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THE TOWNSVILLE DIVING MEDICAL AND AEROMEDIVAC SYSTEM EXPERIENCES, LESSONS, AND THE FUTURE

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Since 1977 the Townsville Recompression Chamber (RCC) (Figure 1), located at the Australian Institute of Marine Science (AIMS) about 70 kms south of the city, has been used to recompress 68 patients to April 1988, the vast majority of them (64) divers. The RCC is a twin lock Comex deck recompression chamber, constructed in Singapore, and placed at AIMS with the birth of the latter, in 1968. Before 1977, it was used for equipment tests and AIMS diving staff familiarisation only, under the care of and maintenance by two of us (WE and JH).

The chamber weighs 6 metric tons, and has working pressure of 8.5 bars (86.7 metres of sea water, 127 psi, 900 kPa (approx.)). Its overall volume is 10,830 dm^3, or 383 cu ft (main chamber 7,600 dm^3, or 268 cu ft), and its external dimensions are:-

Length	4,700 mm
Width	2,500 mm
Height	2,100 mm
Diameter	1,819 mm
Single end (small lock), circular entrance door (Figure 1), diameter	700 mm.

From the inception of the service a splendid attitude of co-operation existed between AIMS and the Townsville General Hospital, which profoundly facilitated its operation. This happy state of affairs was continued and complemented by the arrival of the National Safety Council of Australia (NSCA) in Townsville in 1985. The NSCA brought with them the Drager "Duo-Com" portable RCC, which enhanced the treatment of divers requiring recompression. Some months later, the AIMS RCC had an adaptor flange (generously donated by the Utah Foundation Australia at a fitted cost of about $25,000) attached, which permitted transfer under pressure (TUP) between the DuoCom and the fixed RCC (Figure 2).

The NSCA also brought a superb integrated team of pararescue personnel, pilots, and maintenance and administrative staff to Townsville. They have a modern, well established Airport Base in Townsville which co-ordinates an extensive 24-hour search-and-rescue (SAR), and retrieval aerial service for the whole of Northern Australia. Their equipment available for the diver retrieval service is truly state of the art (Figure 3).

ACTIVITIES 1977-APRIL 1988

The table summarises overall experience of the team in treating patients with decompression sickness (DCS) and cerebral arterial gas embolism (CAGE) to April 1988.

With the exception of 1 fully categorised profes-

Figure 1. The Townsville Recompression Chamber (RCC), (showing the transfer-under-pressure flange for DuoCom attachment, generously donated by the Utah Foundation of Australia.)

TABLE 1
TOWNSVILLE DIVER RETRIEVAL/RCC TEAM EXPERIENCE
10 YEARS, 1977 - APRIL 1988

YEAR	D.C.S.*					C.A.G.E.**
	Spinal	Cerebral	Skin	Pulmonary		Joint
1977	1	1				
1980						1
1982	5	1				
1983	12	1	1			
1984	6	1		1	1	1(1)
1985	5					1(1)
1986	8	3				3 (1***)
1987	10	5				1
1988(4 months)	2			1		1
TOTALS	49	12	1	2	1	8(3)

* Decompression Sickness
** Cerebral Arterial Gas Embolism (Fatalities in brackets)
*** In addition to this fatality, another during that year in a recreational scuba diver, never reached recompression facilities alive.

The totals add up to more than 64 because some patients had more than one form of DCS co-existing.

