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Photogrammetry Is Many Things

The avoidance, symptoms, and alleviation of the more common medical problems that may arise from aerial photographic missions.

"'The time has come,' the walrus said, 'to talk of many things—of shoes and ships and sealing wax, of cabbages and kings, and why the sea is boiling hot, and whether pigs have wings.'" (from *Through the Looking Glass)*

Abstract: *Some of the common physical problems that can arise on data collecting aerial missions for photogrammetry are dealt with. Such subjects as eating habits, middle ear problems, decompression sickness, hypoxia, hyperventilation, scuba diving, and sickle cell anemia are covered; and some suggestions for preventive measures that may be of value to personnel engaged in flying are offered.*

Photogrammetry evolved after the walrus spoke, but photogrammetry speaks of many things and one of these is the acquisition of photographic data. Although great achievements have been made in photogrammetry in the past decade, the heart of the science of photogrammetry is still the aerial photograph, without which photogrammetry would not exist. One of our greatest weaknesses, up to this time, has been the lack of significance placed on the physical well-being of the flight crew. The health of flight crews, with which we must be concerned, becomes a matter of prime importance when one realizes that a well-tuned flight crew will produce optimum results, whereas even one member of a flight crew who does not feel up to par will degrade the whole mission. Little has been reported with regard to the physical needs of pilots and photographers engaged in photogrammetry, and usually all that is required is a medical clearance as to their fitness to fly.

The authors have made a study of many of the potential problems arising from high altitude flight, particularly in unpressurized aircraft. The following findings, although not intended to be a bible for flight crews, are reported in order to alert crew members to some of the potential hazards that can be averted by following the simple procedures outlined. To have a person die or become confined to a wheel-chair for the rest of his life due to ignorance is totally unforgivable. It behooves all of us who are responsible for the acquisition of data to know that our personnel are informed of the necessary steps to take to avoid a tragedy. There will, of course, be some flight crew members who will not be concerned with their own safety and, consequently, will be a burden on other members of the crew. But if the crew knows what to do in time of crisis, a real disaster can be avoided. It is with this hope in mind that this information is presented.

Eating Habits

A well-balanced diet is, of course, a requirement to maintain good health, but certain foods should not be eaten for 24 hours prior to a flight mission. These foods may create gas that can be trapped, especially in the lower intestines and the abdominal area. At an altitude of 18,000 feet, the atmospheric pressure is one-half that of sea level and will cause gas to expand to twice its volume (Ta-

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TABLE 1. STANDARD ATMOSPHERE

Altitude feet	Pressure barometric	Temperature F.	C.
Sea Level	29.92	59	15
1,000	28.86	55	13
2,000	27.82	52	11
3,000	26.81	48	9
4,000	25.84	45	7
5,000	24.89	41	5
6,000	23.98	38	3
7,000	23.09	34	1
8,000	22.22	31	−1
9,000	21.38	27	−3
10,000	20.58	23	−5
11,000	19.79	20	−7
12,000	19.03	16	−9
13,000	18.29	13	−11
14,000	17.57	9	−13
15,000	16.88	6	−15
16,000	16.21	2	−17
17,000	15.56	−2	−19
18,000	14.94	−5	−21
19,000	14.33	−9	−23
20,000	13.75	−12	−25
21,000	13.18	−16	−27
22,000	12.63	−20	−29
23,000	12.10	−23	−31
24,000	11.59	−27	−33
25,000	11.10	−30	−35
26,000	10.62	−34	−37
27,000	10.16	−37	−39
28,000	9.72	−41	−41
29,000	9.29	−44	−43
30,000	8.88	−48	−44
31,000	8.48	−52	−46
32,000	8.10	−55	−48
33,000	7.73	−59	−50
34,000	7.38	−62	−52
35,000	7.04	−66	−54

ble 1). At 35,000 feet, the atmospheric pressure is one-fourth that of sea level, causing gas to expand to four times its volume. To someone with ulcers, this could be fatal as the ulceration on the walls of the stomach can cause the stomach to rupture. Persons with a hernia or any other known abdominal disorders should be extremely careful with their diets. It is almost impossible to say what foods will cause gas in a particular person, and while each person will have to determine for himself what foods should be avoided, some of the most common foods known to cause gas are—

