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27 August 2008

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Re: Robert Barrett

I have written the following supplemental report as requested in your email of 25 Jul 2008 to the original report I submitted on 26 Jan 2008. This report is based on the following additional information:

- Your email of 25 July 2008
- Document 149-3, Exhibit A, filed 10 Apr 2008 , 'Dr. Deas' Report Nov. 19, 2007 v. Dr. Deas' Report April 4, 2008'
- Document 202-2, filed 16 June 2008 , 'Motion to Strike the Expert Report of Alex Deas'
- Document 202-3, Exhibit A, filed 16 June 2008 , 'Inspiration Logic Demonstration'
- Document 202-4, Exhibit B, filed 16 June 2008, 'Deposition of Lt Stephen Englert, excerpts'
- Document 202-8, Exhibit F, filed 16 June 2008, 'Dr. Anthony letter'
- Documents 166-2 to 166-5, filed 18 Apr 2008, 'Dr. Alex Deas Supplemental Report'
- Autopsy Report on Robert Barrett
- Models re Barrett O2 consumption

Document 202-2, 'Motion to Strike the Expert Report of Alex Deas' identifies many points in Dr. Deas' supplemental report where his data, assumptions, methodology, opinions, and conclusions drastically deviate from what is actually know. It also states on page 24 of 43 that the heart of Dr. Deas' supplemental report is the section on 'Oxygen Metabolism Calculations and Dive Modeling' (pgs 79 to 106 of 183). As my areas of expertise include oxygen metabolism, specifically diving and exercise physiology, I will point out some of the significant errors in this section. Dr. Deas is obviously very bright and dedicated, but when you try and write in areas outside your training you tend to make fundamental errors. Dr. Deas obviously is not trained in medicine or physiology, and the evaluation in document 202-2 on page 30 of 43 that "Dr. Deas' methodology is akin to junk science" definitely has validity.

From the accident data available, it seems quite likely that Mr. Barrett died from hypoxia, however this is not known for certain and it is clearly not the only possibility. It is also known that Mr. Barrett was conscious for approximately 10 minutes into his last dive. In this section of his report, Dr. Deas attempts to make the point that Mr. Barrett could not have remained conscious for as long as 10 minutes into his final dive unless his Inspiration CCR was functioning normally at the beginning of the dive. Specifically, that Mr. Barrett's Inspiration must have added some oxygen to the breathing loop during the dive. He does this by performing some complex calculations to attempt to show that the amount of oxygen available in the breathing loop if Mr. Barrett had conducted the dive with the Inspiration not functioning would have been insufficient for Mr. Barrett to remain conscious for the first 10 minutes of the dive.

On page 79 of 183 Dr. Deas states, "In the case of Robert Barrett, there is no question that the cause of death was drowning, the disabling injury was hypoxia, and since the diver was breathing from a rebreather at the time of sudden LOC, the disabling agent for hypoxia was failure to deliver oxygen to the breathing loop. This leaves the trigger as the item to be investigated: what caused the rebreather to fail to deliver oxygen? That trigger is the root cause of this accident." This paragraph is fundamental to the entire discussion, but it contains several basic errors.

"There is no question that the cause of death was drowning". In fact, what is known is that Mr. Barrett died while in the water. In these cases, the death certificate and sometimes the autopsy report lists the cause of death as 'drowning' but there is no 'test' for drowning. What is really meant is 'death while in water'.

In recreational scuba diving, the most common cause of 'death while in the water scuba diving' is heart attacks. The second most common cause of death is arterial gas embolism. Both problems can be very difficult to identify on autopsy. Specifically, arterial gas embolism can not be reliably identified with the standard autopsy procedure. Unless the pathologist is trained to perform autopsies on diving fatalities and special procedures are followed, the cause of death will usually be 'drowning'. Any other medical problem that causes LOC while in the water will also usually result in death and frequently a diagnosis of 'drowning'. Examples include stroke, diabetes, epilepsy, etc. Dr. Deas statement that "There is no question that the cause of death was drowning" is simply not true.

The autopsy report for Mr. Barrett reveals that the autopsy was partially conducted in accordance with recognized procedures for diving fatalities (the brain was examined before the chest was opened). Some air was found in the veins of the brain, and in the veins of the heart. If Mr. Barrett had suffered arterial gas embolism after such a short and shallow dive, only a very small amount of gas would be expected to be discovered in the circulation. The autopsy report does not mention if a meticulous examination of the lungs was carried out to search for the usually very small area of damage that would be present if Mr. Barrett had suffered arterial gas embolism. Therefore, it is my expert opinion that arterial gas embolism can not be ruled out based on the autopsy report. If Mr. Barrett made a panicked or hypoxic ascent approximately 10 minutes in to the dive as shown on his dive computer, arterial gas embolism is quite likely.

