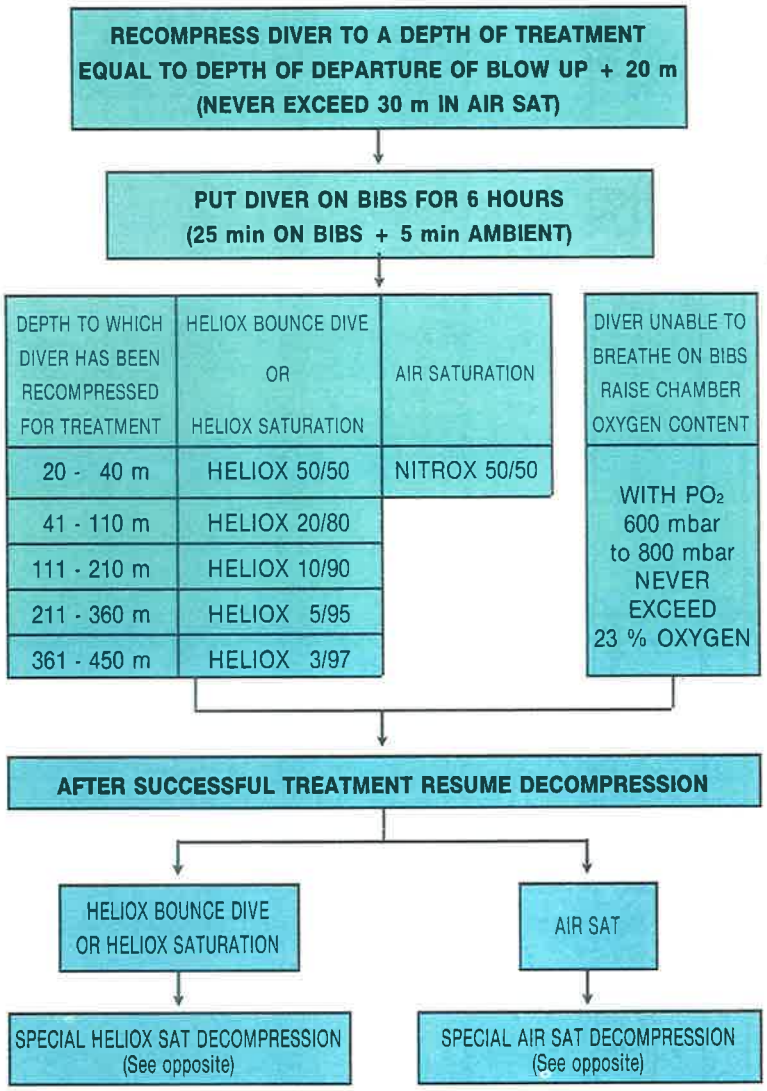
NO RELIEF/RECURRENCE/WORSENING OF SYMPTOMS

— Recurrence of symptoms later in decompression : apply a second Table **Cx N**.
— No relief of symptoms : keep patient on BIBS on 25min/5min sessions (for no more than 3 hours) and wait for instructions.

FOLLOW-UP

— Paperwork ..... : see pages 118-119
— Flying after an accident ..... : see page 135
— Diving after an accident ..... : see page 134

Cx N_{86}



OTHERS

CHAPTER 5

OTHER DIVING RELATED INCIDENTS/ACCIDENTS

5.1 DIVING FIRST AID : BASIC PRINCIPLES

When dealing with a casualty the life saving principles are :

RECOVER THE DIVER IN A SAFE PLACE

Send the standby diver in, or lock out the bellman.

ASSURE CLEAR AIRWAYS

— Make sure the diver's airway is clear by running a finger around the inside of the throat and clearing out any debris.
— Ensure that the tongue has not fallen back to block the throat. If it has, pull the jaw forward and this will bring the tongue with it.

RESTORE BREATHING (mouth to mouth respiration : see **sketch 1**)

— Bend the head well back and close the nostrils with the thumb and finger.
— Inflate the lungs by blowing into the partially open mouth, making sure your lips form a good seal.
— If blowing into the mouth is difficult, it may be found more convenient to keep the mouth closed and blow through the nose.
— If a guedel tube is available, insert it over the tongue.
— If the chest can be inflated it will empty spontaneously by its own recoil when you take your lips away.
— Repeat this cycle 8 times per minute.

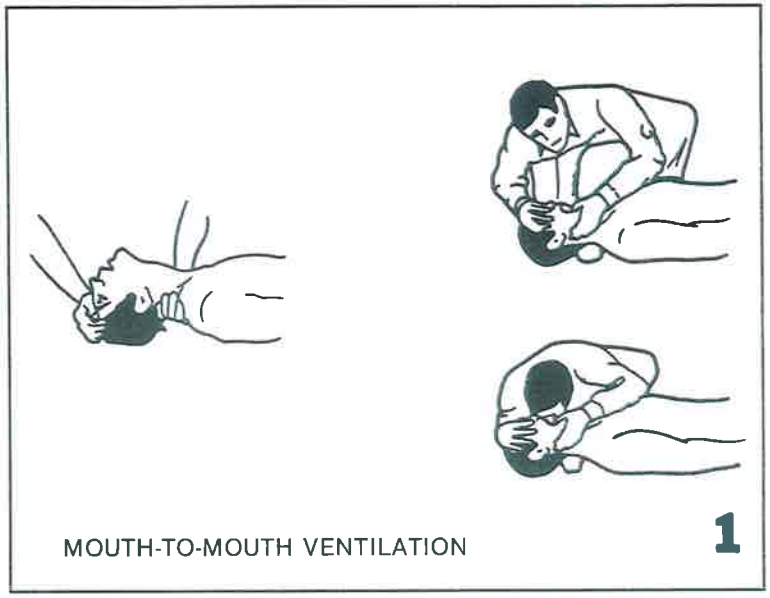
STOP MASSIVE BLEEDING

Use compressive bandage, tourniquet.

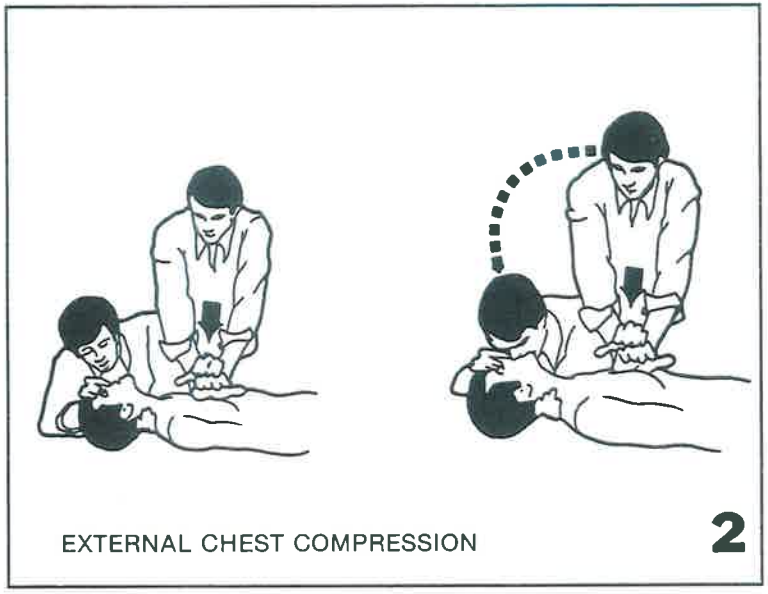
ASSURE HEART FUNCTIONS (external cardiac massage : see **sketch 2**)

In addition to cessation of breathing, the diver's heart may have stopped, as indicated by :
— absence of pulsation felt over the heart, or at the carotid artery,
— wide dilatation of the pupils of the eyes.

External cardiac massage must be carried out in addition to artificial respiration, as follows :
— Place the patient on his back on a firm base,
— Apply enough pressure to the lower part of the breast bone to push it down about 5 cm and then release the pressure,
— Repeat this ten times at the rate of one per second,
— After ten presses, inflate the lungs three times as in artificial resuscitation and then continue with external cardiac massage for ten presses and so on.



MOUTH-TO-MOUTH VENTILATION **1**



EXTERNAL CHEST COMPRESSION **2**

5.2 LOSS OF CONSCIOUSNESS

A variety of factors may cause a diver to loose consciousness.

INABILITY TO CONTROL BREATHING RATE

If the diver's breathing rate becomes too rapid then due to breathing restrictions of the demand valve, his respiration may become faster and shallower thus accumulating CO_2 in his body up to a point where he passes out. This phenomenon can be accelerated by cold, fatigue, fear, etc...

COLD (HYPOTHERMIA)

If the diver, though some malfunction or misuse of his heating system, tries too hard to finish a job despite feeling extremely cold, he could find himself in a situation of hypothermia.

OVERHEATING (HYPERTHERMIA)

If wrongly adjusted (too hot), diver's hot water suit and gas heater can heat the diver's body, thus causing his core temperature to rise. Increase body temperature may cause the diver to faint, when re-entering the bell.

ASPHYXIA

Reducing the supply of Oxygen to the brain causes the diver to lose consciousness. This can originate from :

— interruption of gas supply,
— wrong mixture being supplied to the diver,
— paralysis of respiratory muscles due to electrical or emotional shock, etc ...
— Drowning : this can happen if the diver's head equipment is pulled off accidentally, voluntarily or in panic.
Inhalation of vomit : vomiting could be induced by over-heating prior to a dive, indigestion, CO_2 poisoning, over- exertion, traumatic injury, fear, etc... This is a very dangerous situation if breathing apparatus is being worn at the time because inhalation of the vomit may occur and lead to asphyxia.

O_2 POISONING

Wrong selection of gas, or the operation of the wrong circuit supplying the diver with a mixture containing a higher partial pressure of O_2 will lead to hyperoxic convulsion, and unconsciousness.

CO_2 POISONING

If for some technical reason, the quantity of CO2 drastically rises in the breathing gas, discomfort then unconsciousness can set in rapidly. An aggravating factor is that it causes anxiety and thus accelerates the breathing rate.

PHYSICAL INJURY

While diving, a direct blow on the head could cause unconsciousness, or other traumatic injury may cause the diver to pass out from pain or loss of blood, or induce vomiting and subsequent drowning.

Whatever the reasons, an unconscious diver underwater is in danger of dying and no time must be wasted in removing him from his situation.

5.3 THE HANDLING OF AN UNCONSCIOUS DIVER AT SURFACE

SITUATION

If a surface diver runs into difficulties and requires to be rescued back at the surface, the following situations may be present :

— Diver is conscious with no symptoms.
Short bottom time, shallow depth ; no need for decompression. No signs or symptoms. No action required.

— Diver is conscious with or without symptoms.
Bottom time requires decompression : refer to blow up flow chart chapter 4, page 23.

— Diver is unconscious.

DISCUSSION

During the course of an emergency ascent to surface, it is unlikely that decompression sickness would have caused unconsciousness, but pulmonary barotrauma, drowning or asphyxia are likely possibilities.

— Drowning/asphyxia requires primarily resuscitation (although recompression may help marginally).

— Embolism requires immediate recompression to 30 metres.

As differentiating between these conditions in the case of an unconscious and possibly pulseless patient is near impossible. (Blood and froth in the mouth may indicate pulmonary barotrauma as well as tongue biting).

As a CONCLUSION, as we are in doubt, the patient must be transported to the chamber while resuscitation is applied.

PROCEDURE

Transport the patient to deck chamber on a stretcher.
The ventilation component of CPR (Cardiac Pulmonary Resuscitation) can be performed during transport using the CX Pro Oxygen resuscitator.

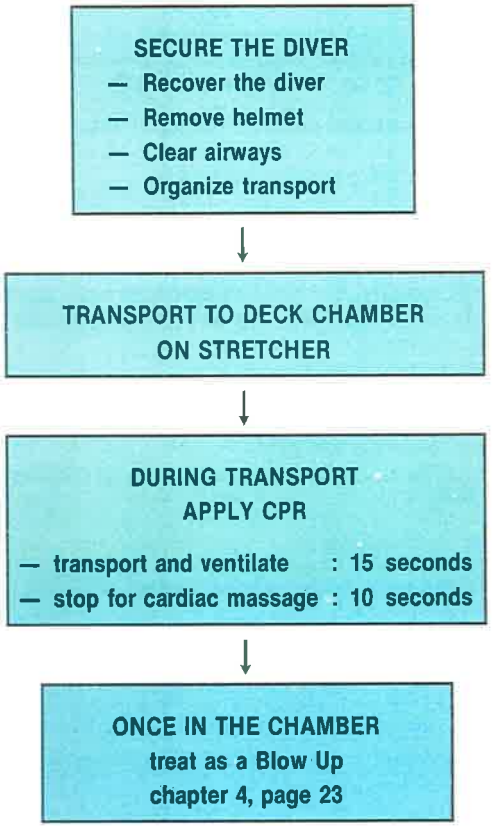
Schedule for transport with CPR :

When ready —	Transport and ventilate	15 seconds
	Stop for cardiac massage	10 seconds
	Transport and ventilate	15 seconds
	Stop for cardiac massage	10 seconds

This cycle is to be continued until the patient is in the chamber, where CPR can continue.

Once the diver is in the chamber, treat as a Blow Up/Shortened decompression accident, see chapter 4, page 23.

HANDLING OF AN UNCONSCIOUS DIVER AT SURFACE



5.4 THE HANDLING OF AN UNCONSCIOUS DIVER IN BELL

SITUATION

When a diver becomes unconscious out of a bell, for whatever reason, it must be assumed that he is not breathing or not breathing sufficiently. **Thus he is in danger of death.**

Knowing that after a short period of oxygen deprivation, permanent damage will occur to the brain, **the man must be brought back to safety as soon as possible either by :**
— The bellman pulling him by his umbilical line (providing neither he nor his line is tangled anywhere) ;
— Or the bellman going out to free him and bring him back.

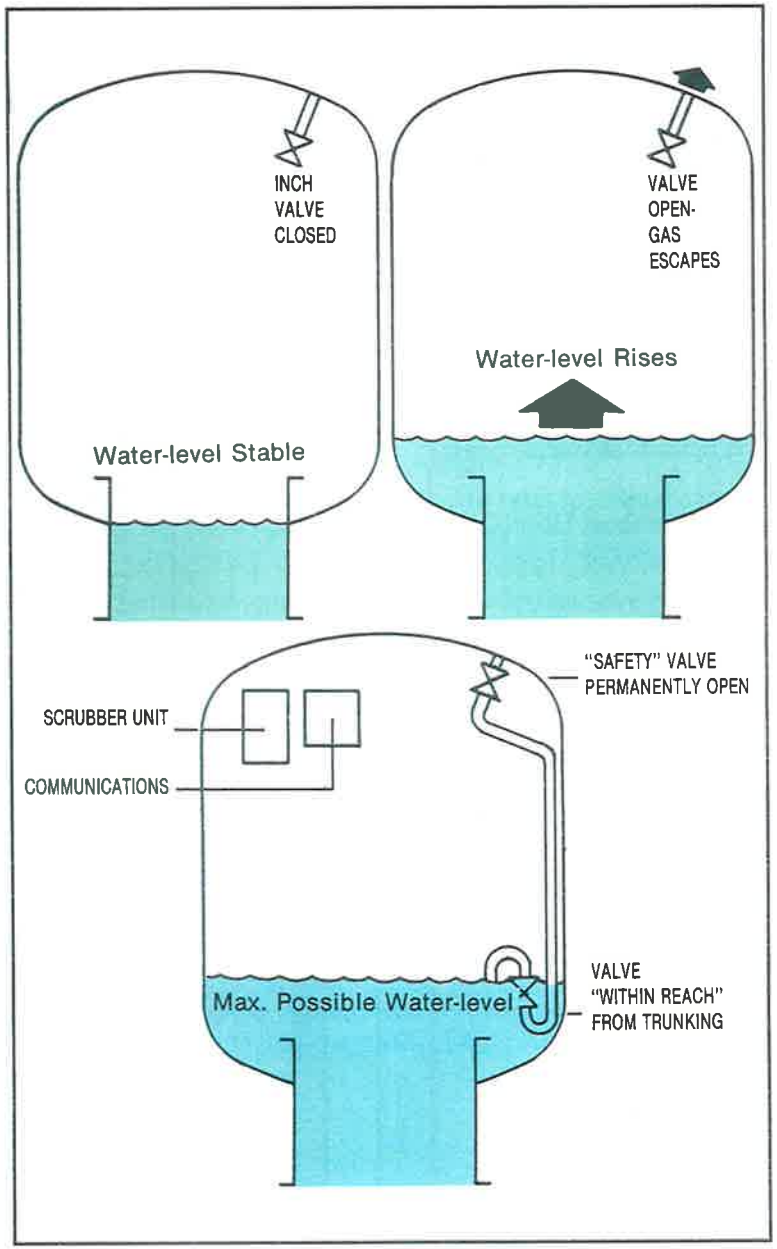
The bellman is the ONLY PERSON who can help at this stage. No further help is available until the bell is back to the surface and mated to the chamber.
However, experience has shown that :
— bringing the man inside the bell,
— clearing him out of trunking,
— closing and sealing the door
can take a surprisingly long time and therefore **resuscitation must take place first.**

ACCESS TO THE BELL

The lifting of a helpless body fully inside the bell from a point below floor level requires strenuous physical effort.
The procedure is thus to raise the water level in the bell.

However, if the valve is left open by mistake whilst the bellman is out, the bell will be totally flooded when he returns. Care must be taken not to flood equipment (Scrubber units, communications systems, etc ...).
On the other hand, if the bellman does forget to raise the level before leaving the bell, he may have great difficulty in getting back inside.

The arrangement described on the opposite page is therefore recommended :
— It prevents accidental complete flooding,
— and the valve can be reached by the bellman from the trunking.
Raising the water level will also have a therapeutic value as described further herein.



DIVER'S HARNESS

A diver is permanently attached to the diving bell by his "Umbilical" line.
Should he become unconscious, it may be possible for the bellman to pull him all the way back to the bell providing he and his line are clear of any obstructions.

The problem then is how to get a helpless body vertically through an opening with a 600 mm to 800 mm in diameter.

If the line is attached to the body somewhere on the chest (as in surface orientated diving), it is impossible to lift him quickly and smoothly into the bell (**see sketch 1**) thus creating further delay and hazardous manoeuvres.

For this reason, at least with trunkings of 600 mm and 700 mm the diving line must be attached to the back between the shoulders (**see sketch 2**).

The lifting into the bell through the trunking, by pulling the line, will have to be relayed by mechanical means in order :

— To secure the diver in the bell and allow the bellman to release his hold.

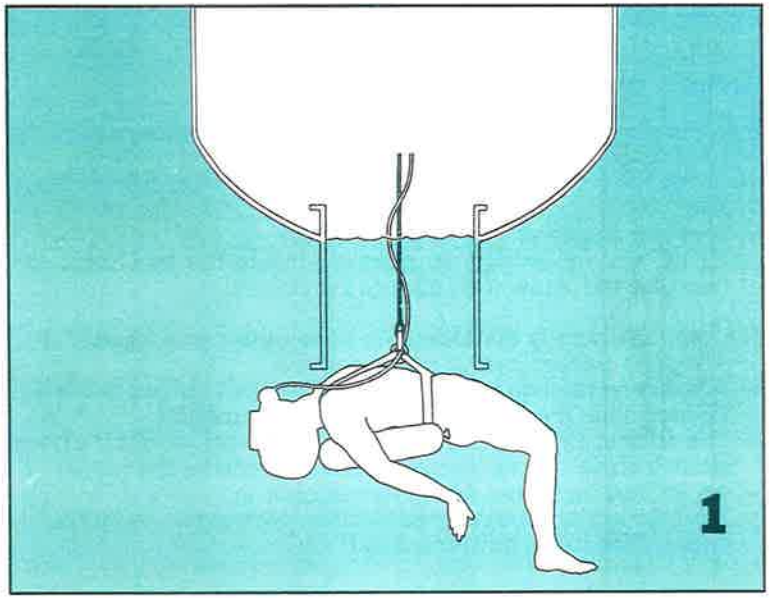
— To spare the bellman's strength.

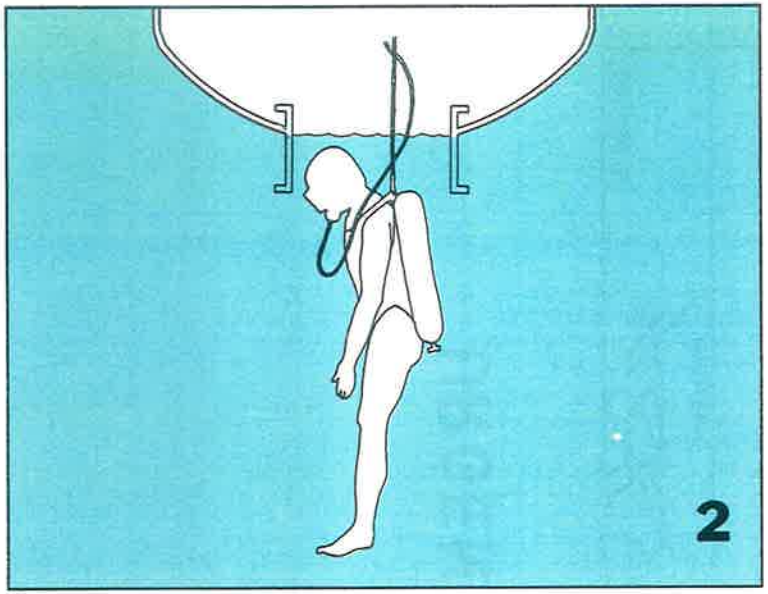
Thus the diver will literally be hanging from a lifting point which necessitates a special SAFETY HARNESS.