Anchovies	Cucumbers
Apples, fresh	Eggplant, fried
Asparagus	Garlic
Beans, baked	Green peppers
Beans, green	Horseradish
Beans, kidney	Lettuce
Beans, lima	Liver, fried
Beans, navy	Liver, sausage
Bean soup	Lobster
Beef, corned, hash	Milk
Broccoli	Onions
Brussels sprouts	Oysters
Buttermilk	Pears, fresh
Cabbage, raw	Peas
Cabbage, cooked	Peppers
Cantaloupe	Radishes
Cauliflower	Sauerkraut
Chicken livers	Sausage
Clams	Turnips
Crab	

ALL FRIED FOODS, highly spiced foods, carbonated beverages, shell fish, foods high in fat, and foods hard to digest.

This, of course, is not a complete list, and anyone who suffers from gas pains should consult a flight surgeon. The consumption of excessively large meals is to be avoided since some of the food will decompose and ferment, some bloating will follow, and the bowels will become filled with gas. Smaller meals eaten more frequently are recommended, as this will tend to help minimize the amount of gas created. Other factors that can cause gas are apprehension, emotional stress, and fatigue.

THE MIDDLE EAR

When the atmospheric pressure is different from pressure in the middle ear cavity, severe pain can be expected. This is known by the medical term "Otitic Barotrauma." Middle ear blockage can be caused by a number of unrelated problems: a simple head cold, too rapid a descent from high altitudes, sinus congestion, infections, etc. Although middle ear blockage can develop during climb to altitude, it is very rare. Gases in the middle ear expand while the aircraft is climbing, but will normally escape through the eustachian tube, thus releasing the pressure. However, on descent the gas will compress and cause the eustachian tube orifice to close, thereby trapping the gas within the ear. The results of this can vary from mild discomfort to the rupture and internal bleeding of the ear and to a permanent loss of hearing. The necessity to ventilate the ear at these times cannot be stressed too strongly. Normally, the middle ear can be ventilated by a few simple exercises: yawning, swallowing, or holding the nose and mouth closed and trying to exhale (valsalva). These usually will equalize pressure and cause the ear to "open." If this is not done periodically during descent, the eustachian tube orifice may close because of lower air pressure. If this happens the problem can at times be corrected by climbing to a higher altitude and clearing the ears, and then making a more gradual descent while continuing to keep the ears open by muscular exercise. Also, the use of a nasal inhaler will at times help to keep the ears open. It is interesting to note that ear blockage begins to occur more often when the aircraft reaches and then goes below the 15,000-foot altitude. Under no circumstances (except emergency), should the aircraft (especially unpressurized aircraft) descend from altitude without notifying each member of the crew that descent is about to begin.

A delayed form of "Otitic Barotrauma" may sometimes occur after long flights on which 100 percent oxygen was used. The use of 100 percent oxygen tends to increase the oxygen concentration in the middle ear. After landing, this oxygen will gradually be absorbed by a membrane within the middle ear, causing the eustachian tube to close because of the lower internal air pressure. This reaction typically occurs when a crewmember has gone to sleep immediately after a flight. When asleep the rate of swallowing and, thus, the rate of ventilation of the middle ear is one-fifth the rate when awake. Also, a horizontal or head-down position increases the difficulty of middle ear ventilation. The pain associated with oxygen absorption, Otitic Barotrauma, will normally disappear in a few hours and is usually only a mild discomfort.

Decompression Sickness

Decompression sickness or "dysbarism" of flying personnel is a unique syndrome resulting from a reduction of ground level atmospheric pressure to subatmospheric pressure caused by ascent in an aircraft (Table 1). Decompression sickness can manifest itself in a variety of different symptoms, including the bends, a deep-seated pain in the region of a limb joint; the chokes, a pain or soreness behind the sternum, developing into a convulsive cough which limits aspiration and may cause air hunger and collapse (it is a serious symptom); tingling or itching of the skin; mottling of the skin; various afflictions of the nervous system including vision disturbances, weakness, paralysis and numbness, and/or vague tingling of a limb; neurocirculatory collapse which consists of anxiety, cold and clammy sweat on the brow and palms, nausea, and unconsciousness; and severe lower abdominal pain.