The autopsy report also revealed mild occlusion of the left main and 50 to 60% occlusion of the left anterior descending arteries in Mr. Barrett's heart. For a man of only 32, this is unusually advanced coronary artery disease. Occlusions of over 50% are considered highly significant and definitely placed Mr. Barrett at increased risk of a heart attack. A heart attack due to complete occlusion of an artery should have been apparent on autopsy, but a heart attack due to an arrhythmia usually results in no autopsy findings. Therefore, it is also quite possible that Mr. Barrett suffered a heart attack during the dive.

Dr. Deas then proceeds to state that "the disabling injury was hypoxia". I have already shown that many other things could have resulted in the death of Mr. Barrett. Even if Mr. Barrett lost consciousness as a result of the gas he was breathing from the Inspiration CCR he was diving, this LOC could also have been due to hyperoxia or hypercapnia. In the analysis of rebreather fatalities, all three causes of LOC are common and to simply 'assume' that the cause of LOC in this case was due to hypoxia is unreasonable.

Hypercapnia (too much carbon dioxide) while diving on a rebreather frequently results in sudden LOC. Mr. Barrett was diving with unapproved absorbent material (Drager DiveSorb) and there is some evidence that this absorbent may have been 'fully used'. Therefore, LOC due to hypercapnia is a definite possibility and it can not be ruled out.

Hyperoxia (too much oxygen) can also cause sudden LOC while diving. Given the facts that Mr. Barrett's final dive was short (approximately 10 minutes) and shallow (max depth of approximately 43 feet for only a few minutes), LOC due to hyperoxia is possible but unlikely. None-the-less, to blindly assume that "the disabling injury was hypoxia" excludes many other real possibilities.

The heart of this section of Dr. Deas' report is the assumption that the "disabling agent for hypoxia was failure to deliver oxygen to the breathing loop". If in fact Mr. Barrett lost consciousness due to hypoxia, it certainly was because there was insufficient oxygen in the breathing loop of his Inspiration CCR. In this case, I completely agree with Dr. Deas that the "root cause of the accident would be what caused the rebreather to fail to deliver oxygen".

Dr. Deas attempts to show that Mr. Barrett would have suffered LOC in less than 10 minutes if his Inspiration had not delivered at least some oxygen during the dive, therefore 'proving' that Mr. Barrett had set up his Inspiration properly and that the Inspiration was working properly for the first part of the dive, and 'proving' that something else then happened to cause the Inspiration to stop working properly. To do this Dr. Deas makes some very unrealistic assumptions and ignores known data.

The critical variables in performing these calculations are the volume of the breathing loop at the beginning and during the dive, the oxygen content of this gas volume, the volume of oxygen added to the breathing loop by the diver during the dive, and the diver's rate of oxygen consumption. In his calculations Dr. Deas has deviated from reasonable values for at least some of these variables to arrive at the results he needs to support his conclusions.

What was the probable gas volume of the breathing loop at the beginning and during the dive? Dr. Anthony in Doc 202-8 shows that the volume of the rigid components of the breathing loop on the Inspiration is very close to 5 liters. Doc 202-2 points out some of the errors Dr. Deas made when he arrived at a volume of 4.6 liters.

Dr. Anthony assumes that a diver will not voluntarily generate high negative pressures at the end of every breath to completely empty the counter lungs of the rebreather, and that this will result in approximately one additional liter of gas remaining in the flexible components of the rebreather at the end of normal inspiration. Dr. Deas assumes the counter lungs will be completely empty at the end of normal inspiration. He states that there will be about 200 ml of gas left in the counter lungs due to folds in the material, but he ignores this volume in his calculations.

Breathing so that you completely flatten the counter lungs at the end of every breath is hard work, very uncomfortable, and causes significant distress in most people. To end every breath while diving with a forceful inhalation and the feeling that you are suffocating because even though you are trying very hard to inhale, you are not getting any further gas causes significant distress in most people. In addition, if you descend even a couple of feet, or if you increase your level of work even slightly you will find yourself unable to inhale even a normal tidal volume. On the Inspiration the only solution is to ascend or to manually add gas. Therefore, Dr. Anthony's assumption that the diver will leave at least a liter of gas in the loop at the end of inspiration to avoid this very unpleasant experience is highly probably, and Dr. Deas' assumption that Mr. Barrett would not, very unreasonable.