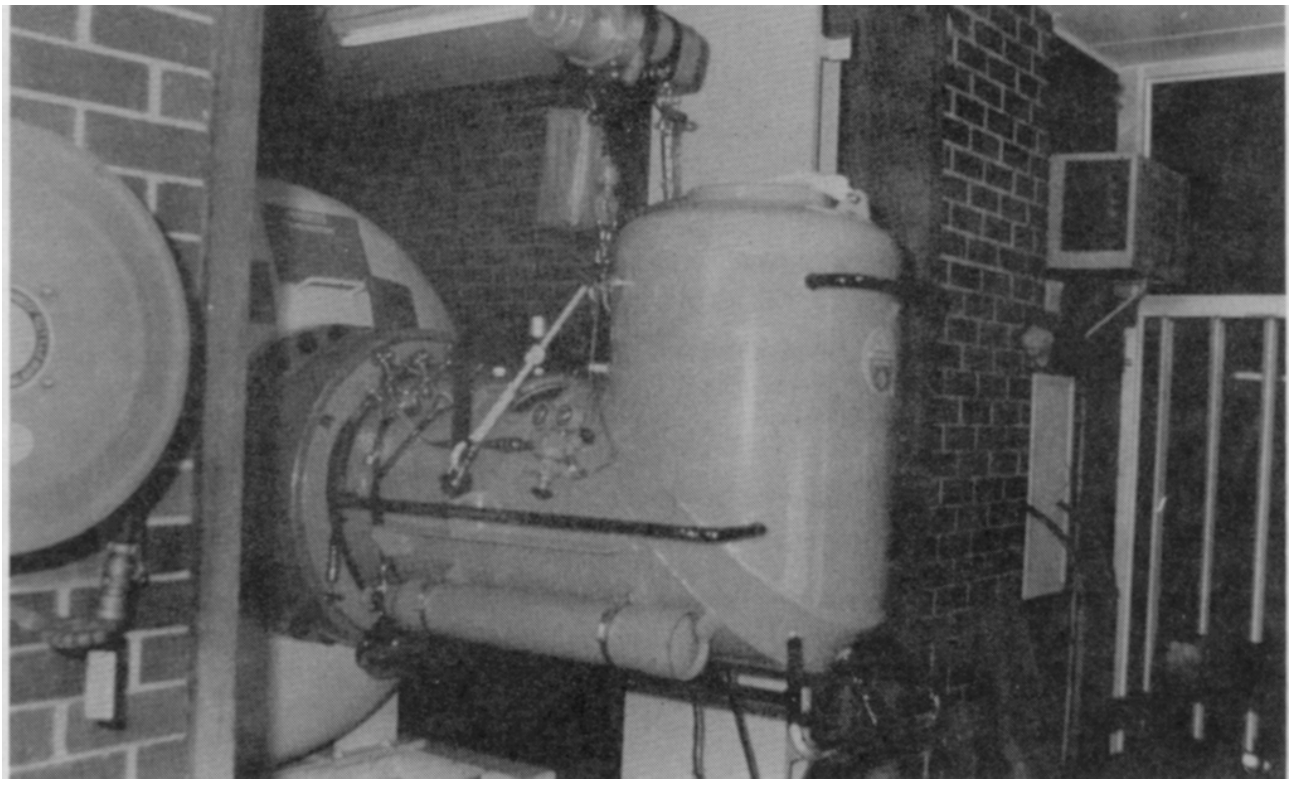

Figure 2. Shows the “lock on” position for a transfer-under-pressure from the DuoCom into the mainplace RCC.

sional diver (pulmonary and spinal bends), all cases were either recreational or occupational divers, i.e. trained to Australian "sport diver" levels, or their equivalent. At least 5 had no formal training whatever.

The overwhelming majority of divers in the area serviced by the Townsville facility (Great Barrier Reef and West Pacific area) indulge in relatively shallow (less than 30 m), repetitive recreational diving, using scuba to breathe compressed air. Only 7 were on "hookah" (surface supplied compressed air) at the time of the accident.

This diving pattern appears to produce predominantly spinal decompression sickness. Co-existing cerebral DCS is not unusual.

In our experience, a diver with DCS in whom central neurological signs cannot be elicited clinically, is rare. We currently doubt the existence of such a clinical entity!

We find no clear difference in the susceptibility to DCS between the sexes (24 female). Ages ranged from 18 to 63 years. Non-Australian nationals comprised about 17 of the 64 treated.

Both cases exhibiting pulmonary DCS had, or rapidly developed, spinal DCS.

True joint "bends" are rare, in our experience, with this pattern of diving.

The need for recompression in Northern Australian is steadily increasing, as is the amount of tourist diving.

It is clear that CAGE is not a rare event (see page). Episodes of loss of consciousness in association with recreational diving are more common than are indicated by the number of our CAGE cases. In view of the recent work by Gorman and his colleagues[1], some of these people who do not present for treatment would be expected to have central neurological sequelae.

CAGE may occur at all levels of experience, in "sport-diver" trained scuba divers breathing air, and in the complete absence of any detectable error or other misadventure. It is always associated with ascent, either planned or unplanned[2].

AEROMEDIVAC RETRIEVALS

Before 1985 and the regular availability of NSCA and the DuoCom only 3 long distance retrievals by air were made (2 from Thursday Island), out of a total of 24 patients treated. The patients mostly came to us. Since 1985, the management of 22 of the 40 patients has involved air retrieval in the King Air or the 412 (Figure 3), or rarely a Lear Jet. The three longest journeys were from Christmas Island in the Indian Ocean using a Lear Jet, and twice to Adelaide using the King Air. A combination of rotary-wing and fixed-wing aircraft was used on one occasion to deliver the doctor onto a boat at sea by winch, and subsequently to bring the patient back from Cooktown, once the boat had made land there. These all-weather aircraft with their skilled NSCA crews, and sophisticated navigation equipment, make such journeys relatively comfortable and "hassle-free" for the medical team. Using the NSCA facilities, no diver in need of medical attention and recompression in our area of responsibility, the West Pacific and from Papua New Guinea to Brisbane, has ever had his treatment delayed on our account. The location of the fixed RCC for such a huge area, in Townsville, with its large medical, intensive care, and NSCA bases, makes geographical and functional sense.