The two main features of this harness will be :

— It holds the man in a VERTICAL POSITION.

— It supports the WEIGHT FROM THE PELVIS (as the man is already unconscious, it is dangerous to squeeze his chest further by lifting him from around his chest).





DIVER'S WINCH

A mechanical lifting device must be used when the man is partly inside the bell in order :

— To secure the man, thus leaving the bellman free from holding him.
— To allow a greater pull to be exerted.
— To lift him up as high as possible inside the bell, clear the trunking and allow the hatch to be closed.

The unit selected is the **Maasdam rope puller (see sketch 1)** :

— A rope is passed over a grooved wheel.
— A lever and ratched mechanism allows a pull limited to 500 kg. Beyond this, the rope begins "slipping through".
— The ratchet system on the wheel allows fast recovery of any excess slack simply by pulling the free end of the rope.
— An inch-by-inch lowering device is built in.
— The rope is fitted with a "snap shackle" allowing a safe and quick connection using only one hand.

LIFTING THE DIVER

Due to the lack of vertical space available, the lifting device is fitted onto the side wall **(see sketch 2)**. Thus :

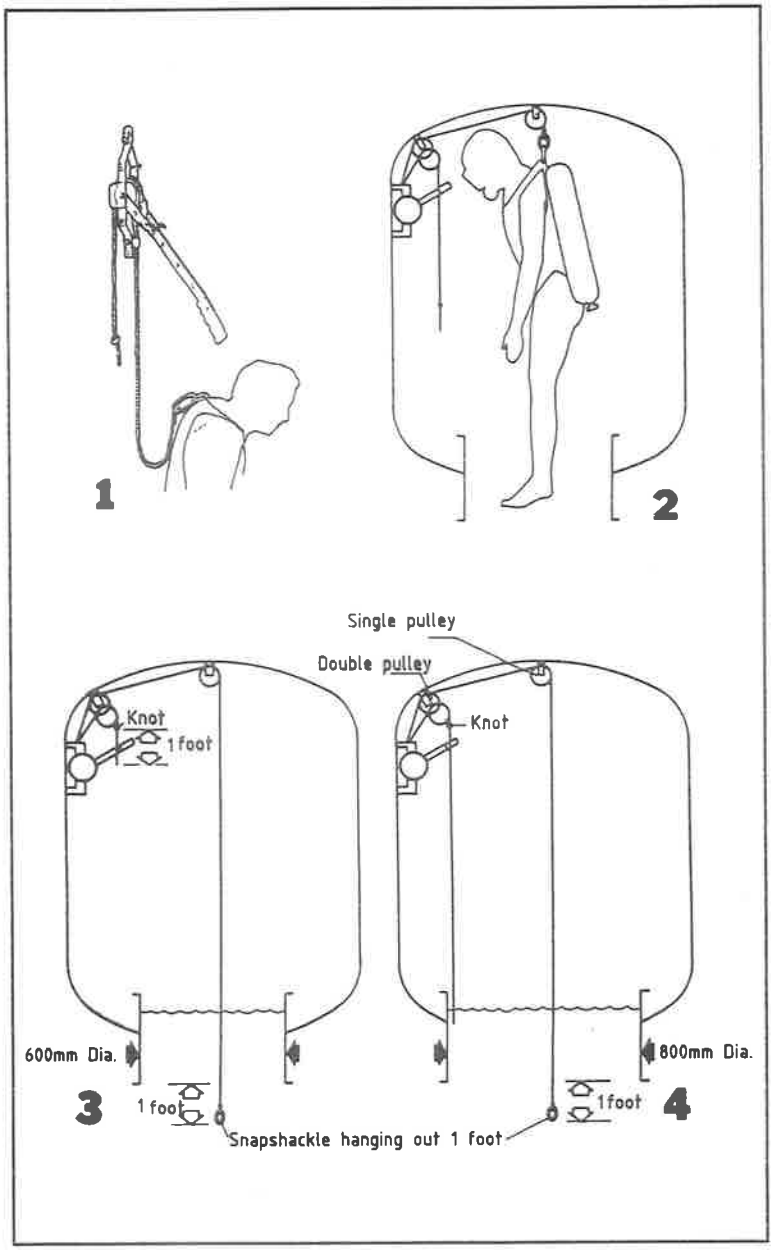
— The man can be lifted "all the way up".
— The device is operated by a handle in a downward movement.
— The free end of the rope can still be pulled downward to recover slack.

The rope on this device must be as follows :

— The snap shackle can be left hanging 1 foot below the bell.
— A knot must be tied to prevent the free end from slipping through the pulley.

In bells with a 600 mm trunking :
A length of approximately 1 foot is left beyond the knot on the free end **(see sketch 3)**.

In bells with a 800 mm trunking :
The free end of the rope should be long enough to reach the water level in trunking **(see sketch 4)**.



RECOVERY OF THE DIVER

In case the bellman has to go out, the whole operation should be carried out as follows :
— Get "ready" (fins, weight, hood, etc)
— Open valve to raise water level
— Pull out rope of lifting device (shackle hanging one foot below trunking)
— Unfold bellman's umbilical
— Fit mask on
— Go out
— Follow diver's line
— Open free flow or bail out on reaching victim
— Drag him back, keeping lines clear.

Then, in the case of a 600 mm trunking :

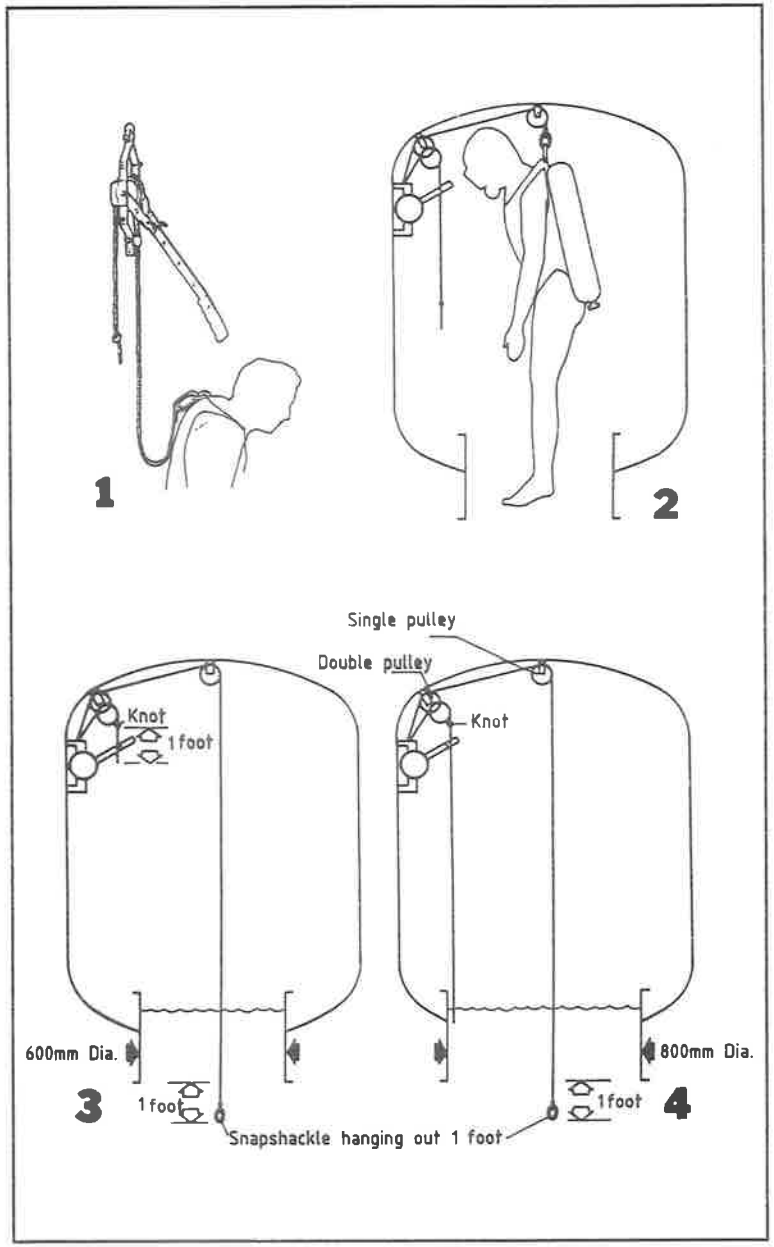
— Attach him to the snap shackle
— Get him up and secure him
— Begin resuscitation.

Or, in the case of 800 mm trunking :

— Get inside trunking with him
— Secure him to the lifting device
— Begin resuscitation.

ASSESSING THE STATE OF THE DIVER

When the unconscious diver is back and secured inside the bell, the bellman must assess the state of the diver :
— He may be unconscious.
— Breathing may have stopped. Presence of breathing will be confirmed or not as soon as his mask is removed.
— Heart beat may have ceased. Cardiac function will have to be checked at the carotid artery.
— He can present some visible injuries.



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— Unfold bellman's umbilical
— Fit mask on
— Go out
— Follow diver's line
— Open free flow or bail out on reaching victim
— Drag him back, keeping lines clear.

Then, in the case of a 600 mm trunking :

— Attach him to the snap shackle
— Get him up and secure him
— Begin resuscitation.

Or, in the case of 800 mm trunking :

— Get inside trunking with him
— Secure him to the lifting device
— Begin resuscitation.

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— He may be unconscious.
— Breathing may have stopped. Presence of breathing will be confirmed or not as soon as his mask is removed.
— Heart beat may have ceased. Cardiac function will have to be checked at the carotid artery.
— He can present some visible injuries.

RESUSCITATION OF THE DIVER INSIDE THE BELL

When the unconscious diver is back and secured inside the bell RESUSCITATION MANOEUVRES MUST TAKE PLACE FIRST.

Closing and sealing the hatch plus eventual lowering of diver will take place only after resuscitation is successful.

ONLY A SEVERE HAEMORRHAGE SHOULD BE DEALT WITH PRIOR TO RESUSCITATION ATTEMPTS.

Due to both a shortage of time and space availability **RESUSCITATION MUST TAKE PLACE WHILST THE DIVER IS HANGING ON HIS HARNESS**

But, because in such a situation :

— Cardiac massage cannot be performed as there is no support and applying pressure would simply make him swing.
— Blood will have a tendency to pool down the legs of patient due to gravity.
— Head will hang forward thus hindering airway.

The procedure is therefore to :

— Use different cardiac compression techniques (see page 53).
— Maintain patient's body immersed as far as practicable in flooded bell. The blood density being similar to that of sea water, the blood pooling effect will be avoided.
— Raise chin to free airways by means of a semi-rigid collar. In this position mouth can drain naturally saliva, blood, (eventually) vomit ; and tongue would hang out, rather than in, naturally.

ASSISTED VENTILATION

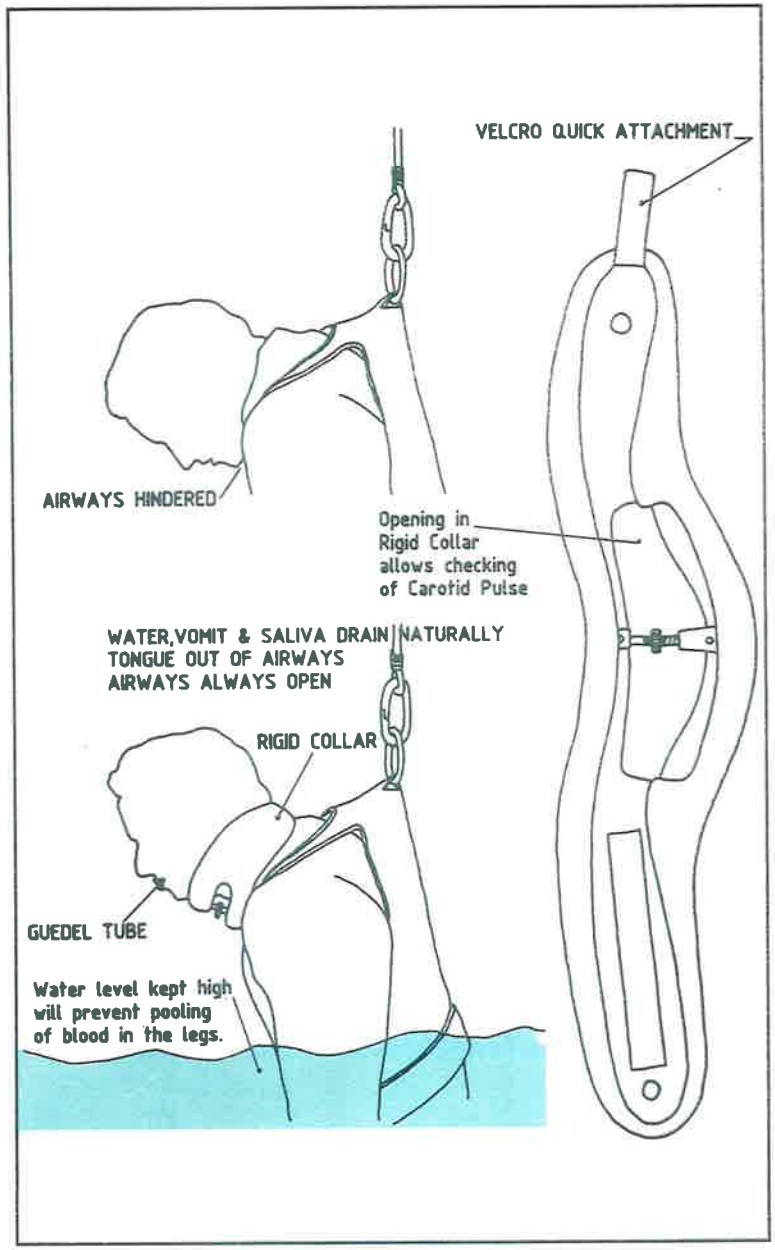
When it has been established that the diver is not breathing :
— Airway must be cleared of vomit or other foreign matter,
— Respiration must be restored.

The rigid collar fitted around the neck will raise the chin and open the airway.

The Guedel tube must be inserted (A wooden screw type mouth opener is provided in every bell) :

— It will ensure the tongue "out of the way"
— It will ensure a free airway
— Its rejection (by retching) indicates returning consciousness.

THEN MOUTH TO MOUTH RESUSCITATION WILL HAVE TO BE STARTED ALONG WITH CARDIAC MASSAGE IF NECESSARY.



EXTERNAL CARDIAC MASSAGE

Any attempt to apply external cardiac massage in the normal way will simply make patient swing as he hangs from his harness. Thus his body must be pressed against something.
As the bell walls are too far away the bellman will have to provide both pressure and support.

Two techniques are possible :

1 — With the patient suspended at bellman's level (**see sketch 1**) :

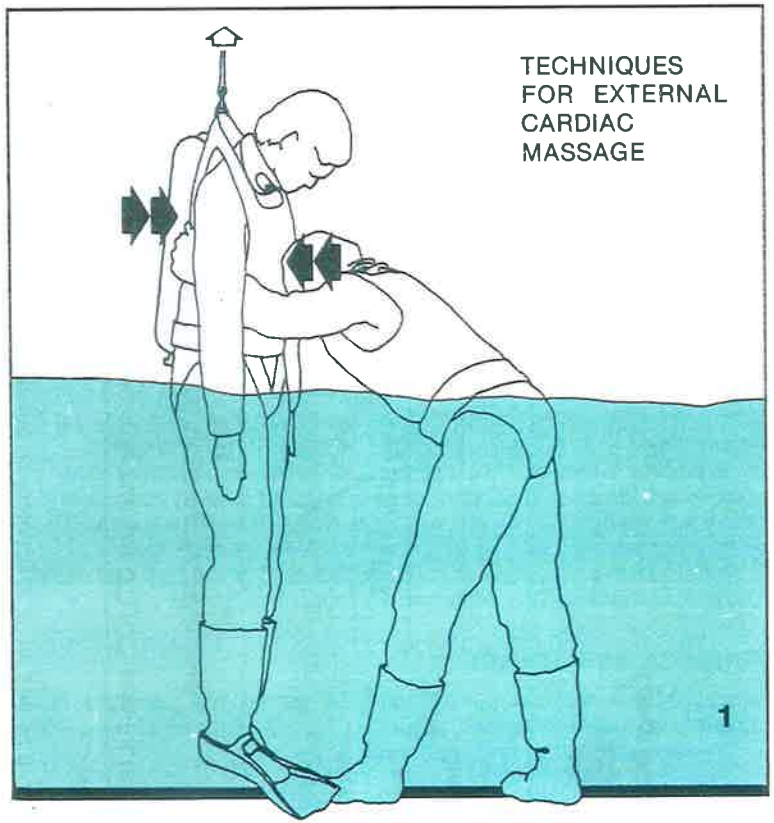
- embrace diver from the front under his arms
- lower and apply your head against his sternum
- pull patient against your head rhythmically.

This technique is quite efficient and can be applied for extensive periods of time.

2 — With the patient suspended chest high (**see sketch 2**) :

- get hold of patient's harness at shoulder level from the front
- apply your knee against his sternum
- pull him against your knee rhythmically.

Both these techniques allow cardiac massage to be performed without first removing the back pack, thereby saving some precious seconds.



WHEN CARDIAC AND RESPIRATORY FUNCTIONS ARE RESTORED

If the man is still not conscious, priority should then be given to :
— clear him off the trunking
— lower the water level
— close and secure the hatch
— check the patient again.
When the hatch is closed the bell can be lifted up and the bellman can devote all his attention to the patient.

He should not be left hanging in the vertical position. Attempts should be made to sit him up.

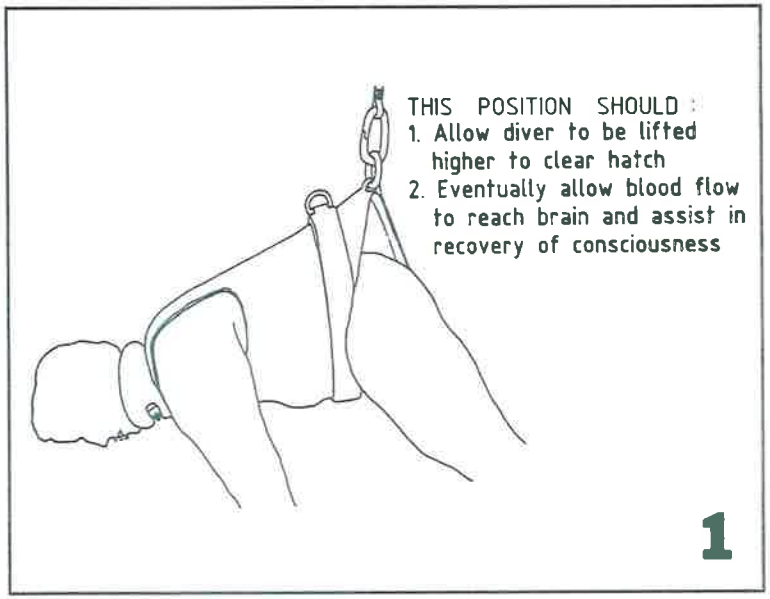
Unconsciousness is a sign that blood circulation may not yet be normal, and that no enough blood is reaching the brain.
In order to help in this respect, another manoeuvre can be attempted, which will consist of re-lifting the man by means of the Maasdam device, but this time, from one of the lifting eyes fitted on his harness at belt or bottom level (**see sketch 1**).
This manoeuvre may be restricted by the size of the bell but should allow a sufficient flow of blood to reach the brain.

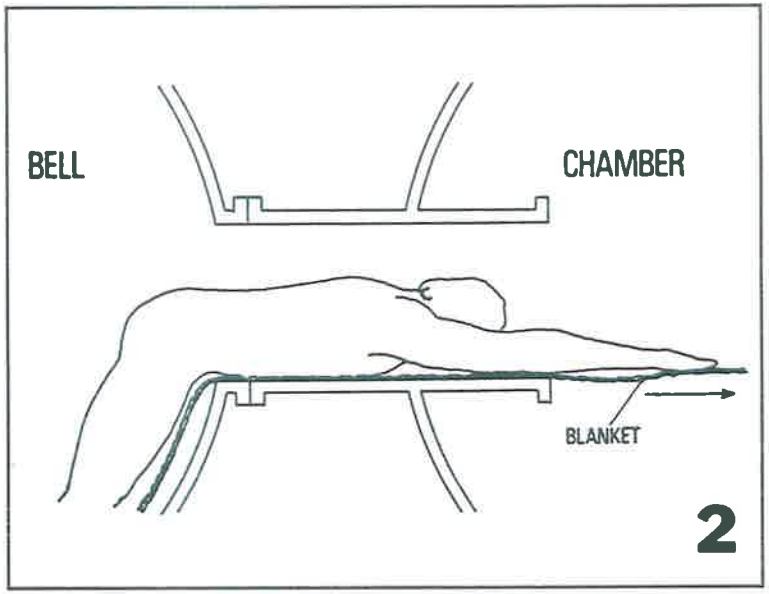
SURFACE ASSISTANCE

Although the surface cannot directly assist the bellman, it is possible to guide him by :
— keeping calm and thinking clearly,
— issuing instructions in a calm manner,
— not harassing the bellman with questions,
— monitoring the breathing rate of the bellman and telling him to quiet down, if necessary, when outside the bell,
— reminding him to watch both diving lines on the way back,
— not expecting the bellman to keep the surface informed of every move.

PATIENT'S TRANSFER TO CHAMBER AT SURFACE

The patient is passed through the lateral hub after mating the bell to the chamber, as follows (**see sketch 2**) :
— a blanket is laid in the hub,
— the diver is laid on the blanket,
— the blanket is gently pulled into the chamber.
While waiting for instruction from the Medical/Safety Network, put the patient on BIBS with high PO_2 breathing mixture (Table **Cx B** on page 17).





