Post-Flight Chest Discomfort in Aviators:
Aero-Atelectasis

Bureau of Medicine and Surgery
Work Unit MRO05.13-0002.18
Report No. 1

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Prepared by:
Elihu York, LCDR, MC, USN

Approved by:
Carl F. Schmidt, M.D.
Research Director
Aerospace Medical Research Department

Released by:
E. M. Wurzel, CAPT, MC, USN
Director
Aerospace Medical Research Department
Three jet pilots recently flew high G bank maneuvers, while breathing 100% oxygen and wearing anti-G harnesses, as part of an in-flight project for weapons systems development. As a consequence, on more than one occasion, all three pilots experienced shortness of breath, cough, and aching in the chest - this latter symptom persisted as long as 3 hours following flight. Physical examination was unremarkable. Pulmonary function study revealed a reduction in vital capacity, immediately following flight, of 20-28% as compared to pre-flight levels outside the plane. A partial, reversible collapse of lung tissue ("aero-atelectasis") may be the mechanism for the observed finding, which could conceivably contribute to aircraft accidents, if not modified.
TABLE OF CONTENTS

SUMMARY ........................................................................................................... ii
INTRODUCTION .................................................................................................. 1
CURRENT PROBLEM ......................................................................................... 1
SYMPTOMS .......................................................................................................... 1
EXPERIMENTAL PROCEDURE ........................................................................ 2
RESULTS ............................................................................................................... 2
DISCUSSION ......................................................................................................... 6
REFERENCES ....................................................................................................... 7

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Portable Vital Capacity Test Device (&quot;Vitalor&quot;, McKesson Co.) ....................................</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Sample Graph of Pilot WRR, showing results of Vital Capacity measured under 5 conditions</td>
<td>4</td>
</tr>
</tbody>
</table>

LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Respiratory Measurements ....</td>
<td>5</td>
</tr>
</tbody>
</table>
INTRODUCTION

Within the last five years, several authors have published accounts of a post-flight chest syndrome (1, 2, 3, 4). In a number of instances, pilots or aircrew members have complained of a variety of symptoms, particularly chest pain, cough, or difficulty in breathing. Physical examination generally has been unrewarding, although in some instances basilar rales and/or diminished breath sounds have been detected posteriorly. X-ray changes have been more striking, revealing linear or plate-like basilar opacification, consistent with atelectasis. Pulmonary function studies in some instances have revealed decreased vital capacity, increased respiratory rate, and reduction in expiratory reserve volume. A spectrum of findings has been observed in the subjects reported upon: that is, some symptomatic subjects have had X-ray and pulmonary function abnormalities, whereas asymptomatic subjects had X-ray abnormalities only occasionally. In the most severe cases, a common denominator appears to have been the presence of three factors: acceleration exposure, oxygen breathing, and anti-G suit utilization.

CURRENT PROBLEM

Recently, three jet pilots at the Naval Air Development Center, Johnsville, Warminster, Pennsylvania were required to fly "high G" profiles (from +4.0 to +5.0 Gz ("positive") ) for an instrument development project to perfect an automatic pilot for the QF9J aircraft, as part of a program of weapon systems development for the Bureau of Naval Weapons. The pilots were required to fly at an altitude of 15,000 ft., at an average speed of 375 knots, for a total flight time of approximately one and one-half hours, during which they flew alternating 360° bank maneuvers at an average angle of 75°. A typical flight sequence would involve fifteen alternating bank maneuvers, wherein the pilot experienced the high G forces for approximately 45 seconds; following the acceleration exposure, the pilot would fly "straight and level" for approximately two and a half minutes before entering the next bank maneuver. All pilots flew alone in the aircraft, utilizing 100% oxygen from a liquid oxygen generator system, supplied by a Robertshaw-Fulton 17600 series mini-regulator and an A13-A oxygen breathing mask. Each pilot flew the typical flight profile once every three or four days for several weeks.

SYMPTOMS

On numerous occasions during their flying periods, all three pilots experienced a tightening sensation in the mid-precordium, associated with a desire to cough. Frequently, they complained of difficulty in taking a full breath while experiencing the peak acceleration load during the bank maneuver. At the completion of the flights all pilots frequently complained of some residual aching and soreness at the xiphoid area, which would last for two to three hours.
EXPERIMENTAL PROCEDURE

In order to assess the significance of the variable complaints, which did not occur on every flight in every pilot, it was decided to make some simple measurements of pulmonary function in each pilot. Utilizing a McKesson model VC-25 "Vitalor"* (Figure 1) each pilot performed breathing tests before and following one typical high G flight. Following maximum inspiration, a maximum expiration was performed, with recording of vital capacity on special graph paper. Figure 2 is a sample graph showing results of vital capacity measured under five conditions. One-second timed vital capacity and maximum expiratory flow rate were extrapolated from the graph. Thus, three measurements were made with the "Vitalor": a vital capacity (VC), a timed vital capacity after one second (TVC) and a maximum expiratory flow rate (MEFR) (5). The pilot was tested in the following conditions:

1. Sitting upright in pilots' lounge, clothed with flight suit, Z-3 anti-G harness, integrated torso harness, and "hard hat" helmet.

2. Sitting upright on the Martin-Baker ejection seat in the cockpit of the QF9J aircraft, prior to breathing oxygen before takeoff.

3. Sitting in the cockpit, immediately after removal of the oxygen mask post-flight.

4. Within five minutes of the completion of flight, sitting in the cockpit of the plane.

5. Within fifteen minutes of completion of a flight, after walking, then sitting upright with all flight gear on in pilots' lounge.