In 1981 the team published from AIMS a set of "Field and radio communication instructions for retrieval at sea", for the benefit of vessel masters, dive masters, and district medical officers. This proved most helpful in the smoother co-ordination of such events, which is always a challenge to participating persons. In 1985, the instructions were rewritten and updated, incorporating the facilities of NSCA, and published by them[3]. These are in current use, and continue to prove useful, especially for the burgeoning tourist charter boat operaters in North Queensland.

USE OF THE "DUOCOM" PORTABLE RCC

This device has made the rational and early application of recompression therapy possible to those divers in need. Twenty retrievals using the DuoCom enroute, have been performed since 1985, without incident. With one exception, all of these patients had their initial recompression (usually RN Table 62) completed in the DuoCom, on arrival at the NSCA's Townsville airport hanger. This has been dictated by factors such as the time remaining in the Table, the satisfactory condition of the patient and attendant, and the safety and cost of using helicopter transfer from the airport to AIMS. Only one TUP into the AIMS RCC has occurred to date. However practice runs are carried out on a regular basis. The relatively high usage (50% of patients treated since 1985) of portable recompression in our series reflects both the vast distances in our area of responsibility, and the high level of proficiency practised by the technical members of the team.

LIAISON WITH THE DIVER EMERGENCY SERVICE (DES), AND COMPLICATIONS

It is a pleasure to record the smooth and harmonious liaison our group have enjoyed with DES during the latter years covered by this report. The philosophy of the medical team has always been to consult readily and often, and it has paid off. No major complications in any patient, nor permanent morbidity due to the therapy, occurred in any of our patients, of which we are aware. One suspected case on spinal DCS was produced in a chamber attendant, early in the experience of the team (1983). Equalisation difficulties with first recompressions were relatively common, and

Figure 3(a) The National Safety Council of Australia's Townsville fixed wing aircraft, a Beechcraft "King Air". This is an all-weather aircraft, with a "pressurise-to-one-atmosphere" capability. It can fly, with an operating DuoCom and team on board, non-stop from Townsville to Hobart, or its equivalent, without refuelling.

Figure 3 b) The NSCA's rotary wing aircraft, capable of carrying an operating DuoCom with team. This is Bell twin jet engined aircraft, equipped with state-of-the-art search and navigation equipment for night or day, and a vertical hoist. Its range fully laden is 400 kms. (Townsville to Rockhampton or its equivalent.)

middle ear squeeze has occurred on occasions. Surprisingly, we have had no florid otitis externas, despite our tropical location and non-climate controlled RCC! Sinus squeezes have been rare. Overt central neurological oxygen toxicity has not occurred to date, nor have RCC complications of pulmonary barotrauma. Early and minor signs of pulmonary oxygen toxicity were evident in some (retro-sternal discomfort, cough, small vital capacity decreases), which disappeared with completion of treatment. Initial patient and attendant dissatisfaction with our oxygen-bibs (built in breathing system) disappeared with the installation of silicone, autoclavable moulded face masks and Robertshaw demand-flow, overboard-dump circuits. It is remarkable to record that there was not one mechanical, maintenance, nor equipment failure during treatment in this series. This faithfully reflects the high standard of RCC maintenance that has occurred. The remote location of the AIMS RCC relative to the Townsville General Hospital has made for large logisitic strains upon all members of the team, and an enormous wastage in travelling time and costs, over the years, not to mention considerations of patient safety. We look forward to the re-location of the RCC to inside the Townsville General Hospital, which appears imminent.

RECOMPRESSION THERAPY TABLES USED

Of the formal recompression therapy tables, Royal Navy tables have been used almost exclusively. The commonest chosen have been RN tables 62 (frequently "extended") and 61. Nine metre "soaks" have also been relatively common, towards the end of treatment regimes. No deep air tables have been used in this series. Our 64 diver patients involved 207 recompressions, which were composed thus:-

RN table 62	RN table 61	9 m "soak"	Other
89 (20 extended)	58	38	22

In addition, there were 20 recompressions in the DuoCom (18 RN table 62, 2 RN table 61).

