



The History of Aerospace Medicine

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“History teaches us that man
learns nothing from history.”

GF Hegel, *historian*



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To be fair, Hegel was the originator of the philosophical method known as the dialectic – he presented a thesis, an antithesis and felt that reality was somewhere in between, a synthesis if you will. So this statement is something of an antithesis; the thesis to this would be that history teaches us that man learns everything there is to be learned from history and reality (synthesis) is we should learn some things from history. Whether we do or not is beyond the scope of this paper. But in the context of aerospace medicine, there is much to be learned from our history. First of all, let's define what aerospace medicine is.

What is aerospace medicine?

- **Aviation medicine**, also called **flight medicine** or **aerospace medicine**, is a preventive or occupational medicine in which the patients/subjects are pilots, aircrews, or *persons involved in spaceflight*. The specialty strives to treat or prevent conditions to which aircrews are particularly susceptible, applies medical knowledge to the human factors in aviation and is thus a critical component of aviation safety. A military practitioner of aviation medicine may be called a flight surgeon and a civilian practitioner is an aviation medical examiner.

I would quibble that we have restricted the discussion of other occupants to those involved in space flight. We have a role with others as well, just limited.

Conditions pertains to the aerospace environment and associated effects of moving through that environment. That environment, with all the potential dangers of decreased pressure, temperature, oxygen, increased or decreased g forces, etc....What happens to the normal human in this abnormal environment we weren't specifically designed for? How do we as medics come up with protection or engineering or operational controls to help with performance and survivability in this hostile environment?

Human factors in aviation is a broad term – the construct I would emphasize is that we are interested in the human – machine interface, with plenty of emphasis on the human side.... So, the aerospace platform and how we interact with it and, particularly for us as medics, if that platform crashes, how do we survive it? What caused it, but how do we minimize injury and death? Again, both engineering and operational considerations.

Crash Survivability

- Energy
- Survivable Space
- Restraint
- Pre and Post Crash Factors

As we review crash survivability factors, there are four key elements to keep in mind? 1) Were the crash forces innately survivable for the human being – we have structural limitations with sudden deceleration. In that context, did the vehicle itself have energy absorption mechanisms to prevent the sudden energy changes from being transmitted to the human? 2) Was there survivable space inside the vehicle? If the forces are such that the vehicle is totally crushed, then there is no survivable space – this again relates to the energy absorption capacity of the vehicle 3) Is there adequate safe restraint for the human inside that survivable space? 4) Pre- and post-crash survival factors – fire? Water? Toxic gases? Remote settings with temperature or shelter issues? Food and water? Dangerous factors of nature? Training and last but not least – the pre crash factor of the most survivable crash is the one that never happens.....

**“REGULATIONS ARE WRITTEN
IN BLOOD”**

**We work backwards in all this:
first the crash, then we try to
figure out how the airman
could have survived it, to
include, could the crash have
been prevented in the first
place.**

The First Aircraft Mishap



Herbert Draper

The story of Icarus

Daedalus fashioned two pairs of wings out of wax and feathers for himself and his son. Before they took off from the island, Daedalus warned his son not to fly too close to the sun, nor too close to the sea. Overcome by the giddiness that flying lent him, Icarus soared through the sky curiously, but in the process he came too close to the sun, which melted the wax. Icarus kept flapping his wings but soon realized that he had no feathers left and that he was only flapping his bare arms. And so, Icarus fell into the sea in the area which bears his name, the Icarian Sea near Icaria, an island southwest of Samos. [It also has been said he flew too close to the sea and the feathers got wet, no longer working due to added weight.

So, what if you were Icarus's flight surgeon? What factors would you focus on for the mishap board? The environment – the abnormal heat, certainly, but what about the giddiness? Might there have been an element of hypoxia? Or was Icarus mentally unstable to begin with? What about the human-flying machine interface? Were there egress possibilities? How could the platform have been constructed to prevent the crash or make the crash at least survivable? Might there have been some life support equipment that would have been useful? Were there training factors?