In addition, as an experienced Inspiration diver and instructor, it has been my experience that new Inspiration divers almost always dive with even more gas in the counter lungs. It is VERY unsettling to try and take a breath and find that you have nothing to breath. It takes a lot of experience before you are comfortable enough diving the rebreather to dive at 'minimum loop volume' and Mr. Barrett was an inexperienced Inspiration diver. Keeping more gas in the loop means that you have to wear more lead to counteract the buoyancy of the extra gas. Mr. Barrett was wearing a lot of lead and therefore was most likely diving with even more than the one liter of extra gas in the counter lungs Dr. Anthony assumes.

Finally, when you are diving 'minimum loop volumes', you have to frequently, manually add diluent to the loop to have enough gas to breathe. This requires you to find and press the correct button on the counter lungs and this activity is relatively time consuming for new Inspiration divers, especially when they are wearing wetsuit gloves. It also forces you to focus on yourself and your Inspiration. Mr. Barrett was not only an inexperienced Inspiration diver he was teaching and trying to keep track of three other divers in conditions of poor visibility. It is highly unlikely that he was diving with 'minimum loop volumes' and therefore he almost certainly had one or more liters of 'extra' gas in his counter lungs at the end of inspiration.

Dr. Deas calculates two values for residual volume in Mr. Barrett's lungs using equations available on the internet and then chooses to use the smaller volume. He states "It should be noted that Mr. Barrett was a smoker, which would tend to reduce the lung capacity slightly". Actually, Dr. Deas got it backwards. Smoking causes 'obstructive' changes in the lungs and 'increases' residual volume. It is highly likely that Mr. Barrett had a residual volume larger than the value used by Dr. Deas in his calculations. A larger residual volume would mean that there was more oxygen available to Mr. Barrett during the dive.

Dr. Deas also assumes that Mr. Barrett would have maximally exhaled to descend at the beginning of the dive, reducing his lung volume to residual volume. This is highly unlikely. Sitting in a pulmonary function laboratory, it is incredibly difficult to exhale to residual volume. To assume that a diver would do this at the start of a dive is unreasonable. If Mr. Barrett started his dive with more gas in his lungs than residual volume, this would again increase the amount of oxygen available to him during the dive.

Dr. Deas' assumption that Mr. Barrett started the dive with 6.6 liters of gas in his lungs and the loop and that he had 9 to 10 liters of gas in his lungs and the loop during the main part of the dive most likely understates reality by several liters in both cases. Dr. Anthony and the Plaintiff's other remaining liability expert, David Crockford suggest more realistic values.

Finally, Dr. Deas has calculated that Mr. Barrett had an 'End of Expired Breath Volume under light exercise' of 3.30 liters. Again this is a significantly less than realistic value. EEBV includes the residual volume and therefore the points raised above also apply to this value. In addition, Dr. Deas takes his values from the internet for cycling. It is well known that divers tend to breath at higher lung volumes and therefore have larger EEBV volumes than people performing other types of activity. Had Dr. Deas used more realistic values for this volume, the amount of oxygen available to Mr. Barrett would have been increased.
The second variable in Dr. Deas calculations where the values he used deviate significantly from those I would consider reasonable are the rate of oxygen metabolism of Mr. Barrett.

Dr. Deas correctly states that Mr. Barrett is 36% larger than the average male (95 kg vs 70 kg). He also states that because basic metabolic rate is determined primarily by weight, Mr. Barrett's oxygen metabolism during exercise should be 36% greater than a normal 70 kg male diver. This is not necessarily reasonable.

When you are resting, all of the cells of your body are using oxygen and weight is a reasonable predictor of oxygen utilization. When you exercise blood is shunted away from some tissues (digestion slows down) and to working muscles. Therefore, during exercise oxygen uptake is primarily determined by how hard you are working and how much muscle mass you have. Mr. Barrett was 36% heavier than the average male, but no evidence has been presented to suggest that he had 36% more muscle than the average male. Most 'heavier' individuals are fat, and Mr. Barrett was a smoker. If he was fit and muscular then the assumption that he had 36% more muscle than the average male might be reasonable. Otherwise it is an incorrect assumption. Even so, the assumption that he would use 36% more oxygen than a 70 kg male is most likely not correct.

In diving and other water activities weight is neutralized. Therefore, it is NOT correct to assume that a 100 kg person has to work twice as hard to swim as a 50 kg person. The net effect of all these factors is that Mr. Barrett would almost certainly not use 36% more oxygen to perform the same work while diving as a 70 kg male.

