MIKE GROCOTT

Caudwell Xtreme Everest

The Caudwell Xtreme Everest expedition during the spring of 2007 was not principally a climbing expedition. The aims were scientific, not adventurous, and the members were physicians who were experienced amateur climbers, not professional high-altitude mountaineers or clients chasing a personal life-goal. For us, Everest offered a unique opportunity to study how humans adapt to hypoxia (low oxygen levels). More than 200 volunteers trekked to Everest Base Camp to be subjects of 60 investigators in an experiment designed to investigate why there is such variation in people's ability to adapt to hypoxia (acclimatise) and perform effectively at altitude. We hope that the results will help to improve our understanding of how our patients with critical illness adapt to hypoxia, and perhaps, to develop new treatments for the critically ill. At the same time, higher on the mountain, climbing doctors (and medical students) made novel measurements at the edge of the human physiological envelope, trying to define the limits of tolerance of hypoxia.

Overall, the expedition was a success: we completed more than 90 per cent of the planned experiments, facilitated several major rescues, and everyone involved returned safely. As it turned out the climbing was also safe and successful. Fifteen Sherpas, two cameramen and eight doctors reached the summit of Everest, but the principal high-altitude goal, a blood sample on the world's highest point, was not (quite) achieved. This article tells the story of the expedition.

Why were we there

We set out to understand why there are such dramatic differences between individuals in their ability to adapt to hypoxia (acclimatise). Much previous altitude research has been conducted on small groups of subjects, making it difficult to explore differences between individuals. We set out to study a large group (222 subjects in total) in order to be able to observe a spectrum of normal variability and relate the observed differences to the different genetic profiles of our subjects. In this way, we hope to be able to identify genes associated with beneficial adaptation and thereby better understand the mechanisms responsible for effective adaptation. We believe that the same mechanisms may explain variations in response in critically ill patients and help us to understand why some survive when others do not.

We are particularly keen to explore whether changes in the efficiency with which cells utilise oxygen are responsible for the dramatic differences in performance between individuals at altitude. Until now, the majority of literature relating to acclimatisation has focused on how oxygen gets to the cells, rather than how effectively the cells use it. Studying hypoxia in patients in hospital is rarely fruitful because of the large number of additional factors (type of injury, previous illnesses etc) which make it difficult to separate out the effects of a single variable such as hypoxia.

Our subjects were studied at sea level and in purpose-built laboratories in Kathmandu, Namche Bazar, Pheriche and at Base Camp. All the subjects trekked from Lukla to Everest Base Camp following the same ascent profile. Consequently, we know that any differences we observe between them will be due to their individual physiology rather than to different ascent rates. The logistics needed to achieve this volume of science were substantial. More than 26 tonnes of equipment were flown to Nepal and then flown and trekked into the relevant laboratory. Each one of more than 500,000 items was catalogued on a vast spreadsheet. It is a testament to the abilities of Mac MacKenney and his logistics team that every item was delivered to the correct laboratory at the right time.

The expedition was the culmination of more than three years' preparation, including two previous successful expeditions over 8000 metres (Cho Oyu) and months of testing in cold and low-pressure chambers. The huge volume of results will keep us busy for at least the next five years.

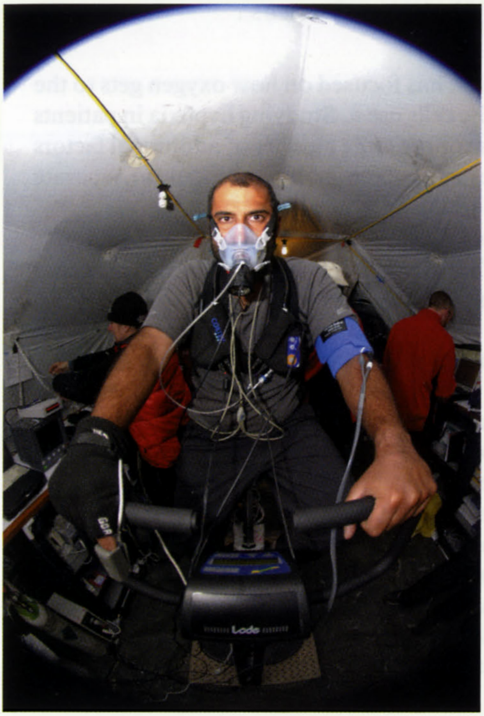
Everest in 2007

Our climb on Everest in 2007 bears little comparison with the pioneering summit successes of the 1950s, '60s and '70s. Fixed rope is now almost continuous from base camp to summit; only on the flatter areas of the Western Cwm and on the South Col do you move around free from an ascender. The 'icefall doctors', a team of five Sherpas paid by a national park levy, prepare and maintain the route through the Khumbu icefall. Each day throughout the season, they make and mend the fixed ropes and ladders whilst the incessant downward flow of ice continuously erodes their work. Higher on the mountain, we were able to have effective radio and telephone communication from the South Col, along with battery banks to power our experiments. We returned with renewed admiration for the pioneers on Everest who succeeded without all these supports and were truly heading into the unknown.