5.5 PULMONARY BAROTRAUMA/ EMBOLISM/PNEUMOTHORAX

CAUSES

A pulmonary barotrauma corresponds to lung damage by pressure. It is caused by a rapid change in the volume of breathing gas in the lung produced by a sudden reduction in pressure.

The gas might have been retained in the lung by choice (voluntary breath holding) or by accident (as when the air passage becomes blocked). Or the diver, reacting with panic to a difficult situation, may hold his breath on ascent without realizing that he is doing so.

Because the change in gas volume for the same reduction in pressure becomes much greater as surface is approached, it is an important problem in surface-orientated diving.

The lung damage may or may not produce pain and the gas may :
— enter the circulation causing embolism,
— tear the outer membrane (the pleura) causing pneumothorax, collapsing the lung,
— escape into the centre of the chest (the mediastinum) causing emphysema.

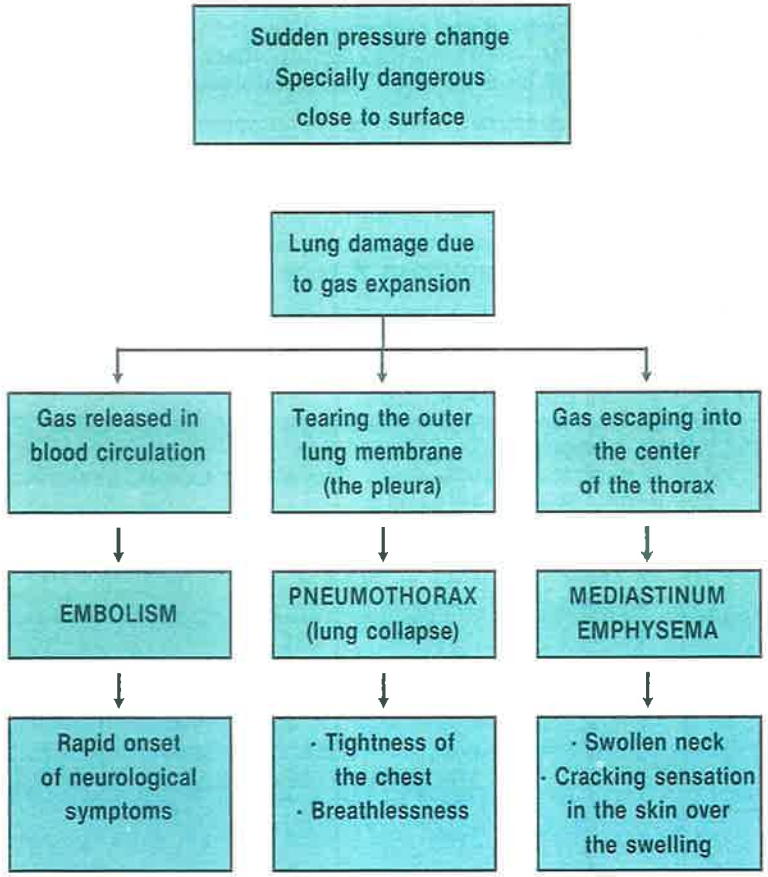
GAS EMBOLISM

Because the gas entering the circulation is from the gas being breathed, large quantities may be involved causing sudden loss of consciousness and even arrest of heart action.
Many different nervous system symptoms may occur.

If the bottom time has been significant, then it may be impossible to distinguish between respired gas embolism and decompression sickness. This is not important because the treatment is the same.

Treatment of gas embolism

- After shortened decompression : treat as a BLOW-UP, chap. 4 page 23
- After normal decompression : immediate recompression to 30 m on Table **Cx 30**, page 9



PNEUMOTHORAX

Rupture of the covering and collapse of either the left or the right lung may occur. No symptoms may occur, otherwise the diver may experience severe localized pain and breathlessness.

If the problem occurs in a chamber, decompression will expand the gas, compress the lungs and prevent breathing. This is called a tension pneumothorax.

If tightness of the chest occurs during any decompression which is immediately relieved by recompression but recurs on decompression, a pneumothorax may be present.

In surface orientated diving the symptoms may be easily confused with respiratory decompression sickness (chokes).

Treatment of pneumothorax

- After shortened decompression : treat as a BLOW-UP chap. 4 page 23
- After normal decompression : immediate recompression to 30 m on Table **Cx 30** page 9.
- At bottom : Pneumothorax may have occurred at depth from an underwater blast.
  Apply Table **Cx B** page 17 and wait for instructions.
  Do not start decompression.

PNEUMOMEDIASTINUM

If the gas ruptures into the centre of the chest it may surround the heart, the great vessels and the trachea appearing as a swelling of tissue at the root of the neck. Minor degrees are silent but typically, there is discomfort in the centre of the chest and a crackling sensation in the skin over the swelling.

Treatment of pneumomediastinum

- After shortened decompression : treat as a BLOW-UP chap. 4 page 23
- After normal decompression : 100 % Oxygen at surface. Do not recompress unless breathing difficulty is present.
- At bottom : apply Table **Cx B** page 17 and wait for instructions.
  Do not start decompression.

5.6 SHOCK

CAUSES

All serious diving accidents may be accompanied by shock. Shock is also present during haemorrhage.

— External bleeding can be controlled by local pressure but internal bleeding cannot be seen and must be suspected when there has been significant trauma.

— Internal bleeding may follow any injury and requires emergency medical attention. Blast may cause lung tissue injury and haemorrhage. Abdominal compression may rupture the spleen or the liver and the bleeding may cause the abdomen to become swollen. All fractures cause internal bleeding. In a fracture of the femur, severe haemorrhage may occur into the tissues.

SYMPTOMS

— The eyes are dull and lacklustre, a sign of poor circulation.

— The pupils may be dilated.

— The face is pale and may be cyanosed. Cyanosis is an important sign of oxygen deficiency, in this case caused by reduced circulation.

— Respiration is shallow, possibly irregular or laboured. The vital centers that regulate respiration are slowing down, as are all life processes.

— The pulse is rapid and weak because the heart is working faster to compensate for the reduced blood pressure and volume.

— The skin is cold and clammy, since blood has left active circulation in the extremities and is pooling in the vital organs.

— There may be nausea, collapse, vomiting, anxiety and thirst.

TREATMENT

Treatment of shock takes priority over all other emergency care measures except for the correction of breathing problems, the re-establishment of circulation, and the control of profuse bleeding. The steps to be taken in caring for a patient in shock are as follows :

— **Ensure adequate breathing :**
If the patient is breathing, maintain an adequate airway by properly positioning his head. If the patient is not breathing, establish an airway and restore breathing through some means of pulmonary resuscitation. If both respiration and circulation have stopped, institute cardiopulmonary resuscitation measures.

— **Control bleeding** :
If the patient has bleeding injuries, use direct pressure, pressure points or a tourniquet as required.

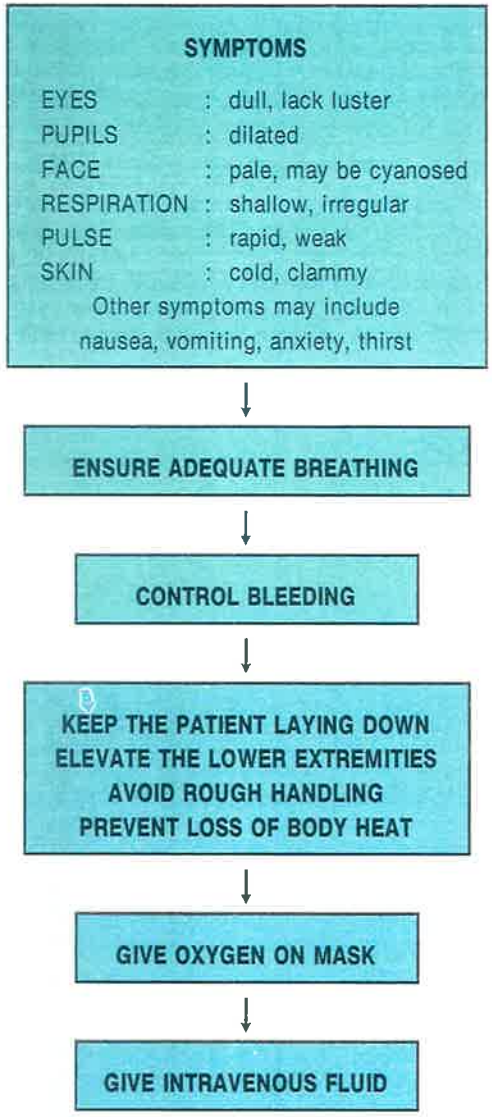
— **Administrate Oxygen** :
Remember that an oxygen deficiency will result from the reduced circulation. Administrate Oxygen to the patient to compensate for this loss of oxygen (2.8 bar maximum).

— **Keep the patient laying down** :
Since blood flow to the heart and brain may have been diminished, circulation can be improved by raising the legs slightly. It is not recommended that the entire body be tilted down at the head, since the abdominal organs pressing against the diaphragm may interfere with respiration.

— **Avoid rough handling** :
Handle the patient as gently and as little as possible. Body motion has a tendency to aggravate shock conditions.

— **Prevent loss of body heat** :
Keep the patient warm, but guard against overheating, which can aggravate shock.

— **Give intravenous fluids** :
Give nothing by mouth ; fluid will be administrated intravenously.



5.7 DROWNING, ASPHYXIA AND ANOXIA

CAUSES

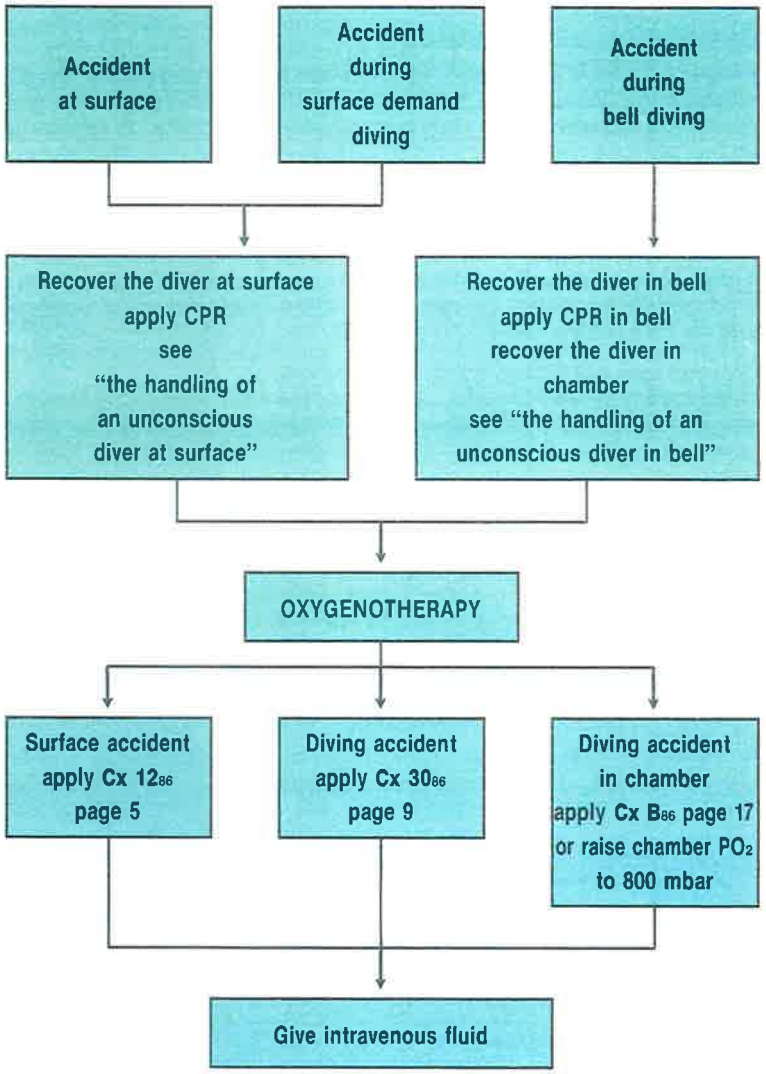
Inhalation of water may complicate many diving accidents.
Inhalation of vomit may cause acute asphyxia either from obstruction of the airway or by inducing acute pulmonary problems.
Gases with a low oxygen content may cause hypoxia and pure gases other than Oxygen cause rapid unconsciousness and anoxia.

SYMPTOMS

When water enters the mouth and nose, the victim's first reaction is to cough and catch his breath. This causes him to swallow large amounts of water, which enter the stomach, not the lungs. However, some water may be drawn into the windpipe, causing spasm of the larynx which can, in turn, effectively block airflow to the lungs. The drowning victim loses consciousness from lack of oxygen (asphyxia).
At this point, only a very small amount of water has actually entered the lungs. If the victim is rescued immediately, attention to the airway and resuscitation efforts will probably revive him. In most drowning victims, however, the development of asphyxia causes the laryngospasm to relax, and the lungs will take on more water. If initial treatment is not adequate, delayed deterioration may occur because of pulmonary and cerebral oedema. Leakage of plasma from blood vessels in the lung interferes with oxygen uptake and causes tissues damage in the brain. This can be prevented by hyperbaric Oxygen (2 to 2.8 bar).

TREATMENT

— Clear the airways. Oxygenation of the circulating blood will occur in spite of some water in the lungs.
— Place the victim in a head low position, if possible.
— Begin Cardiac Pulmonary Resuscitation when a drowning victim is recovered. A few rapid lung inflations at this time may save the diver's life. It is essential to continue resuscitation for one hour in acute drowning as late revival is documented.
— Oxygenotherapy :
  • In non diving accident at surface, apply Table **Cx 12** page 5.
  • In a diving accident with surface demand, apply Table **Cx 30** on page 9.
  • In chamber apply Table **Cx B**, page 17.
  • Hyperbaric Oxygen is effective in the prevention of secondary deterioration. In bell diving, the bell or chamber PO_2 can be elevated for the critical period of treatment.
— Give intravenous fluids : 500 ml Ringers Lactate immediately, then Dextrose/Saline 500 ml over the next hour.



5.8 COUNTER GAS EXCHANGES AND INERT GAS SWITCHES

COUNTER GAS EXCHANGE

When a diver is breathing one gas on BIBS surrounded by an atmosphere containing a second gas, he is placed in a counter gas exchange situation. The first gas, breathed on mask, is taken up by his body tissues, and tends to diffuse from the tissues through the skin, outside the body. The second gas, surrounding the diver, tends to diffuse from the outside, through the skin, inside the tissues. Depending of the nature of the tissues and the physical properties of the gas, these counter exchanges can produce locally a slight supersaturation which, in turn, can generate gas bubbles. This gas phase formation can occur without any pressure change and is sometimes called "isobaric".

Counter gas exchange symptoms include :
— skin rashes and itching, which are the first signs of problem
— nausea, vomiting, vertigo, loss of balance in severe or long exposures.

In order to produce such an effect, different conditions must be fulfilled :
— Some gases do not produce significant counter gas effects, the two gases must have different physical properties ; a highly fat soluble gas on one side (Argon, Nitrogen, Hydrogen) and a rapidly diffusing gas (Helium) on the other side. In diving conditions, the relevant gas couples are :
  • Air and Heliox
  • Hydrox and Heliox (Hydrogen diving)
  • Argon and Heliox (TIG welding).
— The effects are directly proportional to the partial pressures of gases, i.e. to depth of the diver. Most of the time, limitation of Air diving to 50 m would prevent any significant counter gas exchange problems with the couple Nitrogen/Helium but skin symptoms have been reported at around 90 m during experiments. Hydrogen/Helium problems can occur at 150 m.
— The effects are symetrical. If the situation where the soluble gas is breathed on mask has negative effects and produces supersaturation, on the opposite, the situation where the soluble gas is outside is safe and even beneficial, because it produces undersaturation. It is perfectly safe to breathe Heliox on mask surrounded by Air and this has been tested up to 180 m during early times when Helium was expensive. On the other hand, breathing Air on mask surrounded by an Heliox atmosphere might be dangerous deeper than 90 m.

INERT GAS SWITCHES

Gas switch is a technique used in decompression to accelerate inert gas elimination by the body. This is a reason why Oxygen stops are included at end of bounce decompression, or why divers are transferred in an Air filled chamber for some Heliox bounce dives.

However, it is also recognized that during a gas switch, the diver is placed in a counter gas exchange situation :
— The gas he was previously breathing is still present in the diver's body in a dissolved form and tends to eliminate from the tissues to the outside.
— The new gas breathed by the diver tends to be taken up by the tissues.

The mechanism and the effects are the same, except that :
— The process is transient because the amount of gas available, dissolved in the diver's tissues, is limited.
— A slow gas switch tends to minimize or avoid symptoms.

Negative counter gas exchange effects can balance the advantages of inert gas switches. The discussion of each case requires complex study on the gases involved, the depth of the gas switch, whether diffusion or perfusion is involved, whether it is normal procedure or recompression treatment.

However the following statements can be presented as a summary :

— It is safe and beneficial to use Heliox therapeutic mixtures during the recompression treatment of Air diving accident.

— Heliox diving accident should never be treated with Air or Nitrox therapeutic mixtures.

— It is safe to switch from Heliox to Air during an Heliox bounce dive decompression as long as the transfer is not too deep.

— Switch from Heliox Saturation to Air Saturation (or vice-versa) should be avoided. It used to be common practice to ventilate chamber with Air in the last 10 m of Heliox saturation decompression. This was well known to clear little problems such as niggles, and obviously was due to the advantage of inert gas switch (providing better gas washout). However, where the symptoms were serious, this would have had the opposite effects and would have worsened the accident (prevailing counter gas exchange). Moreover, even in a mild case, if the symptoms recurred later in the decompression, this Air switch would have complicated the treatment.

TREATMENT

Consider counter gas exchange or inert gas switch accident as a decompression accident because the primary event for injury is the same : gas phase formation.
In any case, treat as a **TYPE II** accident.

In an emergency situation such as hyperbaric evacuation, where inert gas exchanges cannot be avoided, attempt to produce progressive atmosphere change (ventilation or intermediate breathing gas on BIBS).
In any case, apply a preventive treatment (recompression and hyperbaric Oxygen as for a **TYPE II** accident).

5.9 ACCIDENTS INVOLVING SOLVENTS

Solvents such as trichlorethylene or "Genkelene' could be the source of accidents if splashed or ingested.

INGESTION

— Attempt to get the patient to vomit.
— Never leave the patient alone even if the ingestion appears minimal or is not very well established.

PROJECTION IN EYES

Rinse immediately during 15 to 30 minutes while getting medical help. Remove splashed clothing.

INHALATION OF VAPOURS

— Get the patient out to a fresh gas zone.
— Keep under surveillance. If necessary be ready for artificial respiration.
— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
in chamber apply Table **Cx B**, page 17

In any cases, contact Medical/Safety Network for assistance.

5.10 OXYGEN CONVULSION

CAUSES

This is a generalized convulsion identical to an epileptic fit caused by breathing partial pressures of Oxygen in excess of 2.2 bar. The period of Oxygen breathing required to provoke a convulsion is proportional to the partial pressure of Oxygen. Man's tolerance to high PO_2 breathing is greatly reduced by exercise. For example exercise reduces the time to convulsion at 3 bar from about 2 hours down to 15 minutes (see figure opposite).

SYMPTOMS

Warning signs include :
— Restlessness, irritability
— Twitching of lips and extremities
— Dizziness, nausea, and sometimes vomiting
— "Tunnel" vision, hearing abnormalities
and when the convulsion starts, the risks include tongue biting, airway obstruction and drowning.

TREATMENT

— Provide the diver with breathing gas having the correct Oxygen content. In many cases this will require prior retrieval of the diver. Remove BIBS or mask and have diver breathing chamber/bell atmosphere.
— Prevent the diver from injuring himself. Guide, but do not restrict movements. Do not try to prize his mouth open. If the opportunity arises, put a knotted handkerchief between the jaws to prevent the tongue being bitten.
— Keep the diver under observation for at least 12 hours. Some loss of memory almost always occurs.

5.11 PULMONARY OXYGEN TOXICITY

CAUSES

Breathing a partial pressure of oxygen greater than 0.5 bar over a prolonged period may cause reversible changes in the lung tissue. Man tolerance to oxygen breathing is dependent both on time and partial pressure, i.e. on oxygen dose, a quantity which is sometimes expressed in "UPTD" units.
Interruption of high partial pressure of Oxygen breathing period with low partial pressure of Oxygen breathing period (less than 500 millibar) helps to delay the onset of pulmonary toxicity. This is the reason why 5 minutes breaks are inserted in between 25 min BIBS session.

THRESHOLD LIMIT VALUE

— 500 millibar : indefinitely
— 600 millibar : 6.5 days (decompression)
— 800 millibar : 2 days (bottom mix)
— 1.2 bar : 24 hours (Air diving to 50 m)
— 1.6 bar : 14 hours (mixed gas diving)
— 2.2 bar : 8 hours (Oxygen on BIBS at 12 m)

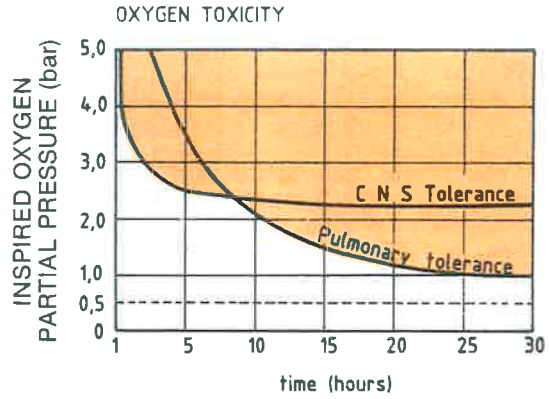
See figure below.

