Federal Air Surgeon's Medical Bulletin

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In This Issue:

Grand Rounds and Other Items

By Susan Northrup, MD, MPH
Federal Air Surgeon

Time certainly flies! In the past six months, the Office of Aerospace Medicine has been leaning forward to innovate and modernize our processes and policies. Hopefully, many of you have availed yourself of the training opportunities afforded by the virtual Grand Rounds we are hosting each month for approved CME. Holidays and late breaking news required us to move the November and December sessions, and I thank you for being flexible. If you haven't looked into attending, please do. We send notifications a couple of days prior to each Grand Rounds with the Zoom details. Please be on time as we cover a lot of details, and we want to award you CME for attending. You will need to clearly display your name to receive the FREE CME Credit for the sessions.

By now, you all should have my goal for the Office of Aerospace Medicine:
To return individuals to flying or controlling as soon as it is safe to do so, in a manner that is transparent, consistent, and timely.

I have three major lines of effort for the next year. They are Education, Early Intervention, and Evolution of Standards. You will see them resonating throughout my messaging in the coming year.

Education

We need to improve the process knowledge for all users of our system starting with the pilot wannabes, but also including the established pilots, AMEs, pilot advocacy groups, industry and internal FAA personnel. Only by educating everyone in the system can we truly attain lasting efficiencies. The better educated a pilot is the greater the likelihood they will provide exactly what we need to make a decision the first time we touch a case. While we have been consistently modifying the AME Guide to put more direction in plain language, AMEs are an invaluable part of helping them navigate our system. This bulletin, the Ground Rounds, our Seminars, and real-time messages through AMCS are some of the methods we are using to update information to the AMEs. We keep striving to reach out to all participants in a manner that is effective for their learning.

Early Intervention

Did you know there is a study quantifying pilots take significantly longer to seek care than the average American citizen? Dr. William Hoffman and crew have published several studies you might want to read. The reasons range from fear to stigma to lack of understanding of the process just to name a few. There is a really good description in the Mental Health and Medical Clearance Aviation Rulemaking Committee report of the barriers. We need a culture change and awareness campaigns to get the word to pilots waiting doesn't help and, in many cases, makes it more difficult to return to flying. Mild to moderate disease of nearly every sort is easier for us to adjudicate favorably. We have to keep beating the drum for change in getting help early.

Evolution of Standards

We are actively taking steps to move to the medical certification process of the future going to science-based approaches using Safety Management System techniques. Almost every month we publish updates in the Guide for Aviation Medical Examiners. We strive to get quality decisions using the most up to date scientific knowledge. We will keep doing this moving forward as part of our commitment to you

Finally, thank you all for what you do for aviation safety. I wish you and yours all the best in the coming New Year!

-Susan

<<back to top

Pregnancy and Flight

By Susan Buriak DH.Ed, MPH, Susan Jay, Ph.D., MPH and Kyle Copeland Ph.D.

The fact that women are in aviation is not a recent phenomenon. Women entered military aviation eighty years ago and were flying aerostats a century before the airplane was invented.[1] As more women enter aerospace, it is necessary to address the issue of pregnancy and flight. Pregnancy is a normal physiologic event. Pregnancy is not a disease or an illness.

Under normal circumstances, it is not disqualifying for a medical certificate. The FAA recommends that pregnant pilots make their obstetrician aware of all aviation activities they plan to participate in, especially during the third trimester.[2] There are several health concerns applicable to the physiology of pregnant aviators:

- Hypoxia
- Fetal Adaptation
- Hypotension and G Forces
- Size of Abdomen
- Pregnancy and Medication
- Circadian Rhythm
- Deep Vein Thrombosis (DVT)/Pulmonary Embolism
- Cosmic Radiation
- Return to Flying

Hypoxia

In a collaborative effort with the Aircraft Owners and Pilots Association (AOPA), the Civil Aerospace Medical Institute (CAMI) has provided information on pregnancy and aviation: per 14 C.F.R. § 91.211, pilots are required to use supplemental oxygen for flights above 12,500 feet up to 14,000 feet, and longer than 30 minutes in duration. Aside from this requirement, the aerospace physiology community typically considers sea level to 10,000 feet to be the physiological “compensatory zone."[3]

At these moderate altitudes, the healthy body is remarkably capable of compensating for the slightly lower partial pressure of oxygen so the exposure should be uneventful. However, there can be considerable differences in individual tolerance to hypoxia, and several factors such as dehydration and fatigue can negatively impact hypoxia tolerance.