Safety-Science-Summit

Any expedition with the aim of improving medical knowledge must be very careful not to cause harm. Consequently, our priorities had to be very clear: safety first, then science, with the summit a distant third, and only in the pursuit of our scientific goals. We stuck to this mantra throughout the expedition and it served us well.

Formal risk management (required for ethical approval) in the mountains was new to most of us. At the outset, we identified the icefall and the summit ridge as the principal hazards. The icefall concerned us because of the



Left 138.
Sundeep Dhillon undergoing a test to measure oxygen consumption during exercise at Everest Base Camp.
(*By courtesy of Caudwell Xtreme Everest*)

139. Paul Gunning passing a gastric tonometer into his stomach in order to measure gut blood flow during exercise.
(*By courtesy of Caudwell Xtreme Everest*)

ever-present objective danger of structural collapse, whereas the summit ridge presented the well-documented risks of overcrowding, queuing and attendant delays in a potentially hostile environment. We planned to traverse the icefall only three times, once for acclimatisation, once for the Western Cwm science and once for a summit attempt, and we were able to achieve this. To minimise the risk of being caught on a congested summit ridge we deliberately waited until most teams had cleared the ridge, risking the possibility that the weather window would close and the summit would become unreachable. When the first teams from other expeditions started heading up to the summit in early May, we descended to Dingboche for food and rest. We returned a week later to find much of the activity past.

Consequently on our first summit day (23 May) we were the only team on the south-east ridge and the second summit team (24 May) shared the ridge with only a handful of other climbers. 24 May was the last day of the 2007 spring season that Everest was climbed from the south. Our strategy worked well, but it was close.

A well-defined leadership structure with clear accountability and frequent effective communication was essential for such a large project. Climbing decisions were discussed by a group of three (MG, SD and CI, *see below*) and all major moves were preceded by team briefings with clear definition of roles and exploration of contingencies. This was unfamiliar ground for most of us, who had grown up on small, less structured, private climbing trips. Nevertheless, all expedition members signed up to the leadership structure before we left the UK and it worked well. One of the criteria for being selected for the summit team was a previous illness-free ascent over 8000 metres, and all of the medical summit climbers had previously climbed Cho Oyu. We stuck to a 'buddy system' above base camp; anyone moving anywhere did so with at least one buddy and always with a radio. Radio schedules were clearly defined and a continuous listening watch was kept from the base camp logistics tent. Our communication plan on summit night was ambitious and the geography of the ridge meant that we were frequently out of direct contact with base camp. The presence of relay facilities at camp 1 on Pumori, courtesy of the BBC team, and at camp 2 in the Western Cwm, minimised the resultant anxiety for those at base camp. We had a predetermined midday turn-around time on summit day. As it turned out conditions were good, we moved briskly and we had everyone back on the South Col before the midday threshold arrived.

On Everest in 2007 we were very fortunate to work with the same core Sherpa team that many of us had climbed with on Cho Oyu in 2006. The bond of affection and trust between the Sherpas, climbing and base camp science and logistics teams was never more evident than at the party to celebrate the descent of the last Sherpas off the mountain. It was probably a good job that most of the other teams had vacated base camp by this time. Without the Sherpas we would not have been able to conduct any of the science above base camp. Our high-altitude Sherpas completed more than 100 carries to the South Col in a round trip from base camp taking only a day and a half. An early start would see them on the Col by late morning with a return to camp 2 by early afternoon, overnight rest, and return to base camp early the next morning. In contrast, the climbers took four days to reach the South Col with substantially lighter loads. We also had the benefit of their climbing experience. Between the Sherpa (81), filming (6) and climbing research (13) teams we had more than one hundred previous ascents over 8000 metres.