Historical Question Style

1. The first practicing flight surgeon was:
 - A. Harry Armstrong
 - B. Robert Hampton
 - C. Hubertus Strughold
 - D. Louis Bauer
2. Otto Lilienthal made his contribution to aviation in:
 - A. Balloons
 - B. Blimps
 - C. Gliders
3. The first mammal in space was:
 - A. Ham
 - B. Gagarin
 - C. Able
 - D. Laika

1. Paul Bert	A. Headed Germany's Air Force Institute for Aviation Medicine, also called the Father of Space Medicine
2. Louis Bauer	B. First Medical Director of the Aeronautical Branch of the Department of Commerce
3. JAC Charles	C. Director of the United States Aeromedical Research Laboratory
4. Hubertus Strughold	D. Flight surgeon who jumped at 40,200 feet (1943) to test high altitude opening shock attributes, experienced 40g
5. Thomas Selfridge	E. French physicist who used hydrogen to inflate balloons for use in aviation
6. John Paul Stapp	F. First known physician fatality in aviation
7. Charles Berry	G. Died of injuries sustained in a crash with O Wright, 1908
8. Harry G Armstrong	H. The first non-mythical aerial mishap investigation
9. Pilatre de Rozier	I. 1944 physician fatality in high altitude bailout testing
10. W Randolph Lovelace	J. Astronaut's Chief Physician, Gemini and Apollo series
11. Mel Boynton	K. The highest step in the world
12. Joseph Kittinger	L. French politician and Father of Aviation Medicine
13. A sheep, a cock, and a duck	M. The "fastest man in the world"

Pilatre de Rozier

- A. de Rozier's hybrid balloon set the early altitude records for ballooning.
- B. His work with superheated hydrogen earned him an important place in the history of the development of the hydrogen bomb
- C. de Rozier and his passenger became the first ballooning fatalities

For example: JAC Charles, who developed Charles' Law that the volume of a gas is directly proportional to the temperature, was also an avid balloonist. He developed a technique for generating hydrogen gas to fill a balloon, thus giving it lift. His contemporaries, the Montgolfiers, developed a technique using heated air to fill the balloon, which also gave it lift. Their brilliant and adventurous physician friend, Pilatre de Rozier, developed a hybrid mechanism to capture maximum lift. This technique involved heating the hydrogen. The spectacular result was that (pick the best answer):

A Sheep, A Cock, and A Duck

- A. The cage created an asymmetric balance problem which triggered in-flight turbulence. Thereafter, aeronautical design paid a good deal more attention to symmetry.
- B. Inadequate aircrew protection. The cool temperatures and perhaps hypoxia contributed aberrant behavior among the aircrew.
- C. Poor CRM (in this case, cockpit resource management); highlighted by difficulty in communications.
- D. The sheep was observed kicking the cock prior to actual takeoff.

The Montgolfier brothers launched another hot air balloon with a famed royal audience at Versailles – King Louis XVI and his wife Marie Antoinette. The King would not allow manned flight as he feared someone might be hurt but he did permit the Montgolfiers to attach a wicker cage to the balloon. The cage contained a sheep, a cock, and a duck (de Rozier was one of the investigators). The balloon ascended to a height of 518 meters, before gradually descending to earth. When they reached the balloon, the enthusiasts found that the cock had significant damage to his wing. This triggered perhaps the first mishap investigation. The chief finding was that:

Col W. Randolph Lovelace

- A. Safer to descend to a lower altitude before opening the parachute.
- B. Mandatory to develop a two phased parachute – one for high altitude that allowed a higher degree of slip to minimize opening shock, and one to open on lower altitude to minimize force of ground impact.
- C. Important to develop a g absorption mechanism to reduce these high g forces at opening shock.
- D. Important to develop better gear for thermal protection for high altitude jumps

In 1943, US Army Air Corps Flight Surgeon Col W Randolph Lovelace bailed out from 40, 200 feet and immediately opened his parachute to test whether or not the opening shock would be considerably more forceful than at lower altitude. It was – he experienced about 40g and was rendered unconscious. The temperature was - 50F. The shock tore the thick outer gloves from both hands and the thin inner glove from the left hand, which froze, but the bailout oxygen bottle he was testing continued to function. This plus other live human experiments that followed proved that if it were essential to bail out at high altitude it would be: (pick the best answer)

Col Mel Boynton

- A. Live-testing for high altitude escape was suspended for several years
- B. The HALO concept was abandoned
- C. This perpetuated the thought that pre-flight training was essential for these kinds of missions and the effort in this area was greatly increased.