MEDICAL CONTROL DURING RECOMPRESSION

In accordance with currently favoured practice, there was always a qualified medical intensivist outside either the fixed RCC or the DuoCom during every recompression. These persons never entered the RCC during treatment except for a specific medical indication. His or her subsequent decompression was planned beforehand, and undertaken in conjunction with careful discussion with the RCC operator. In the earlier days of the teams experience, the medical person had to act as the RCC attendant. In all such cases, a second medical colleague was placed on site, outside the RCC. The provision of medical manpower has placed and still does place at times, considerable logistic strains on the staffing of the Anaesthetic and Intensive Care Department of the Townsville General Hospital. There seems to team members to be little medical administrative or political appreciation of that fact, although such persons are observed from time to time happily basking in the credit for the service!

RCC attendants, during the years before 1985, were drawn from a pool of interested volunteer sport diving instructors and dive masters with appropriate paramedical training. These wonderful people provided unstinted and troublefree service, frequently through the night, and all in their spare time, unsung over an 8 year period, and totally free of charge. This fact also remains largely unappreciated by the North Queensland community. On behalf of ourselves and all our patients, we gratefully acknowledge this humanitarian effort. More recently, with the advent of the NSCA in Townsville, combined with the establishment of a pool of intensive care nursing staff from the Townsville General Hospital, trained in hyperbaric nursing care, RCC attendants have become an integral part of the hyperbaric team.

All DuoCom attendants were, and are, NSCA Life Support Technicians. Portable RCC attendants require additional training and skills, over and above those necessary for fixed RCC duties.

LESSONS AND CONCLUSIONS TO DATE

The successful management of diving accidents necessitates the close integration of specially trained, and regularly practised teams of medical, paramedical, hyperbaric technical, and highly skilled aero-technical persons, as well as constant access to consultative hyperbaric medical expertise.

State-of-the-art aircraft and equipment should always be the goal, for considerations of safety. It also has the benefit of comfort for the treatment team. Nevertheless, equipment is only as good as the users.

Portable recompression facilities with attendant air transport capability, are now an essential component of diving medical care in Australia.

Decompression sickness is a disease of the central nervous system. Disease may begin before symptoms. The term "mild decompression sickness" is a misnomer, and should be abandoned.

Early adjuvant therapy in DCS, 100% oxygen and, intravenous fluid rehydration, is an important contributor to a favourable outcome. Many involved persons (including some medical ones) do not understand simple oxygen therapy apparatus, nor how to provide 100% inspired oxygen to a spontaneously breathing diver patient.

It is unlikely that even the earliest and most effective recompression and adjuvant therapy presently available for

DCS will reverse all the significant damage already sustained by the central nervous system. Long term follow-up studies are needed on a big scale. Most recreational divers have little understanding of the seriousness of DCS to themselves.

A level of gross irresponsibility still prevails amongst elements of the sport diving population. The pursuit of the dollar causes some to turn a blind eye to safe practices. In others irresponsible behaviour due to a combination of poor self-discipline and sheer ignorance has resulted in an expensive, and occasionally risky, retrieval and treatment; sometimes innocent dive buddies have needed treatment as well! Such financial costs are presently borne by State Departments of Health, or even carried by the NSCA! We believe the time has come for clearly evident irresponsibility by a diver or his supervisors to be rewarded with a bill for the costs of his or her retrieval and medical treatment. We would advocate consideration of carefully worded leglisation to that effect.

A therapeutic recompression chamber is a specialised intensive care patient locality. Its safe application is only possible as an integrated part of a fully functioning in-hospital intensive care unit, with staff trained in that speciality. At the same time its safe operation and maintenance requires full technical support. Large therapeutic RCC's are best located inside, or in immediate proximity to hospitals, and should function as part of an intensive care unit.

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DIVING CASE HISTORY

Lloyd Jenkins

This episode occurred over the Australia Day weekend (January 23rd to 25th 1988). The sequence of events involved a new instructor to the area, hereafter called A, his 22 year old girlfriend, who came up from Melbourne for the weekend, B, another experienced diver employed by the Dive Shop as coxswain and instructor's help, C, and three others, all from Melbourne.

The first dive was on Saturday, 23rd January, 1988, to 15 metres for 60 minutes in a class of 6 people and was uneventful. On Sunday, 24th January, 1988, the same class dived again to 15 metres for 90 minutes in the morning, presumably using 2 tanks, and in the afternoon to 18 metres for 40 minutes, both in open water. The surface interval was not specified but even allowing for 4 hours surface interval the second dive was 4 minutes over the limit for a no-decompression dive on US tables and 14 minutes over on Bassett tables. On Monday, 25th January, 1988, a group of 6 including A, B, C, dived in the morning to 12 metres for 40 minutes and around midday or perhaps 1300 hours, which would give a surface interval of possibly 4 hours, they dived