The only common links between symptoms appear to be—

- Their initiation under similar environmental conditions, and
- Their prevention by a single maneuver, the removal of nitrogen from the body.

A number of factors contribute to the onset of decompression sickness:

- Individual susceptibility.
- Altitude,
- Duration at altitude,
- Exercise at altitude,
- Overweight condition,
- Age,
- Cold temperature,
- Time of day,
- Fatigue,
- Alcohol overindulgence, particularly with a hangover, and
- Heavy salt or potassium intake.

Altitude has a great effect on decompression sickness. The incidence of decompression sickness below 18,000 feet is negligible; however, the incidence increases both with increasing altitude and with time spent at that altitude. There is no question that the longer the time spent at altitude, the greater the chance of decompression sickness.

Heavy exercise during and after a flight at altitude will increase the possibility of decompression sickness, as may heavy exercise before a flight to altitude. The mechanism causing this increase in susceptibility is not completely understood; it may result from an increased release of nitrogen into the bloodstream or it may result from increased production of CO_2. It is sufficient to know that unnecessary exercise above 18,000 feet MSL is to be avoided, as is heavy exercise on the ground for up to 12 hours after flying above 18,000 feet MSL.

An obese condition will greatly increase the chances of decompression sickness. Fat tissue will store more nitrogen and release it more slowly than other tissue. It is believed that this increases the possibility of decompression sickness. A person may be susceptible to decompression sickness because of a large amount of body fat even though he is not overweight according to the height/weight tables. The actual amount of body fat should be determined by a specific gravity analysis, but is quite difficult to determine accurately. Age may also contribute to decompression sickness. However, since the natural tendency is for an individual to become heavier as he becomes older, it may be the additional weight which causes the increased susceptibility.

Cold temperatures also may result in an increased susceptibility. A change in blood flow caused by the cold may be responsible, or the shivering caused by the cold may duplicate the effects of exercise and increase the possibilities of decompression sickness. The time of day seems to be a factor in decompression sickness. Individuals are more susceptible in the morning than they are in the afternoon or evening. Clamann speculates that this may result from the fact that the metabolism is lower in the morning (Randal, 1971).

The overuse of alcohol, with the resulting hangover, also contributes to the possibility of decompression sickness. The body cannot properly combat the effects of decompression sickness when it is fatigued.

Precautions recommended to avoid decompression sickness are—

(1) Prebreathe 100 percent O_2 for 1 hour prior to flights over 18,000 feet MSL and for 1 1/2 hours prior to flights over 25,000 feet MSL. The prebreathing may be done at any altitude below 12,000 feet MSL as long as the prebreathing is completed before ascending to the higher altitude. Prebreathing must be continuous; any interruption invalidates the prebreathing. Continue breathing 100 percent 0_2 at altitude.

(2) Insure that the oxygen mask fits properly. It may be necessary to be clean shaven to assure a good mask fit. The benefits of prebreathing are lost if the mask leaks and nitrogen contaminates the 100 percent O_2. Complete a PRICE check on the O_2 system before ascending to altitude. The elastic straps holding the mask may allow the mask to leak. Try to keep them as tight as possible.

(3) Be well rested prior to flying. Do not consume alcohol within 10 to 12 hours of the flight and do not fly with a hangover.

(4) Avoid heavy exercise prior to, during, and for 12 hours after a flight.

(5) Avoid being overweight.

(6) Stay as warm as possible; avoid staying in a cramped position if it is possible to move. Stand up between flight lines to avoid cramps and to get out of the cold air stream.

(7) Do not drink carbonated beverages immediately before and during flights over 18,000 feet MSL. Also keep salt and potassium intake low.

If an individual has a form of decompression sickness, the time should be noted and descent should be initiated as soon as possible. The individual should continue breathing 100 percent O_2 and after landing should use a walk-around bottle to maintain breathing of 100 percent O_2. He should be taken to the nearest flight surgeon for examination immediately after landing. This procedure should be followed even if the symptoms have been relieved during descent.