In 1944 US Army Air Corps Flight Surgeon Col Mel Boynton performed a parachute test jump to test free fall descent to a lower altitude before opening the parachute. He jumped from 41,000 feet but did not survive. Although an automatic opening device had been developed, he refused to use it because it was thought there would not be any such device available to actual air crews in the event they had to use it. Although there were some other technical problems, it appeared his judgment was faulty – it appeared he was looking at his stopwatch when he crashed into the earth. He made no attempt to pull the rip cord. As a result of this: (pick the best answer)

Paul Bert

- A. Acute altitude sickness overcame both of them, but Tissandier seemed less vulnerable to this.
- B. Hypothermia
- C. At this altitude, oxygen alone was not sufficiently protective.
- D. They ran out of oxygen

Paul Bert, 19th century French politician (he sat at the extreme left of the French Assembly) , is sometimes known as the first practicing flight surgeon, and is also called the Father of Aviation Medicine. He developed and tested altitude chambers rather extensively. He is credited for discovering the causes of altitude sickness, oxygen poisoning, and the bends. As ballooning and the quest to go higher evolved, he was instrumental in equipping and training some of these early aeronauts. In 1874, his friends Croce-Spinelli and Sivel carried supplemental oxygen with them on their high-altitude flight. They noted, however, that Bert's altitude chamber missed one important feature – the cold temperatures. In April, 1875, they and one other friend, Tissandier, set out to go even higher. Against Bert's advice, they ascended to 29,000 feet in a helium balloon over India. Only Tissandier survived. The reason they died was because: (pick the best answer)

Thomas Selfridge

- A. Had he been wearing protective headgear he likely would have survived. Thereafter US Army pilots wore heavy headgear similar to early football helmets.
- B. The material used in the design of the propeller lacked sufficient strength for extended flying times and therefore had to be changed.
- C. The emergency medical response was inadequate. Thereafter all test flying was to be done with full emergency medical response on site.
- D. Flying is inherently dangerous, and Selfridge had let himself go. Only military men in the finest of physical condition should attempt to fly in the future.

Thomas Selfridge was the first aviation fatality in the United States. He graduated from the US Military Academy at West Point in 1903 – the same year as Douglas MacArthur.

On Sept 17, 2008 he was flying with Orville Wright in a Wright Flyer they were demonstrating for the US Army. A propeller broke which lead to further problems and the aircraft crashed nose down. Orville sustained serious but recoverable injuries; Selfridge's head crashed into one of the wooden uprights of the framework and his skull was fractured. He died later that evening. The review of the crash concluded that (pick the best answer):

Evolution of Physical Standards

- A. The first flaw in this system showed up in 1911 when a glider pilot crashed following an epileptic seizure in flight.
- B. The Germans were the first to set up physical standards and establish an Air Force Medical Service with special examinations, periodic re-examinations and psychological tests for their pilot candidates.
- C. In 1914, the US Army Surgeon General came up with an official version of physical standards for aviators, taken arbitrarily from a physiology textbook. After 8 months of trial, no one had been able to pass so the standards were lowered, again arbitrarily.
- D. All of the above.

In 1907, when the Army got its first airplane, the pilot's physical standards were the same for everybody entering military service. He was to have no detectable disease, be physically strong and able to endure the discomfort and hardship associated with flying the fragile open-cockpit aircraft. Over the next decade this changed substantially. Which of the following statements are true:

Hubertus Strughold

- A. He became the first and only Professor of Space Medicine at the US School of Aviation Medicine (Precursor to USAFSAM)
- B. In 1951, he authored the classic paper, "Where does space begin?"
- C. Dr. Strughold was later linked by documents from the Nuremberg War Crimes Tribunal to medical experiments (including pressure chamber experiments) involving torture and death that were conducted on inmates of the Dachau Concentration Camp. Many of the honors bestowed upon him were taken away as a result of this.
- D. A and B only
- E. All of the above

Hubertus Strughold was a famous early pioneer in the field of space medicine and he is often called the Father of Space Medicine. He was the head of Germany's Air Force Institute for Aviation Medicine during World War II. After the war he was brought to the United States as part of Operation Paperclip. He was instrumental in the development of the pressure suit worn by early American astronauts. Which of the following are true?:

Harry G Armstrong

- A. The altitude at which the ambient pressure for the unprotected human body attains the equivalent of a vacuum.
- B. An effective altitude of 43,000 feet.
- C. Barometric pressure is 47 mm Hg.
- D. The altitude at which ebullism occurs
- E. A, C, and D are correct.

Harry G Armstrong applied his medical and aviation knowledge to the improvement of aircrew protection from temperature extremes and the lack of oxygen in the high altitude environment. Incidentally, he was the first doctor to make a parachute jump – he did so to make a professional assessment of possible associated physiological and psychological problems. He later wrote, “So I made the jump and wrote it up. I told them nothing really happens except it really scares the hell out of you.” He served as the long time director of the US Aeromedical Research Laboratory. He is sometimes also called the Father of Space Medicine. The Armstrong Limit is named for him. This represents (pick the best answer):

Louis H Bauer

- A. Waivers for standards might be granted after thorough examination by experienced, well-trained aviation medical examiners.
- B. Waivers to standards were not a medical decision; therefore, should only be granted by operational aviation managers.
- C. In the case of trained, experienced flyers, the Secretary of Commerce could grant waivers for physical defects designated as disqualifying by the regulations when in the Secretary's opinion the experience of the pilot would compensate for the defect.
- D. None of the above.