Our goal on the summit had been to measure the level of oxygen in the arterial blood of some of our team, in order to make a measurement very close to the limit of human tolerance of hypoxia. We know that the level of hypoxia at the summit of Everest is close to this limit for several reasons. The first 63 successful summiters all used supplementary oxygen; it was nearly 25 years after Hillary and Tenzing's first ascent that Messner and Habeler succeeded in reaching the summit without supplemental oxygen. To this day only about 5 per cent of those who reach the summit of Everest do so without using supplemental oxygen. Even the subtle reduction in barometric pressure that occurs during winter may be enough to make the summit unattainable breathing ambient air except by a very few individuals. Only one individual (a Sherpa) has so far reached the summit under these conditions without supplemental oxygen. Sadly, on the days that we climbed, the conditions on the summit were too cold and windy to make this measurement. However, we did manage to obtain four samples at 8400 metres (27,559ft) and these are the highest arterial samples ever obtained, by a margin of more than 2000 metres. The levels of oxygen in these samples are lower than has previously been measured in humans, and are similar to the lowest levels ever measured in any mammal. Interestingly, the two other comparable values that we have been able to identify have been in diving seals returning to the surface after a long dive and in the human foetus in the uterus. More than 80 years ago the British physiologist Joseph Barcroft first proposed the idea that physiology in an Everest climber would be similar to that occurring in a foetus.

Conclusion

As the handful of commercial operators that go back year-on-year already know, it is possible to manage risk effectively on Everest with a modicum of luck on your side. We owe a huge debt of thanks to the CXE team, our Sherpas, the volunteer trekkers, our sponsors (please see www.xtreme-everest.co.uk) and Jagged Globe who provided our logistical support. We also owe thanks to many of our fellow teams on the mountain. In particular, we found the big commercial operators who run expeditions on the mountain every year to be incredibly helpful and supportive and highly professional in all their conduct. This shouldn't be surprising, but it is in marked contrast to the way these individuals and companies are often portrayed in the media.

2007 was also a year when the AC was well represented on Everest. In addition to the six authors of this article, Simon Lowe, Jim Milledge, Victor Saunders, Henry Todd and Kenton Cool were all on the mountain. At the end of April, in the run-up to the summit attempts, we wondered whether there might be enough AC members at base camp to have a full meeting and change the constitution to pursue more civilised (warmer) goals. Several weeks living in the shadow of the Khumbu icefall can do that to you!

Caudwell Xtreme Everest was a huge team effort that succeeded only because of the combined efforts of all those involved. We returned enormously relieved that the trip was completed without significant harm to those involved. We worked, with other teams, to rescue several sick and injured climbers high on the mountain and collected the data that was the goal of our expedition and which will keep us busy at sea-level for years to come.

As we strolled down the Khumbu valley in early June there was a quiet satisfaction for a job well done, mixed with a relief that it was all over. A year on, the same individuals who said 'never again' are busy putting together plans for the next expedition, with new novel experiments addressing the questions arising from our results; as always in science, new questions arise as old ones are answered.

Team leader Mike Grocott (MG) was assisted in the preparation of this report by climbing leader Sundeep Dhillon (SD), deputy climbing leader Chris Imray (CI), Jeremy Windsor, George Rodway and Graham Hoyland. It is hoped to feature more of the scientific results of the expedition in a future AJ.

140. Circus maximus. Everest Base Camp, spring 2007.
(*By courtesy of Caudwell Xtreme Everest*)

141. In the interests of science – Mike Grocott, Dan Martin and Sundeep Dhillon on the summit of Everest, May 2007. (*By courtesy of Caudwell Xtreme Everest*)

Acknowledgements

Caudwell Xtreme Everest (CXE) is a research project coordinated by the Centre for Altitude, Space and Extreme Environment Medicine, University College, London. The aim of CXE is to conduct research into hypoxia and human performance at high altitude in order to improve understanding of hypoxia in critical illness. Membership, roles and responsibilities of the CXE Research Group can be found at www.caudwell-xtreme-everest.co.uk/team. The research was funded from a variety of sources, none of which are public. The entrepreneur John Caudwell, whose name the expedition carries, donated £500,000 specifically to support the research. BOC Medical, now part of Linde Gas Therapeutics, generously supported the research early on and continues to do so. Lilly Critical Care, The London Clinic (a private hospital), Smiths Medical, Deltex Medical and The Rolex Foundation have also donated money to support the research and logistics. All monies were given as unrestricted grants. Specific research grants were awarded by the UK Intensive Care Foundation, the Association of Anaesthetists of Great Britain and Ireland and the Sir Halley Stewart Trust. The CXE volunteers who trekked to Everest Base Camp also kindly donated to support the research.

The expedition was filmed by BBC Horizon and a two-part documentary was released in autumn 2007 and has since been shown worldwide. Two BBC Radio 4 documentaries were also produced. An IMAX film of which the expedition forms a part is scheduled for release during 2009.