7. DIVING DOCTOR'S DIARY:

Diving Details. Semi-closed circuit rebreathing equipment, using 60% O_2 and 40% N_2, with a flow rate of 4 L/min (instead of the manufacturer's recommendation of 6 L/min), depth 60 feet, duration 60 minutes. The two divers were buddied together with a 10 foot line. Swimming speed 1.0 knots.

Both divers surface, one appears unconscious.

(CORRECT DIAGNOSIS - TOP MARKS)

On checking the diving information it was ascertained that the diver started with enough gas, at that flow rate, to last 90 minutes. There was no evidence of diving set malfunction, and the CO_2 absorbent used was of the CIG sodasorb type (the correct type for that equipment).

The buddy diver described the dive as uneventful until his companion lost consciousness. Loss of consciousness occurred during or immediately after ascent, and there was no evidence of any difficulties encountered during the dive, while at depth.

The unconscious diver was fortunate in that he wore a full face mask, preventing him from losing his mouthpiece during his comatosed state. The buddy diver was astute enough to ditch the man's weights and turn the mouthpiece cock so that the affected diver could breathe from the atmosphere once the surface was reached. He was then assisted inboard the diving tender and made a rapid and uneventful recovery.

(CORRECT DIAGNOSIS - TOP MARKS STILL)

The history, as obtained from the affected diver after his recovery, was that he had no difficulty during the dive, and that the reason for the ascent was to obtain a check bearing on his compass. He believes that he was actually on the surface and taking a bearing when he lost consciousness. In discussing the possible prodroma, there was no clearly defined history of these, but there was some suggestion that the diver was a little 'lightheaded', again while he was on the surface.

Perusal of the diving equipment after the dive did not demonstrate any mechanical fault or water contamination. Pressure testing of the supply bottles allowed the examiners to rule out the possibility of inadequate gas supply. Retrospective perusal of the diver's history reveals that he had been diving for four years as a professional, without any evidence of a personality disorder, anxiety state or neuroticism. He was considered a reliable and competent diver, well versed in diving techniques and practices.

(CORRECT DIAGNOSIS - TOP MARKS)

MEDIC: There seemed to be many obvious causes why this man should suffer loss of consciousness. The first question is whether he could have decompression sickness?

DIVING MEDIC: Not possible under these conditions. The maximum N_2 pressures in his gas supply was under 1.2 ATA, although this would have been increased slightly in his inspiratory mixture. Even assuming that the inspiratory O_2 dropped to an average of 20% during the dive, one would still not have expected decompression sickness.

MEDIC: How about the possibility of air embolism and pulmonary barotrauma?

DIVING MEDIC: Although this is possible it is most unlikely. He was an experienced and competent diver, he apparently reached the surface and was taking a compass bearing prior to losing consciousness, and finally the improvement in his clinical state occurred without the advent of either recompression or O_2 administration. There was also no mention of focal neurological features.

MEDIC: I know of three common causes of unconsciousness in rebreathing equipment, namely hypoxia, CO_2 build up and O_2 convulsions. Could any of these be incriminated in this case?

DIVING MEDIC: Let’s take them one at a time. Hypoxia is a very likely provisional diagnosis. The diver was using less than the proposed O_2 flow, and in fact a quick calculation shows that he was introducing only 2.4 litres of O_2 into his breathing bag each minute, and with semi-closed circuit one must accept a considerable loss of O_2 during the dive, over and above that consumed by the diver. He was swimming at a reasonably fast speed, and would have been expected to have consumed something like 2 litres O_2 per minute. This is likely to result in a progressively diminishing O_2 concentration in the inspiratory gas, and even though the latter may finally have something like 10% O_2 or less, this is not likely to cause problems until he ascends and has to breathe this low percentage O_2 mixture at surface pressures. This case could well have been the result of such a situation, especially if it were ascertained that the diver did not purge his breathing set with fresh gas prior to his ascent.

MEDIC: If he did purge his diving set, is the diagnosis still tenable?

DIVING MEDIC: Probably not, however one should also check from the attendants as to whether the diver appeared cyanotic during the resuscitation procedures or while in the water.

MEDIC: How about O_2 toxicity?

DIVING MEDIC: This is a possibility, but is most unlikely unless there has been a mistake in the gas mixtures used. The diver had anticipated using a 60% oxygen mixture. If his equipment was filled with 100% oxygen then O_2 toxicity would be a likely result at that pressure, for that duration. Let us get an O_2 estimation performed on the gas in the cylinder.

(Laboratory estimation - 60% O_2 in gas cylinders).

That excludes O_2 toxicity producing epileptic fits and unconsciousness, as the maximal O_2 pressure he could have experience was less than 1.7 ATA (2.8 ATA x $f_{(60,100)}$ = 1.7).

MEDIC: Oxygen Syncope could still be a cause.

DIVING MEDIC: Does anyone believe in this disease any more? I understood it to have lapsed into diving folklore. There are no well documented cases of O_2 syncope that I can find in the literature - and repeated attempts to produce it under experimental conditions have failed.

MEDIC: I understand that with most rebreathing equipment, carbon dioxide toxicity in the commonest cause of unconsciousness. Is there any way in which we could verify or disprove this possibility in this case?

DIVING MEDIC: Yes, very simply. As soon as the diver is taken from the water, the set should be turned off and passed over the an Underwater Medicine unit for testing. We can test this very simply and easily by putting another diver on the set, and with due precautions, get this second diver to swim at a reasonably fast speed. Needless to say, one has to have an adaptor for the set to regularly remove gas samples of the inspiratory mixture. If the inspiratory mixture starts rising to levels of CO_2 in excess of 10mm Fg, then there is something seriously wrong with the absorbent system. It is then likely to rapidly rise to about 40mm Hg in pendulum breathing equipment, and at this stage the diver is usually incapacitated. I would strongly advise against using this technique unless there are full resuscitation facilities at hand, with immediate CO_2 analysis capability and feedback.

This investigation was performed with this case and the second diver, who was asked to swim at a depth of approximately 3 feet up and down a swimming pool, lasted about five minutes before he became incapacitated with an inspiratory CO_2 in excess of 35mm Hg. More sophisticated tests can be performed on the CO_2 absorbent remaining in the canister, and in the CO_2 absorbent that had not been used, to ensure that it was of an adequate standard. Although these investigations are more sophisticated, they are far less informative than simple tests I have described.

(CORRECT DIAGNOSIS - Top Marks. Anyone who can get the correct diagnosis without the last two paragraphs of information deserves top marks for luck. Those who have waited for the results of the exercise testing of the absorbent canister also deserve top marks, as this is the most rational approach).