Dr. Deas uses an oxygen uptake of 1.2 liters/min for an 'average swimming diver' and then adds 36% for Mr. Barrett to arrive at a value of 1.6 liters/min. I am not sure where the value of 1.2

liters/min comes from. Document 202-2 references Bennett and Elliott, giving values of 0.3 liters/min for a 'resting dive' and 1.5 liters/min when swimming at up to 1.1 knots.

To put these values in perspective, a 'resting' 70 kg male will use approximately 0.25 liters/min of oxygen. I personally use an average of 0.5 liters/min of oxygen when diving the Inspiration on dives that involve a fair amount of swimming (I weigh 80 kg and am quite muscular). A diver swimming at the optimal speed to get from one place to another in the fastest time with the least amount of effort will swim at approximately 0.5 knots. Swimming at 0.5 knots represents a focused effort that can be sustained for a few hours by a very fit diver. To swim at up to 1.1 knots and use 1.5 liters of oxygen per minute as referenced in Bennett and Elliott represents very hard work that can not be sustained for more than a few minutes.

In comparison, the dive performed by Mr. Barrett and his companions involved a descent, a short stop to do some skills, another descent and then a stationary wait on the bottom for the silt to clear. They never swam any significant distance and did not perform any degree of work. Therefore, I would estimate a much more reasonable value for Mr. Barrett's oxygen uptake to be in the range of 0.5 to 0.7 liters/min. Document 202-2 has clearly shown why increasing Mr. Barrett's oxygen uptake from 1.6 to 1.78 liters/min due to 'heat stress' is unreasonable and I fully support the arguments presented there.

The other two variables are the oxygen content of the breathing loop at the start of the dive and the amount of oxygen added to the loop during the dive by the diver.

The amount of oxygen added to the loop during the dive by the diver can be calculated fairly easily from the dive profile. Mr. Barrett would have had to add air (or oxygen) to make up the volume of the loop as he descended. The starting oxygen content of the loop must be assumed.

Dr. Deas used a model to calculate the partial pressure of oxygen in the loop under various scenarios. As the details of this model are not available, I can not comment as to whether the values calculated are reasonable or not.

What is interesting is that Dr. Deas states in his 'Devil's Advocate Test' on page 89 of 183 of his report that using the 'lowest possible metabolic rate' of 0.9 liters/min and the maximum possible dead volume on leaving the surface of 10 liters, Mr. Barrett would not have lost consciousness from hypoxia for 5:48 minutes. He claims that this calculation 'proves' that the rebreather was definitely on at the start of the dive.

If his calculations are correct, using more realistic values for oxygen uptake (0.5 to 0.7 liters/min) and for initial loop volume (11 to 13 liters) would result in Mr. Barrett loosing consciousness at around minute 10 of the dive (when he actually did), thereby 'proving' that the rebreather was DEFINITELY NOT ON at the beginning of the dive. Of course I have no idea whether the "most detailed rebreather model and dive environment model known to exist" (Deas page 79 of 183) has any validity.

The models provided by Mr. Concannon support my observations above. Specifically, if Mr. Barrett had started the dive with more oxygen than is contained in 'air' in the breathing loop, he would not have lost consciousness due to hypoxia during the dive. The model using air and an O2 consumption of 1.0 liters/min show that Mr. Barrett would have most likely lost consciousness due to hypoxia a minute or two before he started to ascend towards the surface. However, if Mr. Barrett's O2 consumption was less than 1.0 liters/min (as I have shown above to be highly likely) then this model would show that the PO2 in the breathing loop would have dropped to around 5% as a result of his ascent and he would have lost consciousness as a result. This is exactly the probable cause of death I suggested in my first report.

There are a very large number of other errors and unreasonable assumptions in Dr. Deas' report but it seems pointless to me to spend the time and effort required to point out all of them. Document 202-2 and this report point out so many errors already that it should be clearly apparent that 'everything' in Dr. Deas' report has to be questioned and nothing should be 'assumed' to be correct.

Dr. Deas is to be commended for the amount of time and effort he obviously expended to produce this report. However, if he expended the same amount of energy and determination to obtain proper training in medicine and physiology, his work might have greatly improved value.

The fundamental question remains, if Mr. Barrett died from hypoxia, why did his Inspiration not deliver sufficient oxygen during the dive. The answer seems to be that Mr. Barrett most likely did not place his Inspiration into dive mode before commencing the dive.

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