The normal blood oxygen saturation level (SpO_2) at an airliner's cabin pressure altitude of approximately 8,000 feet is typically between 90 and 93 percent. The body uses a combination of increased depth and rate of breathing, elevated heart rate, and increased cardiac output to make up for the lower partial pressure of oxygen at this cabin pressure altitude. These compensatory mechanisms increase the amount of oxygen that reaches the tissues. Additionally, elevated fetal hematocrit and increased fetal hemoglobin's capacity to carry oxygen ensures that fetal oxygen saturation levels do not decrease very much at these moderate altitudes. In fact, there is a wealth of research data from flight attendants, air medical professionals, and women living at high altitudes concurring that there is minimal proof linking long-term exposure to lower partial pressures of oxygen, either living at 10,170 feet (3,100 meters) or in commercial aircraft, to serious pregnancy-related issues.[3] However, a pregnant pilot should be aware of her own unique hypoxia signs and symptoms (via hypoxia awareness training) and be ready to use supplemental oxygen and descend the aircraft if necessary.

Fetal Adaptation

The oxygen-hemoglobin dissociation curve is a graphical representation that shows the relationship between the partial pressure of oxygen (PO_2) and hemoglobin saturation. At sea level, maternal arterial oxygen saturation follows the standard sigmoid shape of this curve, where an increase in PO_2 leads to greater hemoglobin saturation up to a plateau. Fetal hemoglobin (HbF), which is distinct from adult hemoglobin (HbA), has a dissociation curve that is shifted to the left compared to maternal hemoglobin, and the hemoglobin concentration is approximately 50% greater than maternal hemoglobin.[4] This shift reflects fetal hemoglobin's higher affinity for oxygen,[5] allowing the fetus to extract more oxygen from the maternal blood supply. At sea level, this leftward shift enables fetal hemoglobin to achieve 20 to 30% greater oxygen saturation[6] than maternal hemoglobin at the same PO_2. At altitude, this leftward shift in fetal hemoglobin's affinity for oxygen provides a physiological advantage in oxygen delivery and protection against hypoxic stress (subtle symptoms). At 10,000 feet (corresponding to the low end of the physiological compensatory zone; Figure 1), both maternal and fetal hemoglobin O2 saturation is approximately 87-88%, but fetal hemoglobin can maintain this blood saturation level at a lower PO_2 compared to adult (i.e., maternal) hemoglobin – an advantage that persists with decreased PO_2 (i.e., increased altitude).

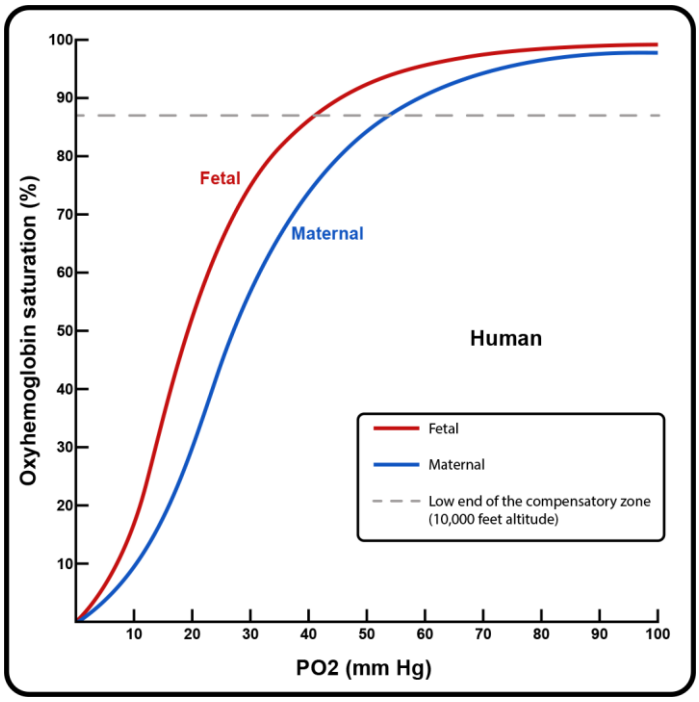

Figure 1: Oxygen disassociation curves for human maternal (HbA) and fetal blood (HbF) at constant pH and temperature showing fetal affinity for oxygen at altitude (10,000 ft). (Data from Metcalf J, Bartels H, Moll W. Gas exchange in the pregnant uterus.

While both maternal and fetal PO_2 levels decrease due to lower atmospheric oxygen, maternal arterial oxygen saturation can fall significantly, causing a rightward shift in the oxygen dissociation curve, which corresponds to a decreased affinity for oxygen.