SYMPTOMS

— Diver complains of being unable to take a deep breath.
— Chest pain behind the breastbone on inhalation.

TREATMENT

If the oxygen pressure is reduced to below 500 millibar, the symptoms will gradually resolve.



5.12 CO_2 POISONING

CAUSES

Carbon dioxide is a normal metabolic product. Average man production of CO_2 is 0.5 l/min at rest, 1 l/min in moderate work, and up to 3 l/min in heavy exercise.
CO_2 plays an essential role in the regulation of respiration. The body monitors the CO_2 level in the blood and regulates the breathing rate accordingly. A rise in the CO_2 level (hypercapnia) will cause an increase of the breathing rate. Poisoning results if CO_2 accumulates in the body through inadequate respiratory exchange or through the inhalation of high concentrations of the gas. Possible causes include :

— Pollution of ambient atmosphere
— Wrong gas supply
— Malfunction of diver gas reclaim system,
— Exhaustion, flooding or incorrect filling of the soda lime in scrubbers
— Incorrect or shallow breathing by the diver
— Over-exertion.

THRESHOLD LIMIT VALUE

— 10 millibar : indefinitely
— 20 millibar : 24 hours
— 30 millibar : 8 hours
— 40 millibar : 2 hours
— 50 millibar : 30 minutes

SYMPTOMS

CO_2 poisoning symptoms include :

— Breathlessness and panting
— Dizziness, nausea, headaches, anxiety
— General distress, sweating and palpitations
— Loss of consciousness.

TREATMENT

— In case of over-exertion, diver should stop working, and breathe deeply. If this brings no relief, then the diver must return to surface or to the bell.
— In case of gas reclaim malfunction or chamber pollution flush through the system with fresh Mixture.
— In case of severe poisoning, use oxygenotherapy :
  • at surface apply Table **Cx 12**, page 5
  • in chamber apply Table **Cx B**, page 17
  Recovery should be rapid. If not, contact Medical/Safety Network for assistance.

NOTE : *The after effect may be a headache.*

5.13 CO POISONING

CAUSES

The effect of Carbon Monoxide (CO) on the body is to cause hypoxia. This is because the CO is taken up by the red blood cells in preference to Oxygen and forms relatively stable compound. This results in bright red blood cells which give to the skin an apparently healthy colour while the body is being deprived from Oxygen.

Possible causes for CO poisoning include :

— Breathing impure gas. Usually due to contamination by exhaust fumes during charging of an Air cylinder or receiver tank with a compressor.
— Breathing CO produced by welding rods in habitat.
— Incomplete combustion of hydrocarbon in chamber or habitat.

THRESHOLD LIMIT VALUES

Because the action of carbon monoxide results from a competitive relationship between Oxygen and CO, a higher level of CO can be tolerated in an environment containing a raised PO_2. Values given below refer to an ambient PO_2 greater or equal than 400 millibar :

— 0,020 millibar : continuously
— 0,100 millibar : 12 hours
— 0,150 millibar : 3 hours
— 0,250 millibar : 1 hour

In Norwegian waters, refer to NPD Safety Notice n° 2/85 which uses different values :

— 0,020 millibar : continuously
— 0,050 millibar : 12 hours
— 0,070 millibar : 8 hours
— 0,100 millibar : 15 minutes

SYMPTOMS

— Breathlessness on exertion
— Lassitude, nausea, headache
— Vertigo (dizziness) and noises in the ears
— Confusion and clumsiness
— Cherry red colouration of the skin, tongue and lips
— Loss of consciousness without warning.

TREATMENT

— Allow the patient to breathe fresh gas
— Apply CPR if required
— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
  in chamber apply Table **Cx B**, page 17
— Contact Medical/Safety Network for assistance.

5.14 OZONE POISONING

CAUSES

Ozone is produced in the welding habitat during TIG welding, in relation with the UV radiation which react on ambient oxygen. However, Ozone being unstable, its concentration tends to decrease into the welding habitat after the TIG welding has stopped.

THRESHOLD LIMIT VALUE

The maximum admissible concentration allowing exposure of 8 hours per day, 5 days per week, without deleterious effect, is 0.1 microbar.

SYMPTOMS

At higher concentration, Ozone is a very toxic gas because of its oxidizing power. Action on mucous tissues such as eyes, nose, throat and airways causes irritation :

— Odor, headache, eyes and nose burning indicate exposure to concentration from 0.1 to 1 microbar.
— Throat burns and cough, exposure from 2 to 3 microbar.

Further development may lead to acute pulmonary oedema and death.

TREATMENT

— Rest
— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
in chamber apply Table **Cx B**, page 17
— Contact Medical/Safety Network for assistance.
— Eventually, after medical advice, use pulmonary œdema kit (see page 109) for treatment.

5.15 NITROUS OXIDE POISONING

CAUSES

The most probable source of Nitrous Oxide is a result of welding operation. In the presence of high temperature and electric discharge involved in welding, Nitrogen present in the habitat is oxidized to Nitric Oxide (NO) and Nitrogen Dioxide (NO_2).
This is specially relevant for shallow Air/Nitrox welding operations.

THRESHOLD LIMIT VALUE

NO : 0.025 millibar maximum
NO_2 : 0.003 millibar maximum

SYMPTOMS AND RISKS

Nitrous oxides are powerful irritants of mucous membranes. Symptoms include :
— irritation of throat, cough
— chest pains
— breathing difficulties, incessant coughing.
Further development may lead to acute pulmonary oedema and death.

TREATMENT

— Rest
— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
in chamber apply Table **Cx B**, page 17
— Contact Medical/Safety Network for assistance.
— Eventually, after medical advice, use pulmonary œdema kit (see page 109) for treatment.

5.16 HYPOTHERMIA/HYPERTHERMIA

METABOLISM AND BODY TEMPERATURE

To function, the body burns blood sugar calories with the help of the oxygen provided by respiration. This chemical reaction, produces energy which is lost as heat. This heat production is uncontrollable, and corresponds to metabolic rate. Its intensity is related to oxygen consumption.

Average man's oxygen consumption is 0.3 l/min at rest, 1 l/min in moderate work and 3 l/min or more in heavy exercise.

The central temperature of the body (core temperature) is nearly constant in normal conditions and remains at around 37°C. Values of 35°C or 40°C are limits beyond which a long duration exposure becomes hazardous.

MAN'S RESPONSE TO COLD

Besides clothing, and postural changes, man's response to cold involve two mechanisms :

— Heat conservation by increasing the insulation : a reduction in the diameter of the skin blood-vessels (vaso- constriction) leads to a cooling of the skin, and finally a decrease in heat exchange.
— Heat production by muscles : increase in muscle tone, shivering, and exercise. Shivering which is triggered by low skin temperatures, is completely efficient, as the muscles are activated but no mechanical work is produced, that is to say that all the energy is spent as heat. Heat production can thus be multiplied 3 to 5 times.

Note that these mechanisms do not exist for the head, and that the heat loss from this area is always considerable.

HYPOTHERMIA

Hypothermia (failure of cold compensatory mechanisms and reduction in body temperature) can occur more or less rapidly, depending on the severity of the environment.
Onset of hypothermia can be insidious. Repetitive exposures to cold conditions can lower the core temperature progressively, not allowing the body to reconstitute enough heat.
Cold gas inhalation tends to cool the body very effectively because of the large lung surface. Such an "inner" cooling is especially dangerous because the diver may not feel it, the human cold receptor being located only in the skin.

A cold diver is unlikely to be effective due to discomfort, loss of manual dexterity and decrease in muscular strength.
He might also be in danger because of impaired judgement and increase in susceptibility to narcosis and decompression sickness.
With a core temperature below 35° C, motor uncoordination, mental confusion, hallucinations and more hazardous disorders like cardiac fibrillation or cardiac arrest can occur.
It must be noted that below a core temperature of 32°C, shivering disappears, as does the sensation of cold. When there is no more body resistance against cold, cooling accelerates, beginning with hands and feet.

HOW TO RESIST COLD

In order to save body heat in an emergency dry situation, a diver without survival suit should :

— Avoid conduction (contact with metal) by sitting on an insulating mattress (suit, fins or umbilical will also do).
— Reduce surface of exchange by adopting the HELP (Heat Escape Lessening Posture) position (see figure below).
— Use at least a space blanket to prevent heat losses by radiation.
— Use any suit, clothes or blanket available as additional protection (including cover for the head).
— Breathe through an emergency rebreather in order to recover some of the heat produced by CO_2 absorption in the sodalime. If not available, at least breathe through a rag or a woollen cloth that will tend to produce an effect similar to the one of an heat sponge.
— Do not try to exercise, movement will lose more heat than muscles will produce.
— Remember that when brain temperature drops, it affects judgment and reasoning power, without the person realizing it.

HEAT ESCAPE LESSENING POSTURE

MAN'S RESPONSE TO HEAT

Man's response to heat involves two important mechanisms :

— Heat dissipation, by increase in diameter of the skin blood vessels (vasodilatation). This is efficient only if ambient temperature is lower than skin temperature.
— Heat consumption by sweat evaporation. Transformation of sweat to vapour needs heat which is provided by the skin, which consequently cools the body. Sweating is efficient only if evaporation is possible (low hygrometry, wind).

HYPERTHERMIA

Divers using hot water suits and gas heaters may be exposed to hyperthermia (failure of heat compensating mechanism and increase of body temperature).
During immersion, the above mechanisms are ineffective. As the water temperature exceeds skin temperature, the body is unable to evacuate heat other than by respiration and this is possible only if the breathing gas is not too hot.
Other causes of hyperthermia include failure of the regeneration system in the chamber in a warm/tropical environment, rapid compression, uncontrolled habitat temperature during welding operations or hyperbaric fire.

When heat cannot be dissipated, the shell warms up and the core temperature increases.
An excessive heat storage by the body has to be avoided because of its effects on behaviour (decreased vigilance, reduced sensor-motor ability, irritability) and effects on the cardiovascular system.The heart rate increases because it is related to body metabolic level and must compensate for the fall in blood-pressure due to vasodilatation (80 to 100 beats/minute at rest).

Because arterial blood pressure is low, there may be difficulty to ensure sufficient brain oxygenation when standing. This can happen if a diver suffering from hyperthermia faints on entering the bell at the moment his head comes out of the water.

If, during a dive, a diver has muscle cramps, and after the dive is thirsty, urinates little and feels very tired (unrelated to the work done), it could be because he has been too warm during the dive. Loss of consciousness could have occurred.

Dehydration and sodium deficiency can occur after few work-days with excessive sweating which can reach 6 to 8 litres per day (loss of water and mineral salts, chiefly sodium). Symptoms include decreased work capacity, faintness, cramps, dry mouth.
See page 78 for the handling of hypothermic diver.

HOW TO RESIST HEAT

— Keep laying down
— Undress to allow heat exchange
— Spray yourself with cold water if possible
— Use ice cubes in a towel on the head if possible
— Avoid any movement or effort

NOTE : *Beware of irritability, depression or loss of confidence that are symptoms of hyperthermia.*

5.17 HANDLING OF HYPOTHERMIC DIVER

The only treatment for hypothermia is progressive rewarming of the body. However, warming must be performed with prudence because core temperature often continue to fall during the initial rewarming process which can produce cardiac fibrillation.

Vasoconstriction has the effect of slowing down blood circulation in the extremities. This aims to give "cold" blood time to rewarm before reaching the "core". Brutal rewarming may cancel vasoconstriction and liberate a mass of "cold" blood into free circulation, the result being a further lowering of core temperature.

Therefore never try to warm up the hypothermic patient brutally by a hot water bath, friction, or using a hot water suit.

Keeping this in mind, handling of hypothermia is as follows :

RECOVER THE DIVER

— Get the diver out of the water
— Handle him gently, avoid excessive movements which can cause heart stoppage.

CONTROL THE SITUATION

— Lay the patient in a safe dry place
— Clear his equipment but avoid undressing him
— Insulate the diver from the environment, use a mattress, a bunk or anything such as a diving suit, blanket, umbilical, etc.
— Re-establish normal chamber or bell temperature if required (no overheating necessary).

TREAT AS FOLLOW

— The only treatment you can provide without a doctor is a progressive rewarming at a normal ambient temperature. Wrap the diver in a blanket, preferably covering the body and head, leaving out the arms and legs.
— If the diver is conscious, let him have warm gas on BIBS or mask from a gas heater (this method is very efficient and prevents the core temperature drop mentioned at the beginning).
— Do not rub the victim's skin or encourage him to exercise.
— If the diver is conscious, give him warm drinks.
Never give alcohol.
— Contact Medical/Safety Network for assistance.

5.18 HYPERBARIC ARTHRALGIA AND HPNS

CAUSES

Deep diving deeper than 200 m or a rapid bounce dive compression to 150-180 m.

SYMPTOMS

A diver suffering from hyperbaric arthralgia feels a cracking of joints which may even be audible and feels that his joint surfaces are dry (no "joint juice"). Joints sometimes hurt especially on movement. A compression stop may avoid the painful effects of this condition although cracking of the joints may continue.

HPNS occurs when the diver is compressed too rapidly to depths greater than 200 m. It varies in severity from one individual to another, and manifests itself as a tremor which, in some men, may be so severe that they are incapacitated. Other symptoms may include uncontrolled muscle jerks, sleepiness, visual disturbances, dizziness, nausea and vomiting.

TREATMENT

Slow compression helps to improve, or even sometimes to eliminate, this undesirable effect. For deep dives, where HPNS may occur, the compression schedule provided should be strictly followed. In that case, symptoms declared are less severe and do not require any intervention.
In the event of severe hyperbaric arthralgia or HPNS, stop the compression and wait for medical advice. It is very likely that a compression stop will ease the symptoms.

5.19 NITROGEN NARCOSIS

CAUSES

Nitrogen at high partial pressure becomes narcotic. Divers can be affected from about 30 metres, and the effect increases as depth increases. This is one of the factors which limit the use of compressed Air to shallow dives (50 m).

SYMPTOMS

The effects are very similar to those of alcohol.
Divers can experience a form of intoxication with euphoria, loss of judgment or memory, loss of concentration, uncoordination. This may lead to irrational behaviour.

Sensitivity to Nitrogen narcorsis can be greatly increased by the following factors :

— heavy exercise and/or high CO_2 level
— inefficient breathing equipment
— cold
— bad visibility, fear
— poor physical condition.

Thus sensitivity may vary from day to day and from individual to individual. Acclimatization can take place rapidly after a few dives. Though experience will help to overcome narcosis effects, it will never eliminate them.

TREATMENT

Once the diver has been removed from the raised partial pressure of nitrogen, recovery is immediate and complete.

Thus, the only action is to abort the dive or to return the diver to shallower depths.

As a prevention, in an Air worksite, divers should be exposed progressively to increasing depth.

5.20 EAR AND SINUS BAROTRAUMA

CAUSES

The middle ear and sinuses in the skull are bony cavities which must equalize during compression, otherwise a squeeze may occur. In the case of the middle ear, this is via the Eustachian tube which communicates with the back of the throat. Failure to equalize causes the ear drum to be forced into the middle ear cavity and it may rupture.

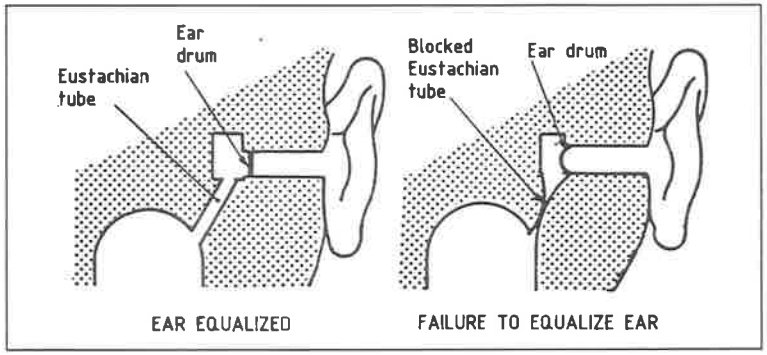
Swallowing or the Valsalva technique during compression will aid equalization. If discomfort is severe the pressurization must be stopped and if equalization cannot be achieved pressure must be reduced. Sinus squeeze is more difficult to prevent but the Valsalva manoeuvre will help.

SYMPTOMS

— Pain in the ear
— Ear drum rupture may cause vertigo and vomiting especially if water enters the middle ear.

TREATMENT

For squeeze, reduce pressure and allow a few minutes before continuing a slow pressurization.
For ear drum rupture, antibiotics must be given otherwise a middle-ear infection may occur. Contact Medical/Safety Network for assistance.
Occasionally, an ear squeeze may be caused by gas expanding during decompression, which cannot escape. This can be treated by recompression therapy.
Do not in any circumstances a Valsalva during ascent.



5.21 ACCIDENTS FROM H.P. WATER JETTING

The following comments about the management of accidents with high pressure water jets have been made by the Diving Medical Advisory Committee (D.M.A.C.) :

SYMPTOMS

The wound caused may appear insignificant and give little indication of the extent of the injury beneath and the damage to deeper tissue. Large quantities of water may have punctured the skin, flesh and organs through a very small hole that not even bleed. Initial mild damage to the wall of an organ may result in subsequent rupture, particularly if infection has been introduced.
The development of subsequent infection is particularly important in abdominal injuries.

TREATMENT

The outcome depends upon the extent of initial injury and the presence or absence of infection, and even though the injury seems trivial on the surface and the patient has no complaints, it is of great importance to arrange for medical examination as quickly as possible.

Where surgical examination is not immediately possible in a remote situation, first aid measures are confined to dressing the wound and observing the patient closely for the development of further complaints over four or five days. The development of fever and a rising pulse rate suggest that the injury is serious together with persistance or occurrence of pain.

On evacuation, the diver should carry the following card which outlines the possible nature of the injury :

> *"This man has been involved with high pressure water jetting at pressures up to 14,500 lb/in² (100 MPa, 1000 Bar, 1019 kg/cm²) with a jet velocity of 900 miles (1.440 km) per hour.*
> *Please take this into account when making your diagnosis.*
> *Unusual infections with micro-aerophilic organisms occurring at lower temperatures have been reported. These may be gram negative pathogens such as are found in sewage. Bacterial swabs and blood cultures may therefore be helpful."*

5.22 INJURY FROM UNDERWATER BLAST

CAUSES

Underwater blast injury is caused by the shockwave generated by an underwater explosion. It causes internal damage.

SYMPTOMS

— Pain due to perforated ear drums.
— Pain due to injuries to internal organs. Internal injury may be extensive in spite of no visible injury.
— Difficulty in breathing because of lung damage.

TREATMENT

— Allow the patient to adopt the most comfortable position.

— Treat for shock.

— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
in chamber apply Table **Cx B**, page 17

— Contact Medical/Safety Network for assistance.

5.23 ABDOMINAL GAS

Gas generated in the intestines or swallowed during a dive is normally released in the usual way during decompression. If not, and if the discomfort increases, ascent should be stopped and the diver should descend or be recompressed slightly until relief. He should then attempt to belch or pass the gas anally, with the caution that overzealous attempts to belch may cause more air/gas to be swallowed.

Most intestinal gas expansion can be avoided by not diving with an upset stomach or bowel, not eating foods which are likely to produce gas, and by avoiding swallowing air/gas during diving.

5.24 BURNING BY SODA-LIME

CAUSES

Water accidentally entering a closed or semi-closed circuit breathing apparatus and mixing with the carbon dioxide absorbent forms a strong alkali solution. This solution or "cocktail" then reaches the face, mouth, lungs and stomach and causes chemical burns of the body tissues.

SYMPTOMS

Burning sensation in the affected parts.

TREATMENT

— Get the diver out of the water and remove his set as quickly as possible,

— Give the diver copious draughts of water,

— Wash all affected external surfaces with fresh water, or with salt water if fresh water is not available,

— Treat serious cases for shock.

— Oxygenotherapy : at surface apply Table **Cx 12**, page 5
in chamber apply Table **Cx B**, page 17

— Contact Medical/Safety Network for assistance.

5.25 EAR INFECTIONS

CAUSES

Divers are particularly susceptible to ear infection when they are exposed for prolonged periods to high humidity.
See prevention page 130.

SYMPTOMS

Irritation, soreness and discharge from the ears.

TREATMENT

Considering that a decompression from saturation takes days, it is important to remove a source of contamination by decompressing the diver as soon as possible. This applies even before the infection is fully declared.

— The course of preventive drops is to be stopped.

— A swab is to be retaken from the diver for finer identification of the bacteria to be treated.

— Both ears of the diver are to be treated at the same time, even if only one is affected.

— Begin treatment 4 times a day with Polymyxin/Gentamicin (Polydexa) ear drops. DO NOT use Otosporin unless pain is very severe or you have no Polymyxin/Gentamicin.

— Put 3-4 drops into each ear and allow to remain, with the head on one side, for 3 minutes. Repeat for the other ear. Repeat 4 times daily for a week, even if symptoms subside, unless treatment is changed by a doctor.

— Panadol (Paracetamol) can be given as a pain-killer (dose 2 tablets/6 hours). Beware of hiding pains due to decompression sickness.

— Do not share medication between divers. Each affected diver must have his own treatment supply.

— On completion of treatment, leave two clear days, then repeat bacteriological swabs for both ears and send to a laboratory ensuring that they arrive within 24 hours.

NOTE : Never use therapeutic drops preventively.

5.26 DANGEROUS MARINE LIFE

JELLY FISH STING

Stings follow contact with the tentacles of some jelly fish. The most dangerous types of jelly fish are the Portuguese Man- of-War and the Sea Wasp.

