SERENDIPITY STRIKES AGAIN

Decompression Studies at University of Wisconsin

Rev EH Lanphier MD and CE Lehner PhD
University of Wisconsin, Madison, Wisconsin

Pasteur once said "... chance favours only the mind prepared." Whatever else, the minds that were trying to put together a high-pressure research program at the University of Wisconsin in the late 1970s were prepared enough to grab a fine hyperbaric chamber for $1.00. That is actually what we paid another university for a large, three-compartment, 1000-foot working depth research chamber and all its adjuncts.

By early 1979, the chamber had been installed in the University of Wisconsin Biotron, a world-renowned facility for environmental research. The Sea Grant College Program helped with installation costs and has supported our research ever since. The initial decompression studies were aimed at characterizing the responses of sheep and pygmy goats. We hoped to use them as subjects for basic research that we were reluctant to undertake in human subjects.

We began by looking at 24 hour exposures with direct ascent to "surface". Results in the pygmy goats matched those reported elsewhere for goats of normal size, and we found that sheep were somewhat more resistant to decompression sickness (DCS). Both appeared remarkably similar to humans. In this phase, we saw very little except "limb bends". The incidence of "CNS hits" was extremely low.

When we looked at 4 hour exposures, there was little change in the range of pressures required to produce "least-detectable signs" of DCS, and there was no real change in DCS types.

The next stage in our plan was to look at 30 minute exposures with direct ascent. To our surprise, this was a whole new ball game. As expected, we had to go deeper to produce any form of DCS, but now signs of spinal cord involvement were frequent and often devastating. Early on, we lost one of our favourite goats to respiratory paralysis despite very prompt recompression. Another old friend, Jane, became quadriplegic. She responded to treatment but then relapsed during the slow ascent. She showed no response to further recompression and was unable even to lift her head to drink. What happened to Jane after that is worth telling.

Our veterinary neurologist found some faintly encouraging signs and recommended that we keep Jane alive to see what would develop in a week. The need for intensive care was met with the help of a large box in Dr Lanphier's study, a great quantity of old newspapers, and not a little effort. In a week, Jane showed some favourable changes, and definite progress continued.

Recovery from Quadriplegia

In the tenth week after her accident, Jane crawled out of her box and tried to join the Lanphiers at dinner. Their joy was tempered by deposits left on her way, so Jane was shifted to quarters outside. There, daily, she was set on her feet and encouraged to take steps. Within another few weeks, she was able to stand for a time, walk a little, and, finally, to get up without help. Except for one transient setback, Jane's condition has been stable for over two years. She is clearly impaired but able to walk reasonably well and even to run a little.

Our astonishment at Jane's recovery sent us to the older literature, where we found a number of accounts of equally remarkable convalescence in divers. Thus, Jane taught us that spinal cord injury from DCS can have a far better prognosis than do more common forms of damage. The implications for management and rehabilitation of cord-injured divers are clearly important.

32% Spinal DCS (Goats) and 64% (Sheep)

That was the good news, but the bad news overshadowed it completely. By far the most important lesson of our 30 minute exposures was in the overall incidence of spinal DCS. In many repeated dives, this reached 32% in 6 goats and 64% in 3 sheep. By then, we were much more willing to believe recent accounts that contradicted older sets of data. We asked ourselves whether the prevalence of short, relatively deep dives with scuba could perhaps account for such a change in statistics. Conversations with the Divers Alert Network (DAN) and friends who were seeing actual cases strongly supported this idea.

We assume that even well-trained divers occasionally take liberties with the tables, and many of them probably do so on the assumption that, even if they do "get bent", the chance of a serious (Type II) hit is remote. But instead of 1-in-10 or even 1-in-4, the risk of spinal cord injury is probably even greater than 50-50 for most scuba divers who take chances (and for some who follow all the rules). We are talking here about dives that are barely sufficient to produce any sign of DCS, and about the proportion of resulting cases that include injury to the nervous system. Obviously, gross violation of the decompression tables can produce almost any form or forms of damage.

With possibilities like lifelong paraplegia in the balance, misinformation can be very dangerous. Even more scary is the fact that many divers still do not realize that a weak leg or numb foot or "pins and needles" somewhere, or an odd kind of belly ache, can signal a very urgent need for recompression. For such a diver, the risk of injury is large, the chance of timely treatment is rather small.

At the 1984 UMS meeting, Dr Lanphier talked with some of the leaders about the need for authoritative information on this subject, specifically aimed at divers. He returned to Madison discouraged by the lack of interest. A Sea Grant writer called just then to ask him to reconsider his "embargo" on a press release that had been prepared on this subject. This time, Lanphier said "Go ahead".