Louis H Bauer (also spelled Lewis Bauer), was the first commandant of the Army School of Aviation Medicine (later USAFSAM). As it became more and more obvious that medical standards were critical to aviation safety, the Department of Commerce requested and obtained his release from the War Dept so that he could become the first medical director of aeronautics, to which he was appointed on 16 Nov 1926. Dr. Bauer was an absolute stickler for medical standards. His original intent was that no waivers at all would be granted to new student pilot applicants who did meet the minimum private pilot standards. What was his approach to already trained pilots with standards deficiencies?

John Paul Stapp

- A. He has been called the “fastest man on earth”
- B. When he originally started his work in 1947, 18g was thought to be the upper limit of survivability for humans. In one of his last rocket-propelled runs, he was subjected to 46.2g.
- C. He sustained repeated and various injuries, including broken limbs, ribs, detached retina and other visual problems which remained with him throughout the rest of his life.
- D. He also participated in wind-blast experiments, including flying a jet without a canopy at a speed of 570 mph, and sustained no wind injuries.
- E. All of the above
- F. A, B, and C only.

John Paul Stapp was a USAF flight surgeon who was a pioneer in studying the effects of acceleration and deceleration forces on humans. He did his work on a rocket sled on 2,000 foot track originally built for the V-1 program at Edwards Air Force Base CA and later also did substantial experimentation at Holloman AFB NM. On one of his sled runs he achieved a speed of 632 mph. He also did a great deal of work in car safety and was one of those most responsible for the mandatory use of seatbelts in automobiles. He is credited with Stapp's Law which states, “The universal aptitude for ineptitude makes any human accomplishment an incredible miracle.” Which of the following are true?:

Joseph Kittinger

- A. Nothing
- B. Marked tissue necrosis which required extensive surgery and occupational therapy thereafter
- C. It swelled to approximately twice normal size but returned to normal size and function thereafter.

Joseph Kittinger is a USAF command pilot who worked with Col Stapp. He is famous for his work in high altitude bailouts. He was the parachutist in three of these. He jumped from elevations of 76,400 feet, 74,700 feet, and on August 16, 1960, he jumped from an altitude of 102,400 feet. The last jump led to the phrase, "The highest step in the world". During the ascent, the pressurization for the glove on his right hand failed. What happened to his hand?

World War I Aviation Fatalities

- A. 10%, 20%, 70%
- B. 50%, 20%, 30%
- C. 2%, 8% , 90%
- D. 25%, 8%, 67%

The first year after the beginning of World War I, Great Britain reviewed its aviation fatalities. Out of every 100 flyers killed the proportions attributed to death at the hands of the enemy, deaths from airplane defects, and deaths due to individual deficiencies – including physical defects, recklessness and carelessness were (select the best answer):

Theodore Lyster

- A. Realizing that a steady nerve was required to be an aviator, he developed the “needle test.”
- B. He studied the British experience for aviation fatalities and as a result insisted on tough physical standards for aviators.
- C. Because he survived yellow fever as a child and had lifelong immunity thereafter, he was able to make significant inroads into research on this disease.
- D. He insisted that aviation surgeons be parts of their squadrons. This meant that surgeons familiar with aviation would deploy with their units in a timely fashion as opposed to waiting on a slower response from a larger medically focused organization.

Theodore Lyster is often known as the Father of Army Aviation Medicine. In September, 1917, he became the first Chief Surgeon, Aviation Section, Signal Corps, US Army. His two primary contributions to aviation medicine were (pick the two best):

The “needle test” was a test where an aviator applicant put a needle between his thumb and forefinger and a pistol was fired unexpectedly behind his head. If he drew blood, he was unfit.....

Charles Berry

- A. He had to fight someone every step of the way. Some said he was too conservative and cautious, and then there were those who called him a murderer for sending men to certain death.
- B. "Pilots and astronauts really feel like they are invincible. All they need is a jock strap, a white scarf, and let's go"
- C. "In my situation, I was responsible for getting the man to the moon safely, and back, and at the same time I have these guys saying, 'Well now, we think we can get onto the moon safely and back anyway.'"
- D. All of the above.

Charles Berry is a noted flight surgeon, particularly famous for his work in the Gemini and Apollo series for NASA. Which of the following is he credited for?