SYMPTOMS

— Pain at site of sting. May be mild like a nettle sting or severe enough to cause unconsciousness
— Redness, swelling or blistering of the skin. Loss of the body sensation
— Muscle cramps
— Admominal pain
— Paralysis of limbs
— Nausea and vomiting
— Severe backache.

TREATMENT

— Get out of the water,
— Remove any remaining tentacle and sting fluid with a stick or cloth,
— Wash copiously with water,
— Apply weak alkali (saturated solution of baking powder), or vinegar.
— Treat for shock.
— Give Steroid (Decadron) intramuscular.
— Contact Medical/Safety Network for assistance.

CONE SHELL STINGS

Injection of venom from certain species of conical shells found in sand and under rocks. Clothing does not afford full protection so that contact must be avoided if at all possible.

SYMPTOMS

— Sting site painful and surrounded by white or blue area
— Numbness spreading rapidly from sting area
— Paralysis may follow
— Unconsciousness.

TREATMENT

— Keep patient quiet,
— Apply a tourniquet above the bite and keep injured area as cold as possible (immerse in ice cold fresh water),
— Treat for shock (see page 59),
— Give Steroid (Decadron) intramuscular,
— Contact Medical/Safety Network for assistance.

VENOMOUS FISH AND SEA SNAKE STINGS

In some areas venomous sea snakes and fishes are prolific, and local information should be sought to indicate which ones may be encountered.

Note that clothing does not afford full protection so that contact must be avoided if at all possible.

Poison is injected into the diver's skin from hollow fangs in the snake's upper jaws or via venom apparatus carried in the tips of spines.

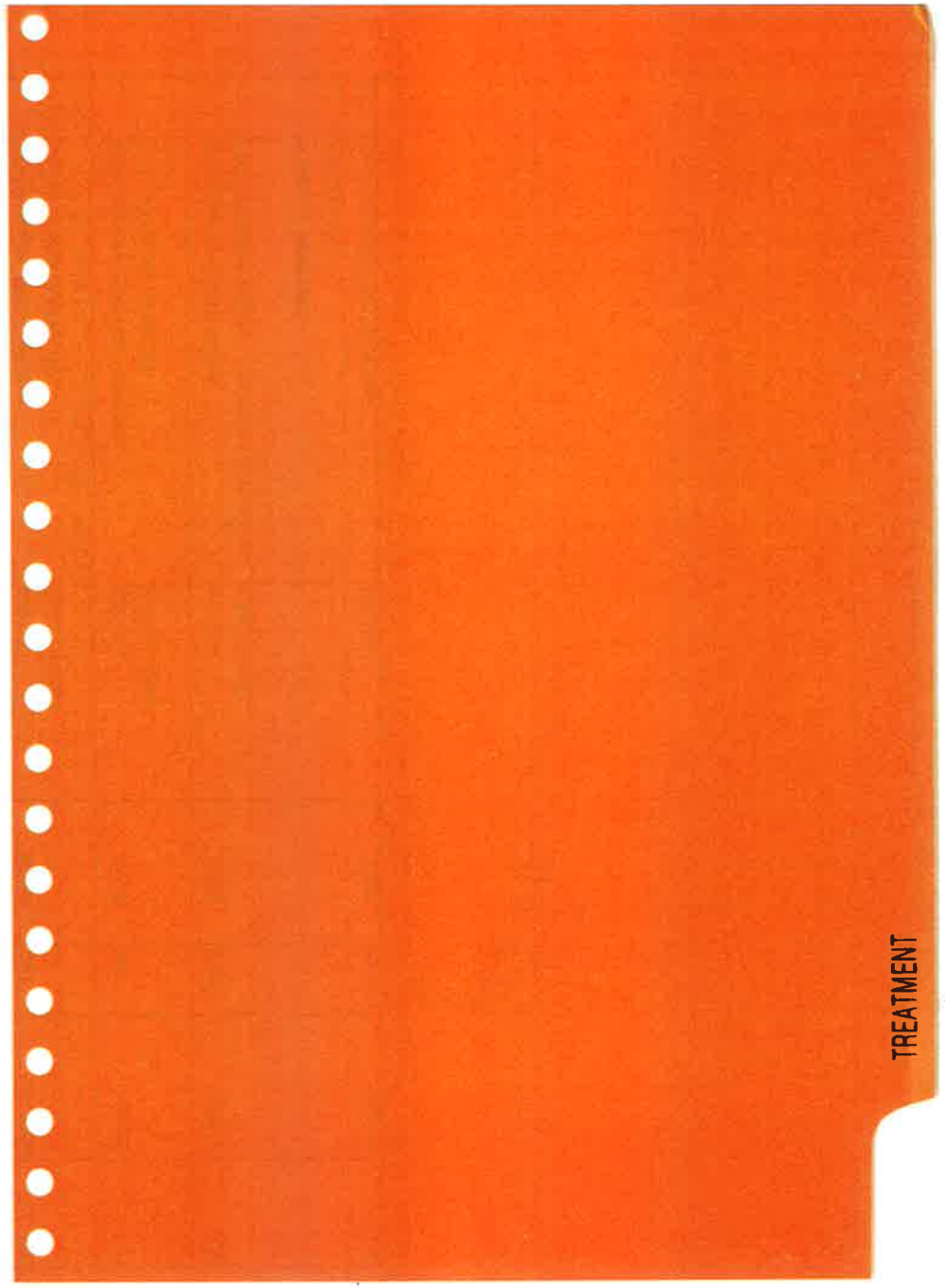
SYMPTOMS

Early onset :
— A vague feeling of being unwell
— Muscle stiffness
— Aching pain on movement

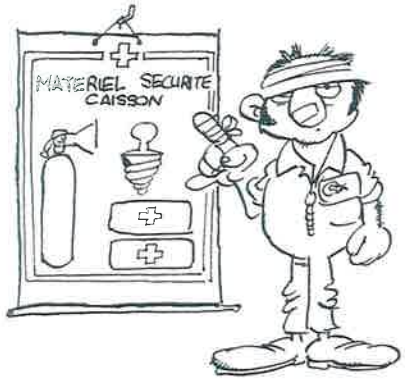
Late onset :
— Spreading paralysis involving the whole body
— Shock
— Convulsions
— Unconsciousness.

TREATMENT

Immediate treatment is imperative.
— Keep the patient quiet,
— Apply a tourniquet above the bite and keep the injured area as cold as possible (immerse in ice cold fresh water),
— Anti-serum must be given intravenously. A doctor should be called to give a polyvalent anti-serum containing Krait (Elapidae) fraction. This should be given by slow intravenous injection,
— Treat for shock,
— Give Steroid (Decadron) intramuscular.



CHAPTER 6
MEDICAL TREATMENTS/KITS



6.1 MEDICAL TREATMENT N°1

COMEX SERVICES AND NORTH SEA UK

MEDICAL TREATMENT N° 1

MEDICAL TREATMENT FOR TYPE I ACCIDENTS

This treatment is contained in the decompression KIT N° 1.

It will be given immediately after arriving at treatment depth. The patient will remove the mask in order to take by mouth :

— 1 ASPEGIC 1000 dissolved in water upon arrival at treatment depth. If ASPEGIC is not available it can be replaced by 900 mg (3 tablets of 300 mg) of Aspirin Soluble BP.

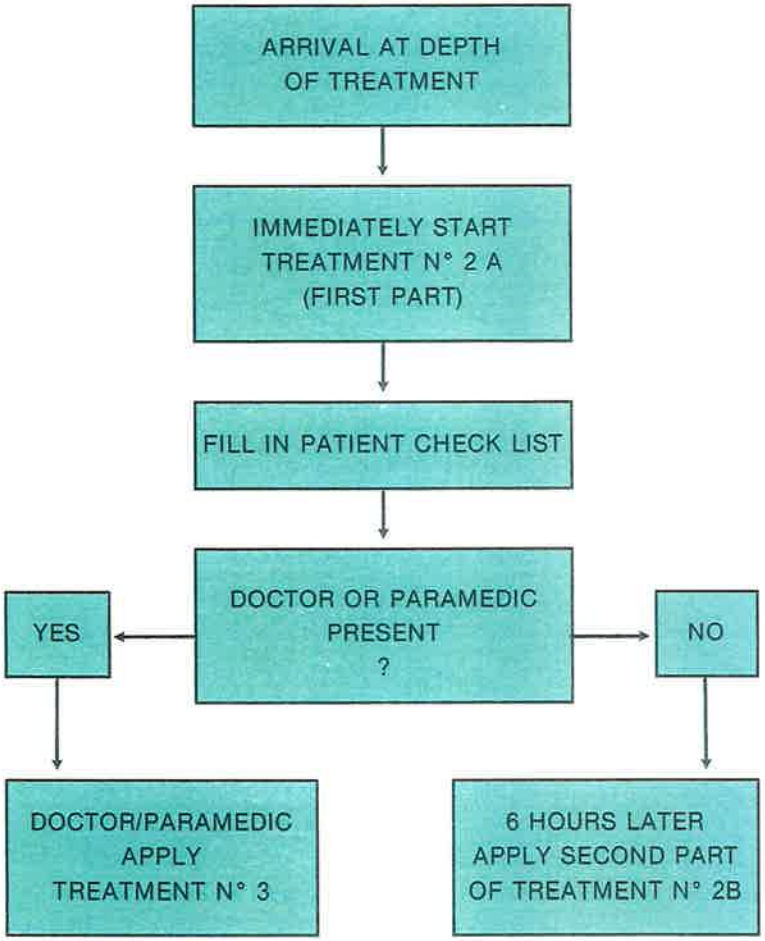
— 1/4 litre of liquid (water, fruit juice) every 60 minutes.

It will be the only treatment to apply with the recompression.

6.2 MEDICAL TREATMENTS N° 2A, N° 2B AND N°3

NORTH SEA UK

MEDICAL TREATMENT OF TYPE II ACCIDENT



MEDICAL TREATMENT FOR TYPE II ACCIDENT

TREATMENT N° 2 A - CONTAINED IN KIT N° 1

APPLIED IMMEDIATELY BY NON MEDICALLY QUALIFIED PERSONNEL

On arrival at depth of treatment :

— ASPIRIN (1 gram/day)
— SYNACTHEN (2 amps of 0.25 mg in 1 ml) - intramuscular injection
— SYNACTHEN DEPOT (1 amp of 1 mg in 1 ml) - intramuscular injection

TREATMENT N° 2 B CONTAINED IN KIT N° 1

APPLIED 6 HOURS LATER IF NO DOCTOR/PARAMEDIC HAS STARTED TREATMENT N° 3

— SYNACTHEN (1 amp. of 0.25 mg in 1 ml) - intramuscular injection

TREATMENT N° 3 - CONTAINED IN KIT N° 2

APPLIED BY DOCTOR/PARAMEDIC (as soon as possible)

On arrival and during the first hour :

— Intravenous infusion :
  • RINGER'S SOLUTION (500 ml in 1 hour - 180 drops/min)
— Injection into the infusion tubing :
  • DECADRON (3 amps of 8 mg in 2 ml) injected into the infusion tube

During the following two hours (second and third hour) :

— Intravenous infusion in the same bottle :
  • SALINE (500 ml in 2 hours - 90 drops/min)
  • SYNACTHEN (1 amp of 0.25 mg in 1 ml)

During the following two hours (fourth and fifth hour) :

— Intravenous infusion in the same bottle :
  • RINGER'S SOLUTION (500 ml in 2 hours - 90 drops/min)
  • SYNACTHEN (1 amp of 0.25 mg in 1 ml)

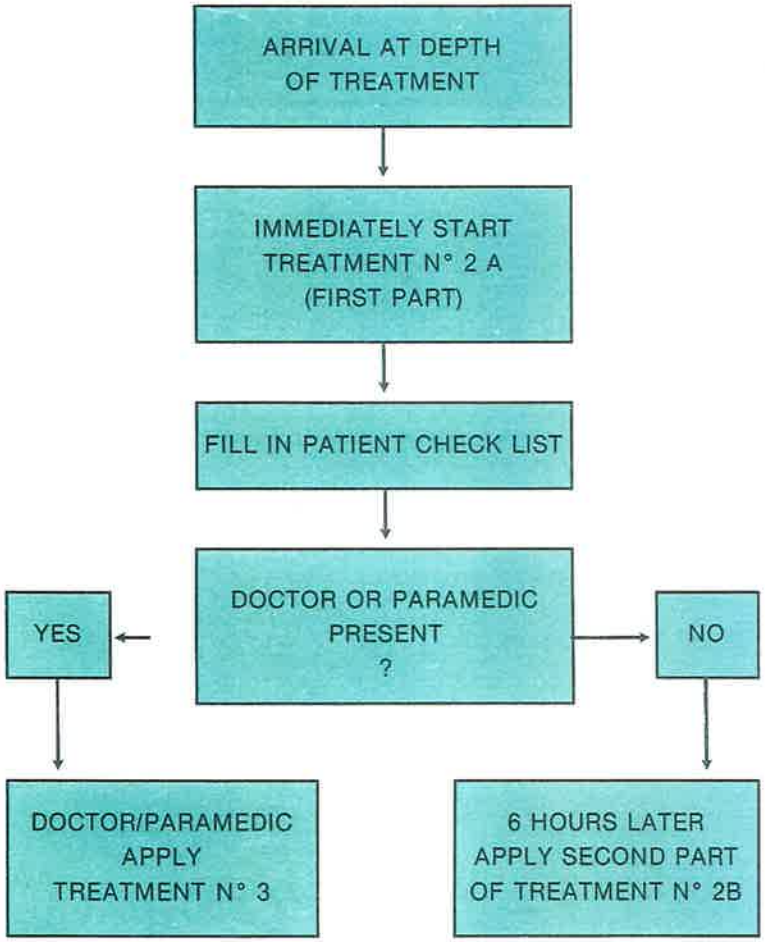
During the following hour (sixth hour) :

— Intravenous infusion in the same bottle :
  • SALINE (500 ml in 1 hour - 180 drops/min)

6.3 MEDICAL TREATMENTS N° 2A, N° 2B AND N° 3

COMEX SERVICES

MEDICAL TREATMENT OF TYPE II ACCIDENT



MEDICAL TREATMENT FOR TYPE II ACCIDENT

TREATMENT N° 2 A - CONTAINED IN KIT N° 1

APPLIED IMMEDIATELY BY NON MEDICALLY QUALIFIED PERSONNEL

On arrival at depth of treatment :

— ASPIRINE	(1 gram/day)	
— SYNACTHENE IMMEDIAT	(2 amps of 0.25 mg)	- intramuscular injection
— SYNACTHENE RETARD	(1 amp. of 1 mg)	- intramuscular injection
— FONZYLANE	(2 amps of 5 mg)	- intramuscular injection

TREATMENT N° 2 B - CONTAINED IN KIT N° 1

APPLIED 6 HOURS LATER IF NO DOCTOR/PARAMEDIC HAS STARTED TREATMENT N° 3

— SYNACTHENE IMMEDIAT	(1 amp. of 0.25 mg)	- intramuscular injection
— FONZYLANE	(1 amp. of 5 mg)	- intramuscular injection

TREATMENT N°3 - CONTAINED IN KIT N°2

APPLIED BY DOCTOR / PARAMEDIC (as soon as possible)

On arrival and during the first hour :

— Intravenous infusion :

• RHEOMACRODEX	(500 ml in 1 hour - 180 drops/min)
• TORENTAL	(2 amps) injected into the infusion bottle
• SOLUDECADRON	(3 amps of 4 mg) injected into the infusion tube

During the following two hours (second and third hour) :

— Intravenous infusion in the same bottle :

• RINGER LACTATE	(500 ml in 2 hours - 90 drops/min)
• TORENTAL	(2 amps of 5 ml)
• SYNACTHENE IMMEDIAT	(1 amp of 0.25 mg)
• FONZYLANE	(1 amp of 5 mg)

During the following two hours (fourth and fifth hour) :

— Intravenous infusion in the same bottle :

• RINGER LACTATE	(500 ml in 2 hours - 90 drops/min)
• TORENTAL	(2 amps of 5 ml)
• SYNACTHENE IMMEDIAT	(1 amp of 0.25 mg)
• FONZYLANE	(1 amp of 5 mg)

During the following hour (sixth hour) :

— Intravenous infusion in the same bottle :

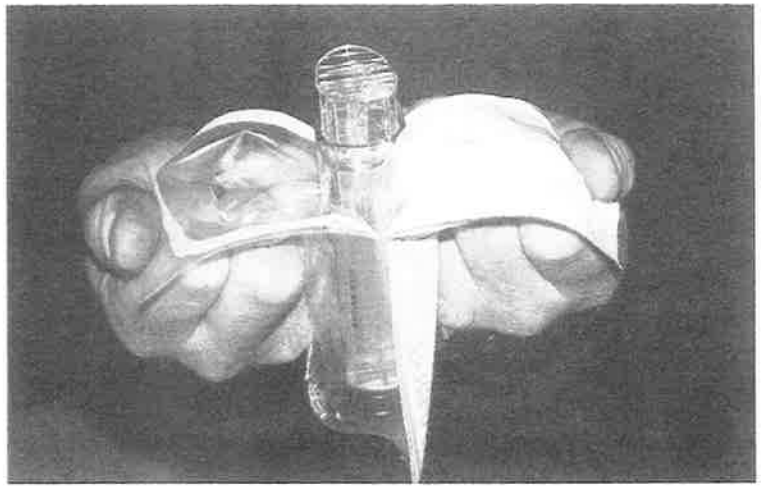
• RHEOMACRODEX	(500 ml in 1 hour - 180 drops/min)
• TORENTAL	(2 amps of 5 ml)

6.4 INTRAMUSCULAR INJECTION

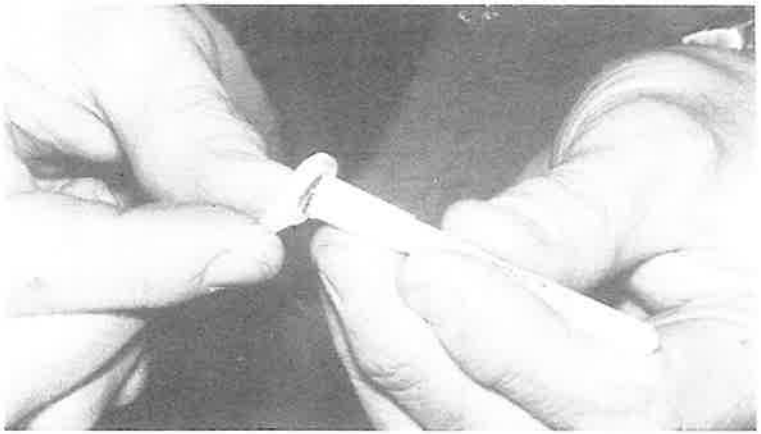
The attendant cleans his hands with the skin cleaner. He cleans the neck of each ampoule with cotton wool soaked in cleaner.

1 - Open the ampoules one after another in the way shown below :

2 - Take the sterile syringe pack and remove one 20 ml syringe :

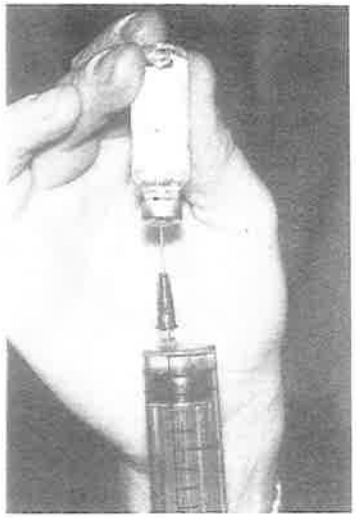


3 - Use the same method for the intramuscular injection needle :

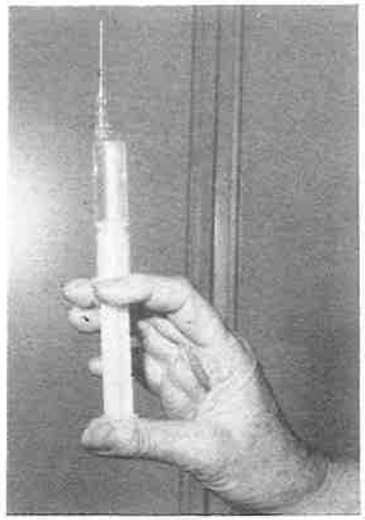


4 - Assemble the syringe and the needle :

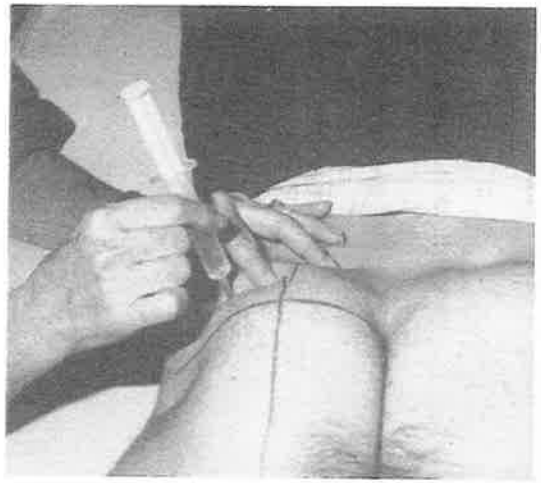
5 - Suck the content of each ampoule into the syringe.



6 - Remove the air contained in the syringe by pushing gently on the piston with the syringe pointing vertically :



7 - Clean the site for intramuscular injection. Injection should be done in the upper outer quadrant of the buttock :



8 - Stretch the skin with the thumb and forefinger and inject perpendicular to the skin . Push the needle almost all the way in.

9 - Suck gently with the syringe. If blood can be seen in the syringe the needle must be withdrawn and introduced again one centimetre to one side.
Inject the solution slowly in 2/3 minutes.