This rightward shift is partially driven by the Bohr Effect, where an increase in carbon dioxide (CO_2) and a decrease in blood pH creates acidic conditions, lowering maternal hemoglobin's oxygen affinity and facilitating oxygen release to the tissues and fetus. In contrast, the fetal oxygen dissociation curve retains its leftward shift even at altitude -- as fetal CO_2 diffuses into

the maternal placenta it creates a more alkaline fetal blood, which in turn increases fetal hemoglobin's affinity for oxygen.[6]

The Bohr Effect underlies the differential oxygen affinity of maternal and fetal hemoglobin. In maternal circulation, oxygen is unloaded to the tissues and to the placental circulation to the benefit of the fetus. Meanwhile, fetal hemoglobin's reduced sensitivity to the Bohr Effect maintains its high oxygen affinity, ensuring efficient oxygen uptake.[5]

The Bohr shift in one direction for maternal blood and in the other direction for fetal blood has been described as the *double Bohr Effect .*[4] This difference ensures that fetal hemoglobin can still bind oxygen more effectively than maternal hemoglobin under hypoxic conditions, thereby preventing fetal tachycardia or bradycardia that could result from reduced oxygen supply.[6]

By understanding these physiological adaptations, we can better appreciate the mechanisms that ensure fetal well-being during maternal exposure to hypoxic environments, such as unpressurized or high-altitude flight.

The in utero human fetus has been compared with a high-altitude dweller, or the resiliency of an adult mountain climber on the Mt. Everest summit.[5] These mechanisms underscore the remarkable efficiency of fetal oxygenation strategies to maximize oxygen capacity and optimize oxygen release where it is most needed.

Hypotension and G Forces

Based on a thorough literature review and analysis of over seven metrics (behavior, body composition, anthropometry, biomechanics, physiology, health and learning), the United States Air Force Academy determined that there are no significant differences in G tolerance between males and females under gradual or rapid acceleration profiles. All factors considered, a woman's G tolerance was reported to be equal to a man's.[7,8]

However, dehydration and low blood pressure caused by hormonal influences on blood vessels are typical during pregnancy. Some abnormal flight conditions such as wind shear, wake turbulence, upset recovery procedures, engine loss, rapid depressurization, and other crises can lead to higher G-loads affecting a pregnant pilot.[8] During pregnancy, about 25% of blood flow goes to the placenta and uterus. This lowers systemic blood pressure, raising the risk of syncope and lowering G tolerance .[9]

Size of Abdomen

According to the American College of Obstetricians and Gynecologists (ACOG), pregnant women should wear seatbelts properly adjusted for their safety. The seatbelt should be "positioned low across the hips, between the protuberant abdomen and the pelvis." [10]

When a pregnancy progresses and the uterus grows, the width of the abdomen may impede use of some of the flight controls and interfere with emergency exit maneuvers.

Pregnancy and Medication

Nausea and vomiting are common during pregnancy, primarily during the first trimester. The only FDA approved medication is docylamine/pyridoxine (Diclegis). The FAA is updating medication

guidance for the administration of antiemetic medication for pilots with morning sickness/nausea. When completed this guidance will be available online in the Guide for Aviation Medical Examiners. Medications for conditions that may arise due to pregnancy, such as gestational diabetes, gestational hypertension, postpartum hypertension, and postpartum depression, will follow the existing disposition protocols within the FAA's medical certification process. These protocols may include issuance by an Aviation Medical Examiner (AME) or deferral to the FAA for a special issuance, depending on the duration of use and the severity of the condition.

Circadian Rhythm

A brief from the International Association of Airline Pilots' Association (IFALPA) reported that a pregnant woman needs more sleep than normal due to the associated hormonal and physical changes of pregnancy.

Pregnancy-related hormones (progesterone, estrogen, cortisol, and oxytocin) have a significant impact on sleep quality during the third trimester. Research indicates that sleep disorders affect two-thirds of pregnant women. Common sleep disorders include insomnia, nocturnal gastroesophageal reflux, sleep apnea, and nighttime urination. Lack of sleep during pregnancy is linked to pro-inflammatory serum cytokines, which in turn are linked to preterm labor and postpartum depression, longer labor, and a higher rate of cesarean sections. A major factor in chronic sleep deprivation is the disruption of circadian rhythms caused by irregular airline schedules. Pilot performance may be impacted by sleep deprivation brought on by shift work, which has been connected to a higher rate of miscarriages.[10]

Deep Vein Thrombosis (DVT)/ Pulmonary Embolism

A medical history of DVT, maternal age greater than thirty-five years, or a heredity predisposition to DVT are significant risk factors for pregnant women making them 5 times more likely to develop DVT when pregnant (NIH). Other risk factors include previous history of lupus, inherited or acquired thrombophilias, a previous history of thrombosis, antiphospholipid syndrome, heart disease, and sickle cell disease.[11]

Increased estrogen levels increase blood coagulation. Deep vein thrombosis and pulmonary embolism are among the most common serious vascular diseases that occur during pregnancy. They account for the highest number of obstetric deaths related to blood pressure disorders including hemorrhage and sepsis ." [9]

Sitting for prolonged periods of time increases the risk of lower extremity edema, thrombophlebitis, and deep vein thrombosis. According to IFALPA, pilots, and especially pregnant pilots, should walk around every 1 – 2 hours.