Serendipity and Chokes

In the course of nearly 1000 simulated dives in our animals, serendipitous development of dysbaric osteonecrosis

(aseptic bone necrosis) gave us the impression that we could produce that condition almost at will. Little is really known about this unfortunate complication of DCS because there has never been a very satisfactory animal model of the condition. We devised a "recipe" for producing necrosis deliberately; the protocol included what we called "altitude provocation", a process that had been extremely useful in our earlier studies.

In the first trial, we exposed 6 sheep to a moderate depth for 24 hours and then, after observation at surface, took them to 8,000 ft of altitude (570 torr). We planned to "park" them there for another 25 hour period.

"... DIVERS WHO MAKE VERY LONG DIVES OR DO MUCH REPETITIVE DIVING MAY BE AT GREAT RISK OF CHOKES IF THEY FLY TOO SOON AFTERWARDS.

The idea was that if any showed undue signs of DCS in the meantime, we could simply take them back to the surface. There, experience indicated, they would almost certainly be relieved without further recompression.

Fate had other plans. To our astonishment, just 45 mins at altitude produced prostration in 3 sheep, and dear old Blanche was dead before we could get them back to ground. The problem was obviously "the chokes", but the two sheep still living did not respond at all rapidly to recompression. Both of them ultimately recovered at treatment depth, but one died abruptly during subsequent ascent. Here was an appalling problem. We were mainly grateful that the subjects were sheep and not divers.

Despite our unprepared minds, serendipity had given us a sure-fire method of producing chokes. We subsequently utilized this method many times in a new project in which we learned much about this condition. We have no proof that our experience applies closely to real-life situations. However, we believe that divers who make very long dives or do much repetitive diving may be at great risk of chokes if they fly too soon afterwards. Eight thousand feet is all it took with our sheep, and that is an accepted cabin altitude. We were also impressed that what we saw in many sheep could easily be mistaken for a heart attack if it occurred in a diver.

Bone Necrosis

Our recipe for producing bone necrosis obviously had to be modified; it has now been tested and the results are entirely encouraging. We hope that this, together with our discovery that bone marrow pressure is often elevated in "limb bends", may lead to significant progress in understanding both these conditions.

Does chance favour only the prepared mind, as Pasteur said? Some of our best "discoveries" suggest that it may be enough just to be "doing something actively" and being willing to appreciate whatever turns out.

(NOTE: Appropriate references etc., will be supplied by writing directly to Dr Lanphier.)

Reprinted, by kind permission of the Editor, from PRESSURE, the newsletter of the Undersea Medical Society.

DCIEM UPDATE
"New Canadian Dive tables coming"

In early 1983, The Defence and Civil institute of Environmental Medicine (DCIEM), a Canadian Department of National Defence Research Establishment located in Downsview, Ontario developed a new decompression model for air diving. This new model, the DCIEM 1983 Decompression Model, is the result of many years of decompression research at DCIEM.

"Standard Air", "In-Water O_2" (at 9 msw) and Surface Decompression on Oxygen (Sur D O_2) decompression tables, as well as very simple "Repetitive Diving" procedures for all the above tables and "Altitude" corrections based on the new model have been developed and are currently being evaluated at DCIEM using Doppler ultrasonic bubble detection techniques.

Although no realistic decompression procedures can totally eliminate the occurrence of Decompression Sickness, it is felt that a more conservative approach to decompression procedures than those published in the United States Navy and Royal Navy diving manuals is necessary (1.2).

Figure 1 provides a simple comparison of the DCIEM, USN and RN "Standard Air" decompression tables. The DCIEM table is consistently more conservative than the USN table and RN Table ll. As the DCIEM "Oxygen" decompression tables are derived from the same basic model, these tables are equally conservative.

Experienced divers have long believed that the USN "Standard Air" table often does not provide quite sufficient decompression and therefore apply the "one longer bottom time" rule for hard working dives quite regularly. For more severe exposures, the actual decompression is often further increased by the "one longer plus one deeper" modification.

Figure 2 shows that when the "one longer" rule is applied to the USN table (USN + 1), the DCIEM and USN methods result in similar decompression times - except at extended bottom times. If, however, the "one longer plus one deeper" philosophy is applied in this region, the results are again very similar.

The current evaluations of the DCIEM 1983 model using Doppler ultrasonic bubble detection procedures have shown that the basic conservatism of this model is indeed justified and necessary. Experimental working dives to 72 msw for 40 minutes bottom time have shown this model as safe in the "exceptional exposure" range as in the "normal" air diving range. This is attributed to the fact that the relative conservatism of the DCIEM model increases as bottom times are extended.

For short, shallow dives, the DCIEM model is perhaps too conservative. However, this extra margin of safety - in the region where most of the diving by "novice" divers and