10 - If for some reason it is impossible to inject the solution in the buttock, use the upper outer side of the thigh, the needle introduced at 45° to the skin.

6.5 DECOMPRESSION KIT N°1 AND KIT N° 2
NORTH SEA UK

CONTENTS OF "DECOMPRESSION KIT N° 1"

(TREATMENT APPLIED BY THE DIVER/ATTENDANT)

	Storage
— Soluble ASPIRIN tablets 300 mg (jar of 25)	1
— Disposable Syringes 2 ml	5
— Disposable Syringes 5 ml	3
— Disposable Syringes 20 ml	2
— Disposable hypodermic needles, 23 G x 1 1/2	10
— Mediswabs	15
— SYNACTHEN injection	6 ampoules
— SYNACTHEN DEPOT injection	5 ampoules

These kits must be kept in a cool place.
They are under the responsibility of the diving Superintendent.
They are not to be opened except in the case of a decompression accident or for a regular checking for the replacement of drugs before expiration.

6.5 DECOMPRESSION KIT N°1 AND KIT N° 2
NORTH SEA UK

CONTENTS OF "DECOMPRESSION KIT N° 2"

(TREATMENT APPLIED BY THE DOCTOR OR THE PARAMEDIC)

	Storage
— Tourniquet	1
— Disposable syringe 10 ml	2
— Disposable syringe 5 ml	5
— Disposable syringe 2 ml	2
— Disposable needles 23 G × 1 1/2	20
— Disposable needles 25 G × 5/8	20
— I.V. cannulae medicut 18 G	6
— I.V. giving sets	4
— Skin cleaning solution, bottle	1
— Roll of dermal tape	1
— Sterile gauze pads	10
— Foley balloon catheter n° 18	2
— RINGER's solution bottle	4
— SALINE, bottle	4
— DECADRON 8 mg injection ampoules	3
— SYNACTHEN injection (Box of 6 amps)	1
— VALIUM 10 mg injection (Box of 10 amps)	1
— XYLOCAINE gel 30 g tube	1
— XYLOCAINE LOCAL ANAESTHETIC 20 ml bottle	2
— Drainage bag	1

These kits must be kept in a cool place.
They are under the responsibility of the diving Superintendent.
They are not to be opened except in the case of a decompression accident or for a regular checking for the replacement of drugs before expiration.

6.6 DECOMPRESSION KIT N°1 AND KIT N° 2
COMEX SERVICES

CONTENTS OF "DECOMPRESSION KIT N° 1"

(TREATMENT APPLIED BY THE DIVER/ATTENDANT)

		Storage
— ASPEGIC 1000		6 sachets
— Disposable syringes 2 ml		5
— Disposable syringes 5 ml		3
— Disposable syringes 20 ml		2
— Disposable intramuscular needles		10
— Bottle of DAKIN's solution		1
— Cotton wool		100 g
— Sterile dressings 40 x 40		10
— Adhesive tape		1
— Aluminium blanket		1
— FONZYLANE Injection	ampoules 5 ml	2 x 3 ampoules
— SYNACTHENE immediat	ampoules 2 ml	2 x 3 ampoules
— SYNACTHENE retard	ampoules 1 ml	2 x 1 ampoule

These kits must be kept in a cool place.
They are under the responsibility of the diving Superintendent.
They are not to be opened except in the case of a decompression accident or for a regular checking for the replacement of drugs before expiration.

6.6 DECOMPRESSION KIT N°1 AND KIT N° 2
COMEX SERVICES

CONTENTS OF "DECOMPRESSION KIT N° 2"

(TREATMENT APPLIED BY THE DOCTOR OR THE PARAMEDIC)

	Storage
— Aluminium blanket	1
— Rubber tourniquet	1
— Disposable syringes 10 ml	2
— Disposable syringes 5 ml	5
— Disposable syringes 2 ml	2
— Disposable needles IV	10
— Disposable needles IM	10
— Disposable needles TROCARD	10
— IV catheters	3
— BETADINE SKIN CLEANER	1
— Sterile dressings	40 x 40
— Adhesive tape	1
— Air inlet tubes	1
— Gauze bandage	1
— Foley balloon catheter n° 18	1
— IV sets	3
— RHEOMACRODEX 500 ml	2 bags
— RINGER LACTATE solution 500 ml	2 bags
— THAMACETAT 250 ml	1 bottle (plastic)
— SOLUDECADRON injection - 4 mg	6 ampoules
— TORENTAL injection 5 ml	8 ampoules
— FONZYLANE injection	2 ampoules
— SYNACTHENE immediat	2 ampoules
— TRONOTHANE gel (30 g)	1 tube
— PERVINCAMINE injection	4 ampoules
— VALIUM injection 10 mg	2 ampoules
— PLEUROCENTESIS needle	1 ampoule

These kits must be kept in a cool place.
They are under the responsibility of the diving Superintendent.
They are not to be opened except in the case of a decompression accident or for a regular checking for the replacement of drugs before expiration.

6.7 CHAMBER DIAGNOSIS KIT

FIRST AID EQUIPMENT

CONTENT

	Storage
— bottle BETADINE 500 ml	1
— elastic adhesive bandage 5 cm x 7 m	1
— elastic adhesive bandage 10 cm x 7 m	1
— gauze bandages 7.5 cm x 3.5 m	2
— box sterile compresses	1
— pairs sterile gloves	10
— packet cotton wool 25 g	1
— roll sticking plaster 5 cm x 1 m	1
— arm splint (wire) 70 cm	1
— tourniquet	1
— pair blunt ends scissors	1
— mouth gag (metal)	1
— mouth to mouth resuscitation tube (Brook or Porter)	1
— suction pump (with notice)	1
— suction pump catheters	1
— Chamber O_2 resuscitator (CX Pro)	1

DIAGNOSIS EQUIPMENT

CONTENT

— sphygmomanometre (modified)	1
— stethoscope	1
— tuning fork 440 hz	1
— reflex hammer	1
— box of wooden tongue depressers	1
— pencil torch/spare batteries	1
— auriscope/spare batteries	1
— box of disposable cones	1
— Thermometers (thermoversicolor) box	1

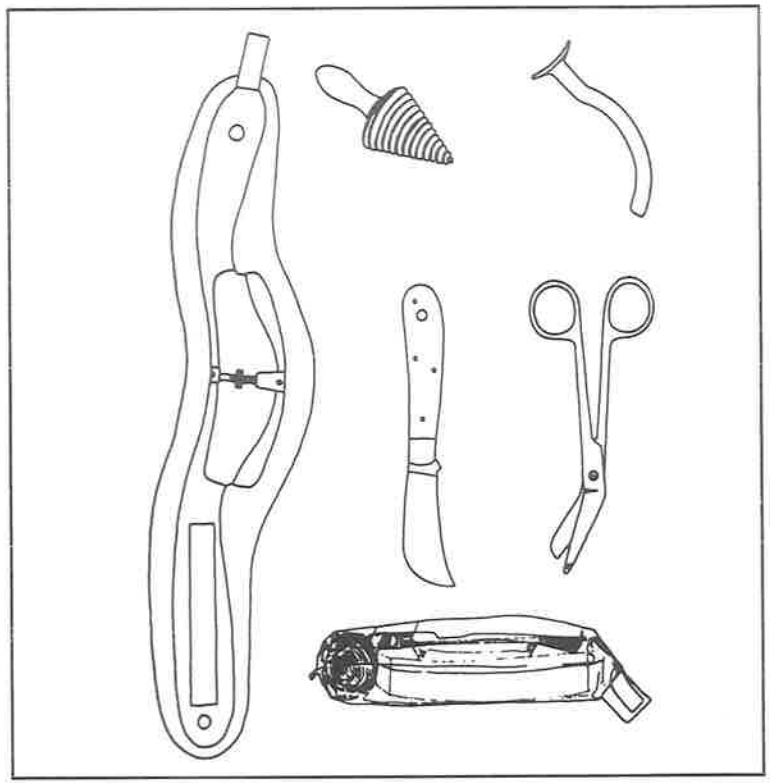
6.8 BELL KIT

The following first aid equipment is available in all diving bells :

— Chute bandage (both tourniquet and pressure bandages)
— Mouth opener - wooden screw
— "Shortened" guedel airway
— Rigid collar
— Blunt ends scissors
— Jack knife.

The Norwegian bell kit (labelled First Aid Equipment I) also includes :

— 1 Laerdal pocket mask
— 1 pc. suction equipment.



6.9 SURFACE OXYGEN RESUSCITATOR KIT

The unit consists of :

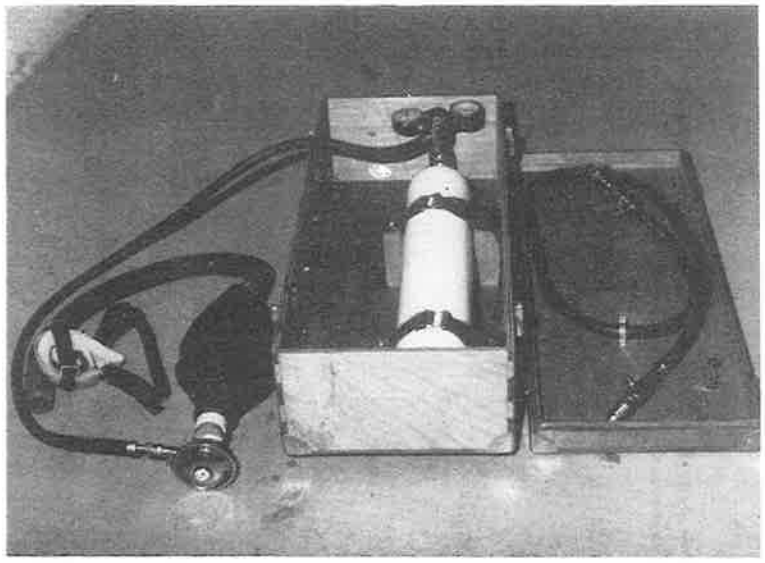
- a small Oxygen cylinder
- a pressure reducer
- a flexible hose
- a demand valve
- an Ambu bag
- a corrugated hose
- an oro-nasal.

all contained inside a wooden box.

Several handles facilitate its handling, while a pair of straps allow it to be carried on the back.

The lid can be removed, and the person carrying the unit on his back can walk along a stretcher and administer O_2 ventilation.

The presence of such a unit is compulsory on any surface diving worksite.



6.10 PULMONARY OEDEMA KIT

	Storage
— Haemaccel Infusion 500 ml	2
— Infusion giving sets	4
— I.V. cannulae medicut 18 G	4
— Dextrose in Saline 500 ml	2
— Decadron 8 mg amp (4 mg per ml)	6
— Xylocaïne 1 % 20 ml bottle	1
— Amethocaine Minims	1 x 20
— Disposable needles 25 G × 5/8	10
— Isoprenaline (Aleudrin) solution at 1 % (dilute 1 ml of this solution in 10 ml of distilled water before inhalation)	1 spray can

6.11 NORWEGIAN SECTOR KITS

In order to comply with the requirements of the Norwegian Contingency Plan for divers, Comex supplies the following additional equipment to worksites operating in the Norwegian Sector.

DIAGNOSTIC KIT : Comex Stock n° 690075

— Sphygmomanometer aneroid type
— Stethoscope
— Oto-ophthalmoscope
— Torch
— Reflex hammer, with brush and needle
— Electric thermometer
— Tongue spatulas (5)
— Packet Labstix-N
— Packet Dextrostix, with lancets
— Tourniquet
— Sterile pack containing : 10 lancets,
3 Wasserman cannulas, 2 test-tubes for blood,
2 test-tubes for blood with anti-coagulation agent
— Bottle Pyrisept, cotton wool, adhesive plaster.

RESUSCITATION KIT : Comex Stock n° 690080
(Medicinal life - saving kit)

— 1 Laryngoscope
— 2 Endotracheal tubes, 7 and 9 mm
— 1 Ambu bag and Ambusug suction device
— 1 Laerdals mask and bag for oxygen supply
— 2 Airways n° 3 and 4 ; 2 padded spatulas
— 2 Catheters for suction n° 12 and 14 and couplings

SURGICAL KIT : Comex Stock n° 690085

Surgical box :	Storage
— curved arterial forceps 12 cm	2
— curved arterial forceps 18 cm	1
— surgical forceps 2/3 tooths 12 cm	1
— anatomical forceps 12 cm	1
— scissors straight 12 cm	1
— scissors curved 12 cm	1
— scalpels	3
— catgut n° 00 with needle	5
— nylon n° 00 with needle	5
— Thoracosentesis kit	2
— Tracheal trocar (Tracheotomy kit)	1

	Storage
— pairs sterile gloves n° 8	5
— pairs sterile disposable sheets	5
— sterile disposable basins	5
— pkts. sterile compresses 10 cm × 10 cm	5
— pkts. sterile compresses 50 cm × 50 cm	5
— gauze compresses 10 cm	3
— gauze compresses 20 cm	3
— head bandage	1
— rolls gauze bandage, sterile 6 cm × 5 m	2
— rolls gauze bandage, sterile 8 cm × 5 m	2
— set equipment to immobilize limbs e.g. pneumatic splint with mounted pressure relief valve	1
— bottle disinfectant solution for cleaning wounds.... 500 ml. e.g. Pyrisept 1‰ "Weifa", plastic bottle.	1
— in addition : safety pins, plaster, face masks.	

MEDICINE KIT : Comex stock n° 690090

Infusion (in plastic bags)

— Bicarbonate of soda 4,2 %	2 x 500 ml	5
— Rheo Macrodex	2 x 500 ml	5
— Glucose 5 %	2 x 500 ml	5

Injections :

— Cedilanid	(amp. of 2 ml)	5
— Lasix	(amp. of 2 ml)	5
— Adrenalin 0.1 %	(amp. of 1 ml)	10
— Adrenalin 0.1 %	(amp. of 5 ml)	10
— Aramine 1 %	(amp. of 1 ml)	5
— Atropine 0.1 %	(amp. of 1 ml)	5
— Primperan	(amp. of 2 ml)	5
— Valium 5 mg	(amp. of 2 ml)	5
— Pethidin 50 mg	(amp. of 1 ml)	2
— Chlorpromazine "Dumex"	(amp. of 2 ml)	10
— Decadron	(amp. of 1 ml)	5
— Actocortin "F.C.F."	(sets of 100 mg)	5
— Xylocain 1 %	(bottles of 20 ml)	5
— Polaramine "Schering"	(amp. of 5 ml)	1

	Storage
— Valium (tablet of 5 mg)	50
— Codeine (tablet of 30 mg)	50
— 5 infusion sets (f.inst. Fenwell w/filter)	10
— Venflon cannulas (1.4 x 70)	10
— disposable syringes 2 ml	10
— disposable syringes 5 ml	10
— disposable syringes 10 ml	5
— subcutaneous needles (G 23'80)	20
— intramuscular needles (G 21'80)	20

TRANSPORTATION KIT : Comex stock n° 690095

— Sphygmomanometer		1
— stethoscope		1
— infusion sets		2
— venflon cannulas (1.2 or 1.4)		4
— Dextran 70 500 ml		2
— Ringer infusion solution 500 ml		2
— Cedilanid	(amp. of 2 ml)	5
— Lasix	(amp. of 2 ml)	5
— Adrenalin 0.1 %	(amp. of 1 ml)	5
— Adrenalin 0.1 %	(amp. of 5 ml)	10
— Aramine 1 %	(amp. of 1 ml)	2
— Atropine	(amp. of 1 ml)	5
— Aminophylline	(amp. of 2 ml)	2
— Primperan	(amp. of 2 ml)	5
— Valium	(amp. of 2 ml)	5
— Pethidin 5 %	(amp. of 1 ml)	5
— Xylocain 1 %	(amp. of 20 ml)	5
— disposable syringes 2 ml		5
— disposable syringes 5 ml		5
— disposable syringes 10 ml		5
— intramuscular needles		10
— subcutaneous needles		10

— Medicinal life - saving kit see page 110.

Norwegian regulations also require a medicine cupboard with stock of medicines for use by the divers on board.

CHAPTER 7

PREVENTION/PRECAUTIONS

7.1 MEDICAL NETWORK AND SKILLS

CHIEF COMEX MEDICAL OFFICER

He is the head of all medical activities, based in Marseille and supervises also the medical research and development programmes. He participates in the emergency medical cover system. He also assists Comex agencies and isolated worksites worldwide for the set up of their own medical organization and back-up.

MARSEILLE MEDICAL DEPARTMENT

It provides standard medical services, examinations, etc... as well as a participation in the emergency medical cover. All decompression accidents are also computerized and analysed as part of a permanent improvement programme.

AGENCY MEDICAL ORGANIZATION

Every Comex agency has arrangements to provide routine medical services such as medical examination for divers, etc..., as well as emergency advice or intervention.
Some medical organizations do provide medical services including emergency ones on a contractual basis and this may include hyperbaric medicine.
They may be used by agencies who are not maintaining a full time or part time doctor, or as a back-up.

OIL COMPANY "RIG MEDIC"

Offshore oil companies normally provide some form of medical expertise. Usually these "Rig Medics" are qualified nurses, sometimes they can be fully qualified general practitioners.
Most of the time they can provide surface care, but cannot be considered as expert in hyperbaric medicine, nor can they be expected to enter a chamber under pressure.

COMEX "RIG MEDIC"

When the support vessel belongs to Comex or is managed partly by Comex in a joint venture, the Rig Medic will be Comex personnel, and in this case is likely to be a qualified nurse with some hyperbaric knowledge.

DIVING SUPERINTENDENTS, SUPERVISORS, AND CHAMBER OPERATORS (L.S.T.)

These people need to have a good understanding of diving physiology and some serious notions of hyperbaric medicine. They will implement the therapeutic treatments but they are not expected to get inside the chambers as their presence is needed outside to manage the crisis.

DIVERS "PARAMEDICS" (Emergency Medical Technicians)

These are divers who have received an advanced First Aid Course specifically on diving medicine.
Being divers, they are expected either to be or to go under pressure in case of medical emergency and to look after the patient.

They can :
— make a complete clinical assessment
— provide advanced first aid
— administer injections and intravenous fluid.

Ideally there should be 2 paramedically trained divers per worksite, (if there was only one, he would invariably be the person who would have the accident!).

DIVERS

Divers have all learnt basic first-aid during their training and cardio-pulmonary resuscitation is a basic skill in which they are all expected to be proficient.

MEDICAL EQUIPMENTS

Every Comex worksite is equipped with standard medical kits (chap. 6) ensuring that help can be administered quickly by competent paramedically trained personnel under telephone medical supervision.

MEDICAL PROCEDURES

The present book, available on all Comex worksite provides both :
— clear guidance in case at emergency,
— background education and information.

CALL-OUT ARRANGEMENTS

Each Comex agency must provide arrangements whereby every worksite can call a duty person 24 hours a day in case of emergency. The duty person does not have to be medically qualified, but he must have a good understanding of diving matters and must be capable of contacting a doctor rapidly.

EMERGENCY CALL OUT PROCEDURES

After having reacted to an emergency ,the diving supervisor or superintendent must call the local Medical/Safety Network as soon as his paramedical personnel have established a clinical assessment of the patient condition.

The duty person ashore will thus :
— be informed of the situation,
— possibly provide some direct advice (or confirmation that action taken so far is correct).

He will then call for medical advice locally, at Marseille or anywhere else and either the doctor will call the worksite back directly or the duty person may have to provide a relay between the doctor and the worksite.

Medical help may be sent to the worksite from local arrangement if necessary.

NOTE : *Experience has demonstrated that under the present arrangement involving the presence of standard kits and divers paramedics on board, over 95 % of all diving medical problems can be dealt with by telephone without having to send a doctor on the site at all.*

7.2 ACCIDENT AND ILLNESS FOLLOW-UP/ ADMINISTRATION

It is the Diving Superintendent's responsibility to record all information about any injury or illness to COMEX or subcontractors personnel for medical, legal and insurance purposes.
The Diving Superintendent will ensure that all the following documents are filled in and forwarded to the BASE :

1 - Telex
2 - Comex Internal accident report
3 - Patient Check List
4 - Diving report
5 - Chamber monitoring report
6 - Statements from involved personnel.
7 - Other relevant documents or artefacts.

1 - TELEX

— Date and time of the accident
— Name of the diving support
— Name of the casualty
— Type of accident
— Circumstances
— Given treatments
— Actual status

2 - COMEX INTERNAL ACCIDENT REPORT

— Fill up section 1 and 6 for all cases
— Additionally fill up section 2, 3 and 4 in case of decompression accident
— Or, fill up section 5 for anything else including diving if not decompression related.

3 - PATIENT CHECK LIST

It is to be filled in by the attendant paramedic in the decompression chamber every hour in case of decompression accident, or other serious condition.

4 - DIVING REPORT

This is the diving report related to the accident.

5 - CHAMBER MONITORING REPORT

Filled in by the L.S.T. during the therapeutic treatment.

6 - STATEMENTS FROM INVOLVED PERSONNEL

Any involved personnel such as :
— Diving Superintendent
— Diving Supervisor
— Stand by Diver
— Other divers, etc...

must write a report or a statement when the circumstances and the gravity of the accidents warrant it.

7 - OTHER RELEVANT DOCUMENTS

Such as :
— Sketches/photographs
— Samples of gas
— Broken or deficient parts
— Voice recording
— Video recording
— Running log
— Client representative report
— Rig medic report
— etc...

7.3 TRAVELLING PRECAUTIONS/ TROPICAL ILLNESS

When travelling or operating in certain areas of the world such as :

— South East Asia
— Africa/Madagascar/The Comoro Islands
— Central America
— South America.

VACCINATION

Some vaccinations are compulsory, some may be demanded by different countries at different times such as :

— Yellow fever (valid 10 years)
— Smallpox (valid 3 years)
— Cholera (valid 6 months).

