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11 February, 2000

Snr. Constable David Upston
Sydney Water Police,
Wharf 25, Harris St.,
Pyrmont NSW 2009

Fax: 9692 5427

Dear Snr. Constable Upston,

Re: The exchange of oxygen and carbon dioxide between subjects and air in a confined space with reference to deaths during the Sydney to Hobart Yacht Race in 1998

Thank you for asking me to comment on the above matter with particular reference to the time of survival for five men trapped in an overturned liferaft in rough seas and confined to breathing an enclosed volume of around 1400 litres of air. You have provided me with a report from Richard Phillips, School of Biomedical Science, University of Tasmania, Launceston, which contains calculations of the changes in oxygen and carbon dioxide concentrations in this confined space over time, and estimated the time of survival for five adult males trapped in this space. You have also provided me with a document "Issues Relating to Liferaft Operation" which is a report to the NSW Police for the Coroner's enquiry. This covers the mechanics of liferaft storage and operation which I do not feel qualified to comment on further. You have particularly asked me to discuss the appropriateness of a strategy of cutting an opening in the base of the liferaft in order to obtain ventilation of the enclosed space.

I found myself in general agreement with Richard Phillips' report, although there are a few of his calculations and assumptions that I would enlarge upon. On page 2 of his report, he states that each individual would have consumed oxygen and produced carbon dioxide at the rate of approximately 2 litres per hour. This should read two litres per minute and I would judge that the oxygen consumption per individual would probably be between one and two litres per minute, given the necessity for them to tread water to some extent and their general anxiety and increasing agitation as the carbon dioxide levels rose and oxygen levels fell. A resting oxygen consumption for an individual is around a third of a litre per minute, with slightly less carbon dioxide being produced. However, during exertion, the oxygen consumption rate can increase up to three litres per minute, with a similar amount of carbon dioxide being produced. Again, I would judge the oxygen consumption of each man in this situation to be between one and two litres per minute.

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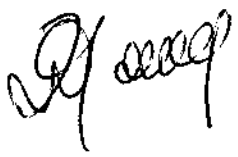
I would therefore agree with the calculations in table 1 showing the changes in oxygen saturation and CO2 concentration with time. However, the fall in oxygen, combined with the increase in carbon dioxide, are potent stimuli to the ventilatory control centre in the brain and this process would initially increase the sense of breathlessness and agitation and further increase metabolic rate, as Mr. Phillips describes. Therefore the prediction of the survival time is likely to be an overestimate rather than an "underestimate" as stated in the last paragraph on page 3. It should also be borne in mind that, once each occupant's consciousness became clouded, he would be far more likely to drown before the atmosphere in the confined space actually became life-threatening. In other words, each individual would have survived for a longer period in a dry space where they would continue breathing, despite clouded consciousness, until the atmosphere itself could not support life.

I would therefore judge that each individual would become disorientated and be at risk of a drowning death within 10 minutes of the circumstances outlined.

It would therefore seem a very reasonable strategy to open the roof of this space (presumably the floor of the inflatable liferaft) within the first 5 - 10 minutes of confinement. I have no experience to judge how practical this operation would be in turbulent seas. Even a long slit-like cut in the surface would be of assistance as this could be splayed open from time to time and this would rapidly allow equilibration between the confined space and the atmosphere where diffusion of the accumulated carbon dioxide out and of fresh oxygen in to the space would occur quite rapidly. The slit would need to be opened quite frequently but this strategy may be preferable and easier than trying to cut a large hole in the surface, which would allow more water to wash over the persons and remove the shelter effect. As long as a reasonable size opening could be splayed quite frequently, it would not have to be held open for much longer than 10 - 20 seconds to allow rapid equilibration of the confined gas with the atmosphere. However, I would judge that the cut would need to be at least half the length of the boat with five men sheltering underneath.

I trust that this provides the information you require. I do apologise for the delay in replying to your request as it took me some time to determine where I could be of most assistance. Please do not hesitate to ask for my further comments if I have not made myself clear or you require elucidation of other problems associated with this tragedy.

Yours faithfully,



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