RESULTS

Table I shows a tabulation of the findings of the three measurements made on the three subject pilots (WRR, AEW, JFW). In Condition 1, each pilot had normal measurements when sitting upright on a chair in the pilots' lounge, fully clothed in all of his flight gear, before takeoff. In Condition 2, however, each pilot had a reduction in his vital capacity, while sitting in the cockpit of the aircraft, prior to breathing oxygen. Immediately following a flight, a measurement was made as soon as the pilot removed his oxygen mask after landing. The results (Condition 3) showed a 21 to 28% reduction in vital capacity from the pre-flight level outside of the plane, and a 13 to 20% reduction from the pre-flight level recorded in the cockpit. Following a deep

* McKesson Appliance Company, Toledo, Ohio
Figure 1. Portable Vital Capacity Test Device ("Vitalor", McKesson Co.).
Figure 2. Sample Graph of Pilot WRR, showing results of vital capacity measured under 5 conditions.
<table>
<thead>
<tr>
<th>Experimental Conditions</th>
<th>Vital Capacity N=100%±10</th>
<th>Timed Vital Capacity 1 sec (normally 80% of total)</th>
<th>Max. Expiratory Flow Rate &gt; 300 Liters/min. (Normal Males)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRR</td>
<td>AEW</td>
<td>JFW</td>
</tr>
<tr>
<td>Normal</td>
<td>4.5</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td>Condition 1 Lounge</td>
<td>5.0</td>
<td>5.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Pre-flight</td>
<td>(111%) (111%) (97%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 2 Plane</td>
<td>4.0</td>
<td>4.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Pre-flight</td>
<td>(89%) (107%) (92%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 3 Plane</td>
<td>3.3</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Post-flight</td>
<td>(72%) (77%) (79%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 4 Plane</td>
<td>4.0</td>
<td>3.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Post-flight</td>
<td>(89%) (87%) (85%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 5 Lounge</td>
<td>4.5</td>
<td>4.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Post-flight</td>
<td>(100%) (98%) (97%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
breath or two, a repeat measurement was made in the cockpit (Condition 4) and improvement in the vital capacity was noted. After walking from the plane to the pilots' lounge, the pilot was re-evaluated while sitting upright wearing all of his flight gear (Condition 5): in all cases, "normal" measurements were obtained in that circumstance. Maximum expiratory flow rates were within normal limits, except for one subject immediately following flight, (Subject WRR, Condition 3) and one subject approximately five minutes following flight (Subject JFW, Condition 4): both of these measurements, however, were very close to the normal range. Timed vital capacities after one second were above 80% of the vital capacity made at the same time, except on one occasion when it was 77% (Condition 2, AEW).

DISCUSSION

All pilots were most reluctant to discuss their discomfort during the actual project: only by a chance remark overheard about "chest soreness and high G profiles" did the author suspect that some measurable physiological change might have occurred, so that each pilot was persuaded to fly the "test" profile on one occasion only, in order to allow a breathing measurement to be made. No pilot experienced difficulty in controlling the aircraft during the "test" profiles flown. The findings which may be of interest are:

1. Wearing flight gear and sitting in the cockpit caused a measurable reduction in the vital capacity in the three pilots concerned.

2. All three pilots had symptoms, both during the flight and immediately following the flight, although no physical abnormalities were noted.

3. Immediately following flight (involving high G stress, 100% oxygen and an anti-G suit) all three pilots had a significant decrease in the vital capacity (P less than 1/125).

"Aero-atelectasis", or the "post-flight" chest syndrome", is most likely to occur in pilots exposed to high G forces, breathing oxygen, and utilizing an anti-G suit (1,2,3). No new information is available about the mechanism, which appears to be a transitory atelectasis (2,3,4). Flight surgeons should be alerted to the possibility of this problem occurring in high-performance jet pilots and aircrew, so that careful assessment of these personnel can be made periodically in an effort to prevent accidents. Although there were no serious consequences with the three pilots during their recently-completed project; nevertheless, should they have flown for more prolonged periods, or more frequently, the very real possibility of "an accident waiting to happen" cannot be dismissed. Furthermore, the use of a simple portable pulmonary function machine, which the author and others (5) have found to be a most helpful adjunct in the clinical assessment of cardiopulmonary complaints can serve as a useful test device for the flight surgeon stationed far from sophisticated pulmonary physiology facilities.
REFERENCES


Three jet pilots recently flew high G bank maneuvers, while breathing 100% oxygen and wearing anti-G harnesses, as part of an in-flight project for weapons systems development. As a consequence, on more than one occasion, all three pilots experienced shortness of breath, cough, and aching in the chest—this latter symptom persisted as long as 3 hours following flight. Physical examination was unremarkable. Pulmonary function study revealed a reduction in vital capacity, immediately following flight, of 20-28% as compared to pre-flight levels outside the plane. A partial, reversible collapse of lung tissue ("aero-atelectasis") may be the mechanism for the observed finding, which could conceivably contribute to aircraft accidents, if not modified.
### KEY WORDS

<table>
<thead>
<tr>
<th>Link A</th>
<th>Link B</th>
<th>Link C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROLE</td>
<td>WT</td>
<td>ROLE</td>
</tr>
</tbody>
</table>

1. High G Profile
2. Atelectasis
3. Post-flight Chest Discomfort

---

**INSTRUCTIONS**

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (corporate author) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether “Restricted Data” is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. Give the inclusive dates when a specific reporting period is covered.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Indicate whether the report was furnished to the Office of Technical Services, Department of Commerce, for sale to the public. Indicate this fact and enter the price, if known.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (either by the originator or by the sponsor), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

   (1) "Qualified requesters may obtain copies of this report from DDC."

   (2) "Foreign announcement and dissemination of this report by DDC is not authorized."

   (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through "

   (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through "

   (5) "All distribution of this report is controlled. Qualified DDC users shall request through "

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (paying for) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report. Even though it may also appear elsewhere in the body of the technical report, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.