Comex further recommends that its operational personnel should be vaccined against :

— Tetanus
— Influenza, specially for saturation divers
— Hepatitis B, for worksites located in country where this disease is endemic (contact Medical Department for information during the preparation of the worksite).

MALARIA

This disease is widely spread in tropical country (refer to map next pages) ; COMEX recommends to personnel working in those areas to use a prevention treatment based on NIVAQUINE or FLAVOQUINE, or FANSIDAR (in area where the parasite has become resistant to Nivaquine and Flavoquine, contact Medical Department for information) :

— NIVAQUINE : 1 tablet every day, 6 days per week, starting the day of departure, ending the 8th week after return in a non infested area.
— FLAVOQUINE : 3 tablets per week (after meal) starting the day of departure, ending the 7th week after return in a non infested area.
— FANSIDAR : 1 tablet every 15 days, starting the day of departure, ending 6 weeks after return in a non infested area.

INTESTINAL AFFECTIONS

In tropical countries where the nutrition hygiene is doubtful it is recommended to avoid to eat fresh food (salads, fruits, ...). Always ask for bottled-drinks in local restaurants.

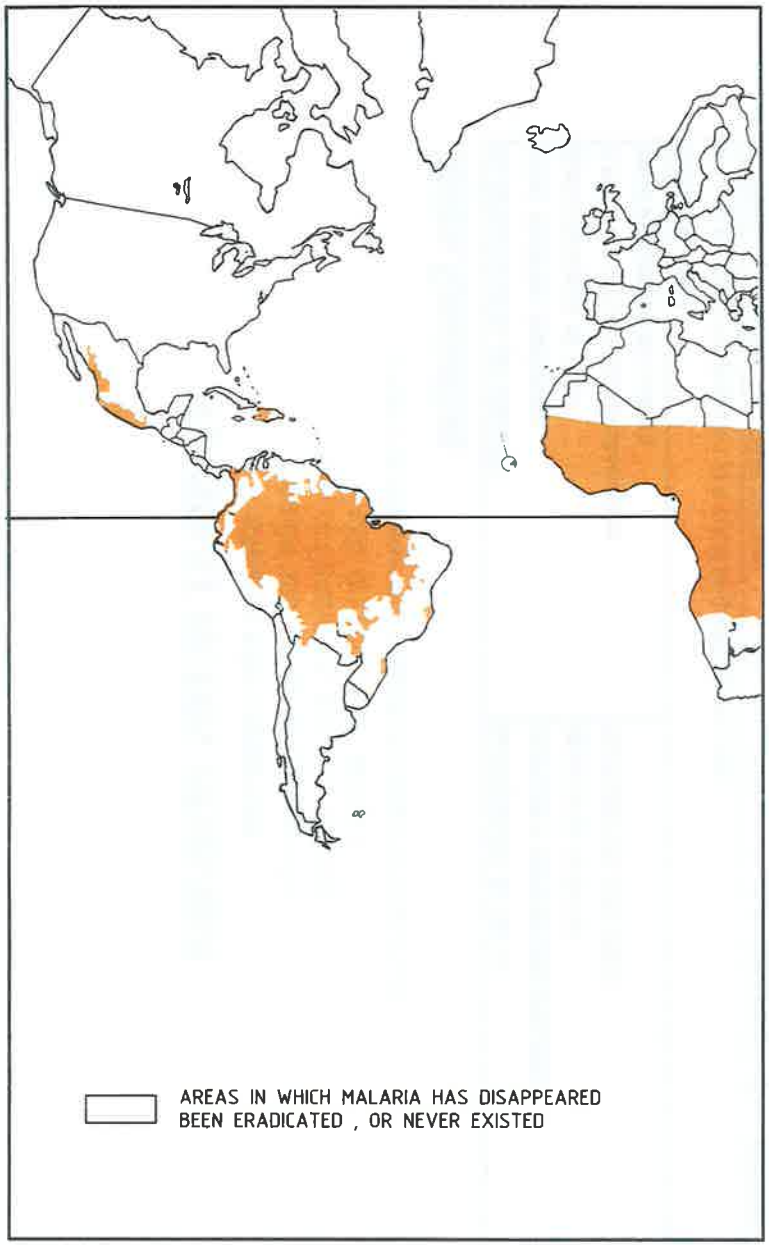
HEAT

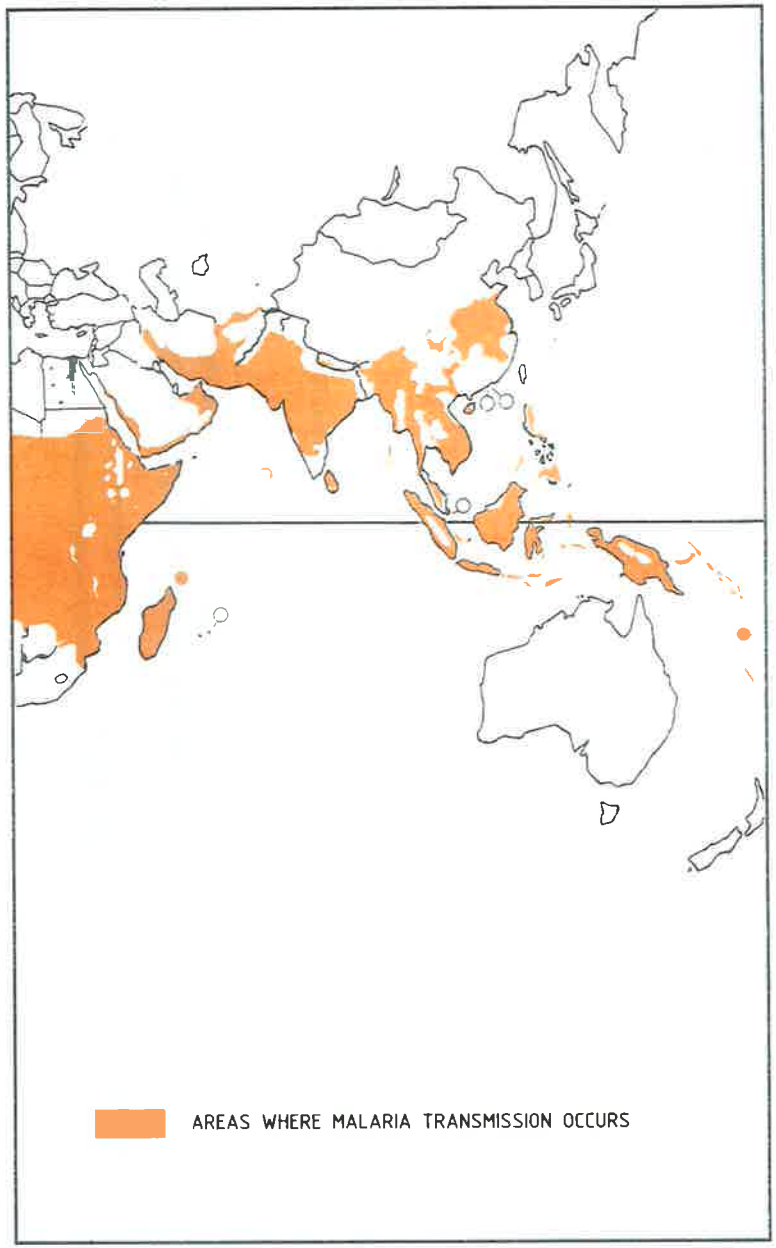
When in tropical countries, it is further advised :
— to take one salt tablet of one gram per day or to abundantly salt the meals.
— drink at least 2 litres per day in order to maintain a normal volume of urine and prevent kidney problems which are widely spread in tropical countries.

V.D.

Beware of sexual diseases. Abstinence is certainly the best prevention. However, a certain efficiency is recognized to condoms. In doubt, or at the first onset of symptoms, contact Medical Department. Note that DMAC has already clarified the problem of genital herpes.

QUOTE :
"Following recent concern about the theoretical risks of genital herpes passing contagiously between members of saturation teams, DMAC sought expert advice from a number of independent specialists in the fields of dermatology, virology and venereology. Having considered the opinions of these specialists DMAC consider that there is no risk of genital herpes spreading between divers in saturation systems. There is no reason to exclude a diver who has genital herpes, except when the lesions are in an active phase, at which time they may become secondarily infected to the hyperbaric environment. A diver with genital herpes, either active or quiescient, will not transmit the disease to others in the course of his normal activities during a saturation dive."
UNQUOTE


AREAS IN WHICH MALARIA HAS DISAPPEARED
BEEN ERADICATED , OR NEVER EXISTED


AREAS WHERE MALARIA TRANSMISSION OCCURS

7.4 MEDICAL FITNESS

Personnel working offshore are expected to be in a reasonable state of health.
This applies even more to divers whose medical examination is more stringent.
This medical examination takes place once a year, according to most regulations.

In the U.K., a person who has a certificate of medical fitness refused, or issued subject to limitations, may within 28 days apply to HSE (Health and Safety Executive) for a review of that decision.

Applications made a reasonable time after the expiry of the a period will also be considered at HSE's discretion. Before any reassessment can be made, HSE will normally require additional information so that the matter can be discussed with the doctor who refused or limited the certificate and other specialists consulted.

It may sometimes be necessary for a diver to attend a further medical examination arranged by HSE. Any certificate of fitness which HSE may issue after such a review may also be subject to any limitations it considers appropriate.
Comex doctors at headquarters provide medical examination to internationally accepted standards.

COMEX divers undergoing their medical examination at other "approved doctors" with the agreement of the local Comex Agency will pay the fee and claim it back to the company.

7.5 PHYSICAL FITNESS

Diving is physically demanding and a good physical standard is expected from professional divers in their work.

At the absolute minimum this includes but is not limited to :

— being physically fit,
— being sober,
— not suffering from a hangover,
— not being under the influence of any drug, medical drug or sedative,
— if undergoing Medical Treatment for any reason, to have checked with the Company doctor that such treatment is compatible with diving,
— not being a heavy smoker.

During diver's medical examination, consideration is given to factors which might lead to illness in the chamber, partly due to the time taken to return to surface from saturation.

For deeper diving, an even closer attention must be given to this in view of the longer decompression time.
The amount of breathing effort or "work of breathing" is less in fit people whose heart and lungs are healthy and in good condition. The increased gas density, therefore, has less effect the fitter the person.
Because of this, the examination, with its special investigations, will focus on heart and lung function and physical work capacity.

7.6 OFFSHORE HYGIENE

PERSONAL HYGIENE

Infections are difficult to deal with in saturation due to :
— the good conditions for bacteria growth (temperature and humidity),
— the restrictions in the use of some drugs under pressure,
— the high risk of infection spreading to others due to close contact.
The strictest attention to the discipline of chamber hygiene is necessary.

Normal hygiene rules must be observed even more stringently so as to avoid the cross infection of bacteria from one individual to the next.
Therefore divers should :

— take one shower per day (after diving)
— change personal clothing regularly and lock outside for washing disinfecting
— do not share toilet items
— do not exchange beds without changing bedding
— follow the ear infection prevention program (ear drops regularly, no ear washing or scratching).

CLOTHING/BEDDING/DIVING GEAR

Washing/laundry services of an adequate standard are normally available offshore.

Procedures for personnel in chamber should be as follows :
— Towels : changed everyday, washed with disinfectant.
— bedding sheets, pillow case : changed every 3 days, washed with disinfectant.
— wet/hot water suits : rinsed after every dive with a little disinfectant in fresh water, dried for next shift.
— Diving masks/helmets : rinsed with disinfectant after every dive.

DECOMPRESSION CHAMBER

Decompression saturation or bounce diving chambers should be washed and cleaned as follows (using PANACIDE diluted 3 cm^3 per liter, or SANYGERM).

— the walls to be thoroughly cleaned and disinfected before saturation.

— the walls to be cleaned and disinfected by the occupants once a week.

— toilet facilities, showertray, wash basin and toilet bowl to be disinfected after each and every use (disinfectant in flushing water).

— Purge drain water from wet chamber as often as possible.

— Swabs to be taken from the chamber walls and toilet area twice a week. Depending on the result of swabs analysis some parts of the chamber may have to be cleared/disinfected more than once a week.

— Reading material should not be allowed to accumulate as they constitute a large stock of flamable material and a nest of bacteria. Some print inks vapours can also be toxic in a confined space.

— Remains of meals (left-overs, soiled dishes, etc..) should not be allowed to linger or accumulate in the chamber.

FOOD-MEALS, ETC ...

Divers should be aware that food constitutes a form of compensation from the social deprivation, hard work, etc.. of offshore life and not over indulge.
This applies even more critically immediately before a dive. A huge meal shortly before diving may not be dangerous in itself, but if vomiting takes place whatever the reason, the effect can be catastrophic in a diving helmet or mask.

On the other hand, it is also important that divers do not get into the water starving (the Norwegian Petroleum Directorate specifies that a meal must have been ingested within the 3 hours preceding a dive), and common sense must be the rule. In particular, drinks should be available during long bell dives.

7.7 PRE-SATURATION CHECK-UP

Before being allowed in saturation, divers must be interviewed by the diving superintendent so as to confirm their physical status :

— reasonably rested (specially after long travel, jet lag)
— in date medical certificate and logbook
— free from cold, "flu" or similar conditions
— any on going Medical Treatment (if so it should be cleared by the medical adviser)
— any physical/medical complaints
— any known allergies
— any known drug reactions.

Before entering the chamber :

— divers must be issued with 2 bottles each of prophylactic ear drops,
— divers should be clean, their clothing freshly washed,
— divers belongings will be checked for forbidden items. The same will apply for parcels that may arrive on board while divers are locked in the saturation chamber.

7.8 DRUGS OR ITEMS FORBIDDEN UNDER PRESSURE

Due to the confinement of a saturation chamber, some potential sources of contamination that would be negligible at surface cannot be allowed. This aims to prevent :

— toxic risks
— fire risks
— problems of behaviour.

Divers are expected to collaborate in these restrictions because they are in their best interest and not to oppose to checks organized by life support personnel.

PROHIBITED ARTICLES

— matches, lighters, tobacco,
— perfumes, aftershave or any other volatile product,
— sprays,
— any form of alcohol or hallucinogenic drugs,
— unchecked medicines,
— large quantities of newspapers and magazines,
— any private electrical appliance using more than 9 volts.

7.9 PREVENTION OF EAR INFECTION

During saturation, divers use systematically a course of preventive ear drops. This is meant to replace natural wax being washed away by repeated contacts with water. The wax or the preventive drops present an effective barrier for bacteria thriving within the ear canal. The drops contain neither antibiotics nor steroids. They are a proprietary mix of 2 % Acetic Acid in Aluminium acetate solution called OTIC DOMEBORO.
Each diver is issued with 2 bottles marked with his name. In addition, one should be marked LEFT and the other RIGHT and used for the respective ear without confusion.
4 times daily including after showering apply about 6 drops in each ear. Do not force anything into the canal, and do not rub or scratch. This would remove the protective layer and irritate the tissues underneath.
Divers ears are swabbed twice a week before using preventive drops.

TAKING SWABS FROM PEOPLE

— Divers should take swabs from each other.
— The diver whose ear is being swabbed should be seated and remain as still as possible.
— The diver taking the swab removes the swab from the tube and handles it only by the plastic cap.
— Remove any hair covering the ear.
— Pull up the ear to reveal the ear canal.
— Place the cotton swab gently in the ear canal so that the cotton end has completely disappeared into the canal. Do not go too far. Never force it : if the entry was right, that is good enough. With the cotton swab completely in the ear canal, there is no point in turning it (the purpose is not to clean the ear).
— Withdraw the swab and replace it in its protective tube.

Check especially that :
— The swabs used correspond to the name and ear marked on each label.
— The swabs touch nothing but the interior of the protective tube and the ear canal. If the swab touches anything else, throw it away and obtain another from the chamber operator.

TAKING SWABS FROM OBJECTS

— remove the required swab from its tube.
— rub it on the surface.
— replace it inside its protective tube.
When all the swabs have been taken, return all the swabs to the container in a vertical position, checking that the caps are not closed completely, and pass them out of the chamber.

7.10 MINIMUM AND COMFORTABLE TEMPERATURES IN DIVING

HEAT EXCHANGES IN DIVING

In any condition, man exchanges heat with the environment. Depending on the ambient media (gas, water), on its temperature, or the speed of movement (water flow, wind), the body can cool, store heat or remain in a stable equilibrium of thermal comfort.

Heat transfer is critical in diving because there is a large temperature difference between the diver (37 °C core temperature) and the environment (4 °C sea water temperature in North Sea). The transfer of energy is also important because both water and compressed helium are very good thermal conductors.

Water draws heat from the body 25 times faster than air of the same temperature. Loss of body heat, in a heliox atmosphere at a pressure of 50 bar is approximately the same as in water.

There are four distinct modes of heat transfer which are recognized : conduction, convection, radiation and evaporative heat loss (sweat, which is important in human physiology in a dry atmosphere).

BODY HEAT LOSSES

Conduction heat transfer occurs by direct contact of the skin with an object.
Water or metal contact tends to remove a lot of heat (walking in bare feet, sitting on a steel bench, laying on a chamber floor), while rubber or neoprene are good insulators.
The body fat layer of course, is the primary heat barrier of man. Further protection can be found with a diving suit by using the neoprene thickness, gas layers trapped in a dry suit, or clothing (wool mesh, synthetic mesh in wooly bear underwear) as heat conduction barriers.

Pressure tends to decrease the thermal protection of the diver by compressing the neoprene thickness and by lessening the insulating properties of the gas layer in suits and clothes (caused by increased gas density).

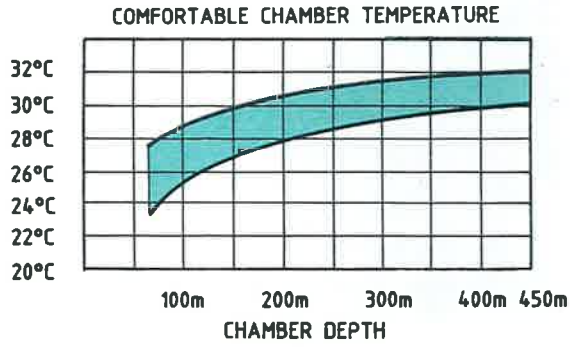
Radiation is a process of heat transmission of no importance in water but that could become quite relevant in a chamber or bell with very cold or warm walls. A space blanket offers good protection against radiative heat losses.

Convection heat transfer is usually the dominating mode of heat transmission in diving.
Heat is carried away by a fluid (water or compressed gas) and exchanges depend on movements and flow characteristics.
Swimming and moving as well as current cause increasing convective heat losses in water. Movements, wind or circulating gas (regeneration circulation, fan) have the same effect in a gaseous environment.
Pressure does not affect heat exchange between diver and water but drastically increases the capacity of a gas to transfer heat during conduction by increasing its density.

Evaporative heat loss only occurs in gas environment. Sweat is produced which is evaporated if the ambient atmosphere is not saturated with humidity. This mode of heat transfer is relatively ineffective in saturation chambers where the humidity is often high.

CHAMBER TEMPERATURE

Divers in the chamber and bell experience body and respiratory heat losses. In order to balance the heat losses and achieve thermal comfort, the chamber/bell temperature needs to be increased. For instance, comfort temperature, which is around 21°C at surface, becomes 30°C at 300 m in an Heliox atmosphere. Moreover, the comfort range narrows significantly as the depth increases. If a 5°C temperature change would not bother us too much at surface, at 300 m, a 1°C temperature change makes the difference between comfort and discomfort.
Values given below should be regarded as guidelines only. Most of the time temperature is adjusted according to diver's demands.



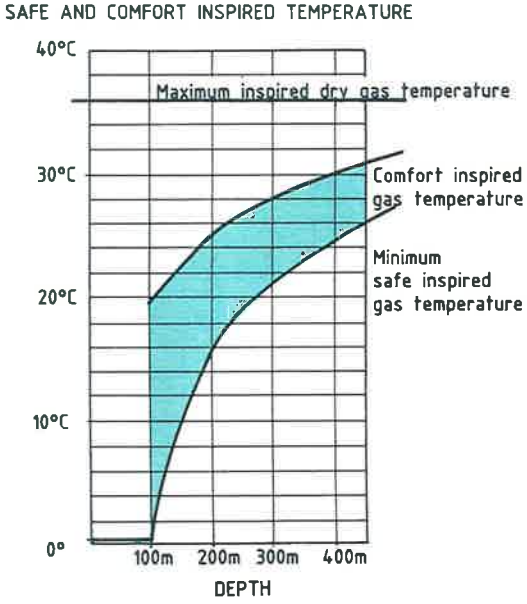
INSPIRED GAS TEMPERATURE

Respiratory heat losses are one of the major problems in deep diving. The inhaled gas exchanges heat by convection over the lung surface. Heat transfers are important because the lung surface is large (around 50 m^2) and Helium is highly conductive.

Respiratory heat loss increases with :
— depth (increased gas density),
— work (accelerated ventilation),
— low ambient temperature (larger temperature difference),
— breathing dry gas (energy required to saturate the exhaled gas with humidity).

Respiratory heat losses are insidious as they cause an "inner" cooling of the body, which, in certain conditions, may not be felt by the diver (the cold receptor of man is located at the skin surface).

Minimum safe and comfortable inhaled gas temperatures for dive conditions are given in figure below as a function of depth.
Maximum inhaled dry gas temperature is 36°C.



7.11 FLYING AFTER A DECOMPRESSION ACCIDENT

Comex policy for surface interval after a decompression accident is in accordance with DMAC guidance n°7.