Should the symptoms of decompression sickness not be relieved by the time the aircraft has landed, every effort should be made to get the individual into a recompression chamber as soon as possible. It is particularly important that anyone with continuing central nervous system symptoms be recompressed immediately. Permanent damage can result if this is not done. The individual should be kept under observation for 8 to 12 hours after the incident, even though the flight surgeon may have released him. This will provide a safety factor in case of post decompression collapse. This syndrome occurs in very few cases. The vast majority of persons who develop symptoms experience complete relief upon descent and few have a persistence of discomfort or disability on reaching ground level conditions. An even smaller number have been found to exhibit worsening of their condition or the development of a new syndrome subsequently.

If the individual is incapacitated by the decompression sickness, he should be placed in a prone position, continue to receive 100 percent O_2, and should be kept warm.

It is sometimes difficult to differentiate between the symptoms of a simple case of the bends and a muscle cramp. If an individual cannot determine whether he has a cramp or a bend, he should get up and move around to relieve possible tension or cramping in the joint. DO NOT EXERCISE THE JOINT! - merely move it about easily. If, after 15 minutes, the symptoms are still present, descent should be initiated and the previously discussed procedure put into effect.

All crewmembers should be assigned the responsibility of closely observing another crewmember who has complained of symptoms of decompression sickness. Insure that the individual does not panic; watch for hyperventilation and watch for any additional symptoms of decompression sickness. Also, any crewmember who appears to be asleep should be awakened as he may be unconscious from decompression sickness.

The most serious form of decompression sickness involves the central nervous system. Fortunately, the great majority of central nervous system problems are post decompression phenomena, and central nervous system disturbances at altitude are almost entirely visual or simple numbness and weakness. A simple case of the bends is unlikely to cause permanent damage. Also, bends are not accumulative; if an individual has a case of the bends, there is no reason to think that he is now more susceptible to them. Also, if the bends do occur again, there is no reason to believe that the bends will be any more severe simply because he has had a prior case.

Very little is known about the causes of decompression sickness. At present there is a method of dealing with the symptoms of decompression sickness (recompression, using 100 percent O_2, if necessary) and a method of preventing decompression sickness (denitrogenation, using 100 percent O_2). Fortunately, the majority of decompression sickness symptoms (the bends) are minor in nature and almost immediately disappear on descent. However, this is no reason to minimize the seriousness of the disease. If the symptoms are ignored, they can increase in intensity and scope, and serious consequences may occur.

Bone necrosis (disintegration of the bone) is an unknown factor in persons in the field of aviation. Bone necrosis is a problem which shows up several years after the individual has been subjected to pressure changes. At present the development of this disease is poorly understood. Nearly all the literature on this subject refers to the fields of compressed air (caisson) and diving operations. Very little is known about the effects of the smaller pressure changes encountered in flying with regard to bone necrosis.

Should any advice be needed, a phone call to the USAF School of Aerospace Medicine, Brooks AFB, (512) 536-3278, can supply information about treatment of decompression sickness and the location of the nearest recompression chamber. This number is manned 24 hours a day.

Scuba Diving

Under the increased pressure of water, excessive nitrogen is absorbed in the body when diving with scuba equipment; even shallow dives to 6 feet can bring on a case of the bends. Consequently, a minimum of 12 hours should elapse after diving before any flights are made. Even flights at the relatively low altitude of 10,000 feet should not be attempted. Also, prolonged swimming after a high altitude flight should be avoided as the over-exercising of the muscles during swimming may cause a form of decompression sickness.

Hypoxia

Hypoxia is a general term defined as a lack of oxygen reaching the body tissues. Body tissue, particularly brain tissue, does not function properly when oxygen is present in less than normal amounts.

Hyperventilation

Hyperventilation is abnormally fast or excessively deep breathing which causes a lack of carbon dioxide in the blood. This lack of carbon dioxide may cause several different and dangerous symptoms. Hyperventilation may be caused by any of the following: (1) anxiety or fear, (2) pressure breathing, (3) heat exposure, or (4) acute hypoxia.

