DAN USA Ascent Rate Study  
(Abstract only – work in progress)  
David Vote and Richard Vann

**Key words**
Decompression illness, diving tables, recreational diving, research

**Introduction:** The practice of safe decompression in recreational divers has not been thoroughly studied. Among the important variables are ascent rate, decompression or safety stops, and oxygen breathing underwater to eliminate nitrogen. The purpose of this study was to assess the rate of ascent, independent of other variables. The incidences of decompression illness (DCI) and venous gas embolism (VGE) were compared for ascent rates of 10 fpm (feet of sea water per minute) and 60 fpm after resting no-decompression dives to 100 fsw in a dry recompression chamber.

**Methods:** For the study to provide useful information, some subjects must develop DCI, but the risk of injury must be acceptably small and the injuries easily reversible. For the purposes of the study, we classified DCI as mild, moderate, or serious according to the following definitions:
- **mild:** limb pain, localised abnormal sensation;
- **moderate:** sensory deficit, weakness;
- **serious:** paralysis, difficulty breathing, cerebral dysfunction.

The experimental design was based on acceptance and rejection rules; a dive time would be accepted if there were only ‘a few’ mild DCI incidents but rejected if there were ‘too many’ mild DCI incidents or a single moderate DCI incident.

When a dive time was accepted, three minutes were added to that time. The acceptance and rejection rules were approved by the Institutional Review Board of Duke Medical Center. Acceptance rules were based on a 95% upper binomial confidence limit that the incidence of mild DCI is not greater than 15%. This equates to:
- no mild incidents in 23 trials;
- one mild incident in 35 trials;
- two mild incidents in 46 trials;
- three mild incidents in 56 trials.

Rejection rules were based on a 95% binomial confidence limit that the incidence of mild DCI is not less than 2.5%. This is an arbitrary limit. The purpose of the first rejection rule (below) is to limit exposure to more than mild decompression injury. This equates to:
- one serious incident;
- two moderate incidents in 10 trials;
- three mild incidents in 26 trials;
- four mild incidents.

The depth was chosen at 100 fsw and initial dive bottom time of 15 mins, based on the Canadian Defence (DCIEM) decompression tables. For reference, no-stop limits for other decompression tables are listed in Table 1.

### TABLE 1. COMPARISON OF NO-STOP LIMITS AT 100 FSW (30M) FOR DIFFERENT TABLES

<table>
<thead>
<tr>
<th>Time (mins)</th>
<th>No-stop limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>DCIEM tables;</td>
</tr>
<tr>
<td></td>
<td>Aladin and Monitor dive computers</td>
</tr>
<tr>
<td>19</td>
<td>Datascan2 dive computer</td>
</tr>
<tr>
<td>20</td>
<td>Royal Navy, British Sub-Aqua Club and DSAT tables;</td>
</tr>
<tr>
<td></td>
<td>EDGE and SkinnyDipper computers</td>
</tr>
<tr>
<td>25</td>
<td>1956 US Navy tables</td>
</tr>
<tr>
<td>27</td>
<td>1993 US Navy tables</td>
</tr>
<tr>
<td>30</td>
<td>French Navy tables</td>
</tr>
</tbody>
</table>

**Results:** The fast ascent rate (60 fpm) arm of the trial was rejected at 24 mins because of a severe spinal cord DCI. There had been only one earlier mild case of DCI at 21 mins. The slow ascent rate (10 fpm) arm of the trial was rejected at 30 mins also because of a severe spinal cord DCI. There had been no earlier cases of DCI in this trial arm. The outcomes from the severe cases were favourable, the first subject being asymptomatic post recompression treatment, the latter having only minor neurological sequelae.

**Conclusion:** The results were inconclusive as to which ascent rate had a lower incidence of DCI. Both subjects developing severe spinal cord DCI were subsequently found to have a patent foramen ovale, one demonstrable at rest and the other with a Valsalva manoeuvre. As a result of these events and another in a NASA study, decompression studies at Duke were suspended until 2-D echocardiography became available to evaluate experimental subjects for left ventricular bubbles both after diving and at altitude. All Duke IRB-approved decompression protocols now require recompression of any subject in whom left ventricular bubbles are detected. The study will continue as funding allows with the objective of testing the hypothesis that there is a difference in VGE incidence between the ascent rates of 10 and 60 fpm.

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Dr David AP Vote, MB, BS, FANZCA, DipDHM, was a Fellow (1998–2000) in Diving & Hyperbaric Medicine at Duke University Medical Centre, Durham, North Carolina USA. Currently he is Consultant Anaesthetist at St.Vincent’s Hospital, Melbourne.

**Address for correspondence:**  
Department of Anaesthesia, St.Vincent’s Hospital  
P O Box 2900, Fitzroy, VIC 3065 Australia  
**Phone:** +61-(0)3-9288-2211, **Fax:** +61-(0)3-9288-4255  
**E-mail:** <voted@svhm.org.au>

Dr Richard D Vann PhD is Director of Applied Research,  
Duke University Medical Center for Hyperbaric Medicine and Environmental Physiology, and Research Director, Divers Alert Network, USA.