ACCIDENT	Time before flying at cabin altitude	
	2 000' (600 m)	8 000' (2 400 m)
Case successfully (treated)	24 hours	48 hours
Case with residual symptoms	Must be decided on an individual basis by a diving medical specialist.	

In case of recurrence while in flight :

— When the diver's symptoms consist only of pain in a limb, he should be treated with analgesics, Oxygen if available, and the plane can continue to its destination without diversion or adjustment in altitude.

— When the diver has any other symptoms, immediate advice should be sought from a diving medical specialist. It may be necessary to reduce the cabin altitude or divert to the nearest airport. In the meantime, the patient should be given Oxygen if available.

7.12 DIVING AFTER A DECOMPRESSION ACCIDENT

Comex policy in assessing fitness to return to diving after an accident is in accordance with DMAC guidance n° 13.

TYPE I with full recovery	24 hours lay-off
TYPE I with recurrence during or after treatment.	7 days lay-off or longer period to be determined after examination by an approved doctor.
TYPE II	7 days lay-off or longer period, to be determined after examination by an approved doctor.
PULMONARY BAROTRAUMA	After incidence of decompression barotrauma with or without gas embolism the diver may be allowed to return to diving within a period of not less than 3 months, but only after an assessment by an approved doctor.

7.13 THERAPEUTIC GASES

Every worksite must have a provision for therapeutic gases that will allow a higher PO_2 to be given to patients suffering from a decompression accident in a chamber.

All therapeutic mixtures used by Comex companies for AIR/NITROX diving as well as for HELIOX diving, bounce or saturation will be HELIOX mixtures.
The only exception is the use of Nitrox 50/50 in Air Saturation diving.

STANDARDIZED THERAPEUTIC MIXTURES

The following gas and mixes are recommended for worksite operation :

GAS/MIX	DEPTH OF USE
Oxygen	Surface to 18 m
Heliox 50/50	19 m to 40 m
Heliox 20/80	41 m to 110 m
Heliox 10/90	111 m to 210 m
Heliox 5/95	211 m to 360 m
Heliox 3/97	361 m to 450 m

ALTERNATIVES MIXTURES

In case the above recommended mixtures are not available on the worksite, the following table gives the range of utilisation of other Heliox mixtures for therapeutic purposes.

GAS/MIX	DEPTH OF USE
Heliox 4/96	265 m to 415 m
Heliox 6/94	175 m to 280 m
Heliox 7/93	150 m to 275 m
Heliox 8/92	130 m to 250 m
Heliox 9/91	115 m to 220 m
Heliox 11/89	90 m to 180 m
Heliox 12/88	85 m to 170 m
Heliox 13/87	75 m to 155 m
Heliox 14/86	70 m to 150 m
Heliox 15/85	65 m to 135 m
Heliox 16/84	60 m to 130 m
Heliox 17/83	55 m to 120 m
Heliox 18/82	50 m to 115 m
Heliox 19/81	45 m to 110 m

7.14 MINIMUM QUANTITIES OF THERAPEUTIC GASES TO BE KEPT ON WORKSITES

AIR/NITROX BOUNCE DIVING WORKSITES

Maximum Depth	O_2	50/50 Heliox	20/80 Heliox
50 m	90 m^3	90 m^3	90 m^3

NOTE :

— In rare cases where a **TYPE II** accident does not respond to standard treatment, the Air atmosphere of the chamber may have to be replaced by Heliox.
This will be done by flushing one single bank of Heliox 20/80 into the chamber atmosphere.
— If weight, space or other constraints prevent the storing of a bank of Heliox 20/80 on a worksite for ventilation purpose, then a bank must be kept available in base as a back-up.
In this case, some Heliox 20/80 should be kept available in separate cylinders that could be flown by helicopter.

AIR/NITROX SATURATION WORKSITES

Maximum Depth	O_2	50/50 Nitrox
45 m	90 m^3	90 m^3

HELIOX BOUNCE DIVING OR HELIOX SATURATION WORKSITE

Maximum depth	O_2	50/50 Heliox	20/80 Heliox	10/90 Heliox	5/95 Heliox	3/97 Heliox
40 m	90 m^3	90 m^3				
110 m	90 m^3	90 m^3	220 m^3			
210 m	90 m^3	90 m^3	220 m^3	400 m^3		
360 m	90 m^3	90 m^3	220 m^3	400 m^3	650 m^3	
450 m	90 m^3	90 m^3	220 m^3	400 m^3	650 m^3	800 m^3

7.15 PATIENT CHECK LIST

The Patient Check List is to be filled in by the attendant at the very onset of symptoms and then every hour during the treatment. (See page 141). Each step of the Patient Check List is described below :

1. Breathing rate

The normal breathing rate in the adult is 12 - 15 per minute when relaxed.

2. Character (of breathing)

Determine the character by looking, listening and feeling :
— Rapid shallow breathing is present in shock.
— Deep, gasping, laboured breathing indicates an airway obstruction.
— Little or no movement indicates respiratory depression or arrest.
— Coughing accompanied by blood at the nose and mouth indicates lung damage.

3. Cardiac pulse rate

The normal pulse rate is 60 - 80 beats per minute. It can be counted at the wrist but carotid pulse at the neck is more reliable.
Feel the pulse with the index and second fingers. Do not use the thumb.

4. Character (of cardiac pulse)

It can be steady or irregular. An irregular pulse may indicate a disturbance of heart rythm.

5. Blood pressure

Two numerical values describe blood pressure : the systolic (high) and the diastolic (low) pressure. Any systolic pressure of 100 mm Hg or lower in an injured victim should be considered as a sign of impending shock.

6. Pupils : note if both pupils are equal in size.

7. Pupils : note whether they appear large or small.

8. Pupils : note if they constrict when strong light in front.

9 to 14 : note for both sides if the reflex is normal or not.(Tendon "jerks" are often difficult to produce. Only large differences between left and right sides are important).

9. Biceps

Put your index finger into patient's elbow joint and hit your forefinger. The reflex is a flexion of the joint.

10. Knee

Knee bent and relaxed, strike below the kneecap and observe the extension of the leg.

11. Triceps

Extension of arm caused by striking tendon on back of arm above elbow joint. Note if the reflex is normal or not.

12. Ankle

Strike the Achille's tendon, the foot having been slightly extended and held in the position by the examiner's hand. Observe a downward movement of the foot.

13. Abdominal

Scratching the abdomen vertically at the end of expiration causes a slight contraction of the abdominal muscles.

14. Babinski

Run a blunt object at the sole of the foot. If the toes curl down towards the sole of the foot, a normal Babinski reflex is present. If nothing happens no conclusion can be drawn, but if the toes flex backwards, upwards and spread, this is a reliable sign of probable spinal involvement.

15. to 21.

These points are self explanatory. Answer by YES or NO.

22. Speech

Check for misplaced words and incorrect word order.
Answer by : normal or confused or inappropriate.

23. Vision

Hold up fingers for the diver to count ; test one eye at a time.
Answer by normal or not.

24. Hearing

Test one ear at a time by rubbing your fingers together 1 inch away from the ear.
Answer by YES or NO.

25. Eye movement

Have the patient watch an object moved in all directions.
If impossible in one direction note which one : right, left, low, high, oblique high or low.

26. Facial movement
Check for the symetry of the mouth in the rest position, and smiling.

27. Nystagmus
Ask the patient to follow the movement of a finger from a central position to the external left and right without head movement. Nystagmus is a flickering movement of the eyes, a fast movement and a slow return towards the initial position. It can exist in any direction and affects both eyes.
Note if the nystagmus is present or not.

28. Tongue protrusion
Ask patient to stick out his tongue. Has he deviated to one side ? Which one ?

29. Finger to nose
Can the diver move a finger from touching your finger to the tip of his nose and repeat the motion ?

30. Point in space
Can the diver touch your finger held in front of his nose ?

31. Balance
Have the diver stand straight, feet together, arms folded in front and eyes closed. Note if balance is normal or not.

32. 33. 34.
Simply note if the patient can answer the questions.

35. Series of number
Note if the patient is able or not to repeat a series of numbers.

36. Recent events
Note if the diver can remember happenings within the last 24 hours.

37. to 40. Movement and power
Ask the patient to move and check power.
Answer by YES or NO or WEAK.

41. to 44. Sensations
Using sharp and dull objects check if the diver can distinguish between them by testing.

COMMENTS : Note any other relevant symptoms.

PATIENT CHECK-LIST

NAME :..... DATE :..... TIME :.....

CONSCIOUS ☐ UNCONSCIOUS ☐

1. Breathing rate : /min 2. Character :

3. Cardiac pulse rate : /min 4. Character :

5. Blood pressure : /mmHg

6. Pupils equal : 7. Pupils size : 8. React to light ?

REFLEXES	RIGHT	LEFT	REFLEXES	RIGHT	LEFT
9. Biceps			10. Knee		
11. Triceps			12. Ankle		
13. Abdominal			14. Babinski		

15. Fatigue : 16. Girdle pain : 17. Pins and needles:

18. Nausea : 19. Vertigo : 20. Vomiting :

21. Ability to urinate :

22. Speech : 23. Vision :

24. Hearing : 25. Eye movement :

26. Facial movement : 27. Nystagmus :

28. Tongue protrusion :

29. Finger to nose : 30. Point in space :

31. Balance :

32. What time is it ? 33. Who is he ?

34. Where is he ? 35. Series of numbers :

36. Recent events :

MOVEMENT AND POWER	RIGHT	LEFT	SENSATION	RIGHT	LEFT
37. Arm			41. Arm		
38. Leg			42. Leg		
39. Hand			43. Hand		
40. Foot			44. Foot		

COMMENTS :

7.16 INSTRUCTIONS FOR PERSONNEL BOUNCING INTO A SATURATION CHAMBER

These instructions are provided as an aid to the diving supervisor who needs to lock in a medical doctor or a paramedic inside a chamber for a short intervention (30, 60 and 90 minutes). As the chamber PO_2 is likely to be in within 400 to 600 mbar, the decompression of this personnel is simply a question of calculating an equivalent decompression.
However, in order to save time, decompression tables for personnel bouncing into a saturation table have been prepared for different practical cases.
Obviously, where the intervention is too deep or too long, that personnel will have to stay in the chamber and be decompressed in saturation with the divers.

AIR SATURATION CHAMBER

— After the lock has been decompressed to surface, flush the chamber with Air before allowing anyone to enter (possible hypoxia risk).
— Pressurize personnel in chamber lock on Air.
— Intervention of personnel (400 to 600 mbar PO_2 in the chamber).
— Decompression of personnel is carried out with Air Decompression Tables using the following equivalent bottom depth.

CHAMBER DEPTH	DEPTH OF EQUIVALENT AIR TABLE TO BE SELECTED
11 m.	12 m.
14 m.	15 m.
16 m.	18 m.
18 m.	21 m.
21 m.	24 m.
23 m.	27 m.
26 m.	30 m.
28 m.	33 m.
30 m.	36 m.

HELIOX SATURATION CHAMBER

— After the lock has been decompressed to surface, carefully flush the chamber lock with Air or Heliox 20/80 before allowing anyone to enter (possible hypoxia risk).
— Pressurize personnel breathing chamber lock atmosphere using the following gas mixes :
For chamber depth down to 60 m. : Heliox 20/80
For chamber depth down to 100 m. : Heliox 10/90
For chamber depth down to 200 m. : Heliox 5/95

— Intervention of personnel (400 to 600 millibar PO_2 in the chamber).
— Decompress personnel in chamber lock.

Personnel is put on BIBS from the beginning to the end of his decompression. He first breathes Heliox 20/80 and then Oxygen from 12m. to surface. If Oxygen stops are not mentioned at 3, 6 or 9 m., the personnel will slowly ascent from his last stop to surface with Oxygen on BIBS in 2 minutes.

DECOMPRESSION TABLE FOR PERSONNEL BOUNCING INTO HELIOX CHAMBER

CHAMBER DEPTH	BOTTOM TIME	TIME TO FIRST STOP	HELIOX 20/80						OXYGEN				TOTAL DECOMP. h : min
			30 m	27 m	24 m	21 m	18 m	15 m	12 m	9 m	6 m	3 m	
12 metres	90 min	1											1
20 metres	30 min	1							10	–	–	–	0:13
	60 min	1							20	–	–	–	0:23
	90 min	1							30	–	–	–	0:33
30 metres	30 min	2							15	–	–	–	0:19
	60 min	2							30	10	–	–	0:44
	90 min	1						5	30	40	–	–	1:18
40 metres	30 min	2					3	3	30	5	–	–	0:48
	60 min	2					5	10	30	40	30	–	2:14
	90 min	2					5	15	30	40	50	–	2:39
50 metres	30 min	2		3	3	3	5	10	30	40	–	–	1:38
	60 min	2	3	5	5	10	15	15	30	40	50	40	3:37
	90 min	2	5	5	15	15	20	30	30	40	50	80	4:54

7.17 RISK OF DECOMPRESSION SICKNESS

Decompression problems **can be minimized but not eliminated** by good diving practice.
The risk, for a given dive, can be assessed in the following way :

— All significant reductions in pressure in diving form gas from solution and risk causing decompression problems. The greater the reduction in pressure, the more gas will be formed.

— The risk of decompression sickness and barotrauma increases the closer the diver is to the surface.

— Decompression tables have evolved to prevent the development of symptoms, but cannot prevent some gas formation.

— Divers may develop symptoms even when decompression tables are followed correctly.

— No method can predict which diver will develop problems.

— No tissue damage has been found after simple decompression sickness in or around a joint or in the skin.

— The nervous system is easily damaged and divers must be encouraged to report symptoms early.

Therefore :

— All personnel should be familiar with the signs and symptoms of decompression sickness.

— Surface personnel must be trained to use the treatment procedures.

— Divers should immediately report to surface personnel any abnormal symptoms, during or after decompression.

— Surface personnel should initiate treatment without delay.

— Each and every case of suspected decompression sickness must be investigated and treated until the possibility of a decompression accident has been ruled out beyond any doubt.

7.18 PATHOLOGY OF DECOMPRESSION SICKNESS

GAS PHASE FORMATION

The separation of gas from solution is now almost universally accepted as the primary event in decompression sickness. This separation takes place in body liquids in association with gas nuclei, which are extremely small amounts of undissolved gas present in the organism.

The reason for this separation is that decompression has exceeded the rate at which diffusion and blood flow can eliminate the gas via the lungs without gas phase formation.

There is conclusive evidence that even shallow dives are associated with the presence of occasional bubbles in the venous system which are carried to the lungs and eliminated without symptoms in the diver. Whether symptoms develop or not depends on the amount of gas present and on its location.

MECHANISMS

The mechanisms by which gas can disturb body function are as follows :

— By blocking arteries, veins and lymphatic vessels, reducing or preventing flow.

— By compressing tissues, causing a reduction in the flow of blood or lymphatic fluid and therefore interfering with gas transfer, nutrition and excretion.

— By tearing tissues, i.e. group of cells, forming artificial tissue spaces.

— By inducing profound disturbances secondary to some of these effects in body function, i.e. increase permeability of blood vessels causing loss of liquids from the circulation and clumping of blood cells.

The symptoms vary depending on the site of the accident.

Skin rashes

The bubbles are present either in skin capillaries or skin lymphatic vessels draining extra-cellular fluid. Their presence may or may not liberate substances responsible for itching and mild pain. Expansion of the bubble is possible without a significant increase in tissue pressure and the small reduction in blood or lymphatic flow is unimportant.

Joint pain

Connective tissue formed from collagen fibres is responsible for the structure of the soft tissues and it forms ligaments for holding the skeleton and tendons together for the attachment of muscle. Scar tissue is newly formed connective tissue and from the rate of formation and appearance, it can be seen that it has a very small blood supply, which in decompression means a slow rate of gas release.
Connective tissue is very sensitive. It requires only about a 15 cm of water increase in pressure within a tendon or ligament to cause pain. Because these fibrous tissues are strong, they resist expansion and therefore the presence of gas will be accompanied by a rise in local tissue pressure and the stimulation of pain nerve-endings. The small differential pressure causing pain indicates that a shallow recompression (to reduce the size of the gas) should relieve the pain. This corresponds with diving experience for, provided the pain is reported early, an increase in pressure of only a few metres can give relief in this form of decompression sickness.

It is important to realize that no pathological changes have ever been described in the tissues at the site of a joint pain in diving.

Respiratory problems

It has been known for some time that bubbles are frequently present in veins during a decompression in which the diver does not develop any symptom. They have been termed silent bubbles and have been detected in veins draining joints and, particularly in air diving, in veins draining fatty tissue. The bubbles are carried by the circulation blood to the lungs where they are trapped in the decreasing vessel size leading to the pulmonary capillaries. The lung is, of course, designed for gas exchange but with gas normally only in the alveoli. The filtration of these bubbles occurs without symptom provided the rate of gas release is not excessive. As little as 5 ml. of air arriving at the lung can be felt as retrosternal discomfort. A large amount of gas bubbles arriving in the lung due to an inadequate decompression may cause serious distress with retrosternal discomfort, a dry cough and a feeling of extreme fatigue ("chokes").

Neurological problems

Nervous system problems are dominated by damage affecting the spinal cord which shows readily by the production of paralysis often of both legs and disturbances of sensation. However cerebral symptoms are very common and may be associated with brain damage only revealed by special investigations. Disturbances of vision, speech or dizziness are common but rarely leave permanent disability.

Three basic theories attempt to account for this presentation :

1 - Bubbles in arteries which have not been filtered by the lungs.

As it is known, venous bubbles may form very early in decompression ; if they cross the lung filter during the ascent and lodge in the spinal cord in an area containing a large amount of dissolved nitrogen, they will increase in size because of both the reduction in absolute pressure and the nitrogen load.

2 - Gas forming locally causing local compression of nerve tissue.

Gas has been observed in the sheaths of nerves in the spinal cord and in the blood vessels in animal experiments. Nitrogen shows the greatest tendency to form bubbles in this way. The mechanics of the cord indicate that the volume of gas tolerated before severe blood flow problems occur is very small because of the back pressure generated by the rigid wall of the vertebra.

3 - Gas bubbles in the veins blocking the drainage causing a damning- back effect.

7.19 PRINCIPLES OF TREATMENT OF DECOMPRESSION SICKNESS

The treatment of decompression sickness is aimed at reducing or eliminating the gas which has separated from solution and correcting any secondary effects like tissue hypoxia and shock.

Treatments are based on a combination of 4 factors :

1 - Recompression
2 - Raised partial pressure of Oxygen
3 - Use of Heliox mix (eventually)
4 - Adjunctive drug therapy

RECOMPRESSION

The corner-stone of treatment is recompression and generally the longer this is delayed the greater the general disturbance to body function, for example the loss of fluid from the circulation into the tissues. Also delay in recompression reduces the possibility of complete reversal of symptoms.

The objective of recompression is a reduction in the volume of gas present by :

— an increase in absolute pressure, which is instantaneous and reliable,
— an increase in the return of gas into solution, which takes time and depends on the rate of diffusion at the gas/liquid interface.

Recompression reduces the volume of gas directly. Doubling the absolute pressure halves the volume (Boyle's Gas Law). Reducing the volume of gas will reduce the local pressure the gas exerts and therefore increase the flow of blood and lymphatic fluid in the tissues, promoting gas transfer and also reducing pressure on pain nerve endings.

It is important to realize that resolution of symptoms does not mean that all gas phase has been eliminated and that the gases have diffused back into solution. Gas bubbles present in the blood eventually become surrounded by a lipid-platelet envelope which may significantly reduce the rate at which the gas dissolves.

RAISED OXYGEN PARTIAL PRESSURE

An increased partial pressure of Oxygen in the gas breathed allows :

a) increased washout of the offending inert gas,
b) oxygenation of areas of the body deprived of an adequate blood supply,
c) treatment by the other properties of Oxygen as a therapeutic agent for example, the control of oedema in the nervous system.

USE OF HELIOX MIX

Over the last few years, because inert gas change had not been sufficiently investigated, Comex policy has been to avoid them by recommending Nitrox therapeutic gas for Air diving and Heliox therapeutic gas for Heliox diving.

Close examination of the objections to the change of inert gas from nitrogen to Helium has revealed that the fears about the use of Heliox were unfounded. In fact, it is even beneficial because it helps to eliminate nitrogen and to reduce bubbles size. Many cases of Air decompression accidents have been successfully treated with an Heliox atmosphere.

The principle is that Air divers can be treated by recompression breathing a Helium-Oxygen mix but **Heliox divers must never be recompressed for treatment using Air or Nitrox as a breathing mix.**

For this reason the only therapeutic mixtures to be used with Comex recompression tables have been reduced to Heliox mix only, both for the treatment of Heliox and Air Nitrox dive.

There is however an exception to the rule which is Air saturation. Decompression accident could be well treated by breathing an Heliox mix but the return to normal Air Saturation conditions after treatment might cause a problem. In that case only, provision should be made for Air and Nitrox 50/50 as therapeutic gas/mix.

ADJUNCTIVE DRUG THERAPY

Drugs are used in the treatment of decompression sickness as a complement to recompression with hyperbaric oxygenation :

— Intravenous fluids in perfusion are useful as plasma expander to reduce haemoconcentration (loss of fluid from the circulation into the tissue).
— Aspirin is used against platelet aggregation and hypercoagulability (lipid/platelet envelope around gas bubbles).
— Steroids (Decadron and Synacthen) are useful in the cases where the nervous system is involved (oedema of the brain and of the spinal cord).

REMEMBER THAT :

Fluids are very important, especially in the treatment of serious Decompression Sickness. They can be given by mouth to the diver **if he is able to retain them, i.e. if he is conscious and not in shock.** Otherwise they should be given intravenously.

MEDICAL BOOK
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KEEP INSTRUCTIONS ALIVE.
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