Symptoms and Treatment of Hypoxia and Hyperventilation

Hypoxia and hyperventilation are particularly dangerous because the brain is not functioning effectively and does not realize there is a problem. Both of these conditions may impaire an individual's judgment, cause muscular incoordination, or even cause the individual to lose consciousness, thus endangering the lives of the entire crew. Table 2 gives a comparison of the symptoms of hypoxia experienced at 25,000 feet and hyperventilation caused by pressure breathing. The symptoms are nearly identical in most cases. This is reasonable when it is considered that the first reaction to hypoxia is hyperventilation, i.e., an increase in respiration rate and depth. This makes it extremely difficult to differentiate between the two conditions. Fortunately, the same treatment is effective for both hypoxia and hyperventilation:

(1) Insure that the oxygen regulator is on, that it is set to 100 percent oxygen, and that it is on emergency (pressure) if these settings are available;
(2) Breathe normally;
(3) Check the oxygen equipment, particularly all connections and the face mask seal; and
(4) Begin descent to below 10,000 feet if possible.

If no improvement is noted within 2 to 3 minutes, change the regulator from its emergency position back to normal and continue breathing 100 percent oxygen for 20 to 30 minutes. This treatment will provide the correct treatment for hypoxia, hyperventilation, and carbon monoxide poisoning. Under no circumstances should anyone who believes that he has hyperventilated hold his breath since this action may cause cardiac arrest and result in sudden loss of consciousness. On rare occasions, a person suffering from hypoxia will have a reversed reaction to oxygen and pass out. If this happens, continue the preceding treatment and take the individual to a flight surgeon as soon as possible.

Table 2. Comparison of Symptoms of Hypoxia and Hyperventilation

Symptom	Frequency of Symptom in Percent	
	Hypoxia (183 Subjects)	Hyperventilation (165 Subjects)
Dizziness	56.8	72.8
Tingling	37.1	61.3
Hot or cold flashes	17.5	15.8
Euphoria	18.6	7.9
Lightheadedness	49.1	64.2
Far away feeling	21.3	24.9
Fatigue	14.7	16.3
Sleepiness	12.5	3.0
Visual disturbances	62.4	33.2
Numbness	20.8	23.0
Apprehension	19.2	1.2
Inability to think clearly	41.5	27.2
Cyanosis	26.3	1.2
Muscular tremor or twitching	8.2	10.3
Tetany	1.6	6.7
Muscular incoordination	36.6	27.9
Sweating	14.7	15.7
Dyspnea	13.6	12.1
Unsteadiness	20.2	23.0
Tightness around head or chest	3.3	10.3
Feeling of warmth in face	14.7	14.6
Headache	5.5	8.5

Sickle Cell Anemia

Reduced oxygen on high altitude flights can be very dangerous to persons suffering from sickle cell diseases, and anyone having this problem should be very cautious in entering flight programs. These individuals should make the disease known to the flight surgeon, as not all sickle cell diseases are equal in intensity and some individuals may qualify for flight duty. In persons with sickle cell anemia, the normal hemoglobin A may be completely absent with just hemoglobin S present. In these cases even a small reduction of oxygen in the blood system can cause sickling which may result in a very serious case of hypoxia.

Conclusion

No attempt has been made by the authors to cover all medical problems that can arise in flying, nor has any attempt been made to cover thoroughly all aspects of the subjects discussed. The intention of this paper is simply to call attention to some of the more common medical problems that may arise from flight. A short bibliography is presented for those wishing further information. However, the authors would like to point out that no amount of reading by the layman is a substitute for direct consultation with a physician who specializes in flight medicine.

Glossary

Anoxia
Without oxygen.

Barometric Pressure
Atmospheric pressure.
29.92 inches Hg is standard.

Barotrauma
The expansion or contraction of trapped gasses. Imbalance in pressure between ambient air and air in the middle ear.

Dysbarism
Resulting from exposure to decreasing or changing barometric pressure. A general term that includes all physiologic effects (with the exception of hypoxia) resulting from changes in barometric pressure.

Eustachian Tube
The canal between the middle ear and the pharynx.

Hemoglobin
The red coloring matter of the red blood.

Hypocania
An abnormally low tension of carbon dioxide in the blood.

Hypoxia
State in which oxygen is reduced in quantity from the normal.

Membrane
A very thin pliable tissue.

Metabolism
The energy yielding process that transforms food into protoplasm.

Otitic
Pertaining to the ear.

Sickle Cell Disease
The red blood cell assumes a crescent or sickle shape when oxygen is reduced.

Sternum
The breast bone.

Tetany
Intermittent spasms usually caused by a defective metabolism.

Tympanic
A part of the eardrum.

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