Other conditions that alter blood flow or normal clotting mechanisms may make some people more likely to develop a DVT. Some of these risk factors include a prior DVT, certain heart diseases, cancer, pregnancy, smoking, older age, and some blood clotting disorders.[13]

Other blood disorders such as a recent history of thrombocytopenia (within 5 years) due to pregnancy which has resolved, may be issued a regular medical certificate by the Aviation Medical Examiner. A special issuance is not required.[14]

DVT Risk Mitigation

Risks for pregnant aviators are similar to overall risks for passengers and frequent flyers. These include dehydration from lower humidity, as well as edema and DVT due to long periods of immobilization in the flight deck, and edema.

ACOG recommends preventive measures including support socks, occasional ambulation and hydration.[10]

Cosmic Radiation

If a pilot is pregnant or considering pregnancy, exposure to ionizing radiation at altitude is a consideration. Cosmic radiation may lead to miscarriage for pregnant aviators. A National Institute for Occupational Safety and Health (NIOSH) study in 2009 reported that exposure to 0.36 mSv (1 milli sievert is equal to 1/1000th of a sievert) or more of cosmic radiation in the first trimester is linked to higher risk of miscarriage.[18]

Radiation sensitivity of the fetus varies throughout development. According to the International Commission on Radiation Protection (ICRP) the fetus should be afforded the same degree of protection from occupational exposure as members of the public. Therefore, radiation exposure to a fetus should not generally exceed 1 mSv. For cosmic radiation, a pregnant woman's body does not provide much shielding, so in a practical sense this limit must also be applied to the crewmember to protect the fetus. According to IFALPA, the average annual exposure for a pilot is between 2-5 mSv. Thus, in operational terms, a dose of 1 mSv could be accumulated in significantly less than 9 months of flying.

FAA recommends pregnant aircrew limit ionizing radiation exposure to no more than 0.5 mSv per month.[16] This limit may be exceeded after only 80 airborne hours on some long, high altitude flight routes.[17]

The specific number of hours one can fly and keep exposures below these limits depends primarily on route choices and cruise altitudes (flight-dose tools such as FAA's CARI software and NASA's NAIRAS website are freely available to the public).

Flight dose calculating software and more information on in-flight radiation exposure is available from the FAA's Radiobiology Services Website Radiobiology Services | Federal Aviation Administration.

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Highly unpredictable, solar particle events also occasionally result in significant doses. Solar particle events can be tracked, and there are some advisory messaging systems (International Civil Aviation Organization, national Oceanic and Atmospheric Administration, FAA)[18]; however, the ability to forecast these events is very limited and not adequate for predicting route dose estimates. The best accuracy for route dose estimation for a flight that occurred during an event requires post-event analysis of all available data.

Both solar cosmic radiation and galactic cosmic radiation are deflected and shielded in the same way, so the same factors control (i.e., reduce) exposure: time, altitude, and latitude. Pregnant pilots are encouraged to reduce long flights, high altitudes, and flights over the poles.

Returning to Flying

Assuming that there are no perineal or other complications, postpartum pilots can return to flying when released by their obstetricians, usually following the traditional six-week recovery period.

- **Altitude exposure:** While commercial flights remain within safe oxygen thresholds, the AME should be consulted about potential risks for pregnant pilots flying at higher altitudes
- **Fatigue and stress:** Pregnancy can increase fatigue and stress. Prioritize adequate sleep, hydration, and healthy eating
- **Radiation exposure:** Cosmic radiation levels increase at higher altitudes. While the risk is negligible for occasional flights, frequent flights should be discussed with the AME
- **Cabin environment:** Low humidity and cabin pressure can lead to dehydration and discomfort. It is important to stay hydrated, wear loose clothing, and move legs regularly

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<<back to top

Spatial Disorientation

By Jason Sigmon MD, FACS

Spatial Disorientation represents a hazard to aviation safety when it leads to a failure by the aviator or flight crew to sense correctly the position, motion, or attitude of the aircraft or of him/herself within space in relation to the earth. While failure of cockpit instrumentation and erroneous information can precipitate these accidents the factors involved are primarily human ones.

Spatial disorientation has been a recognized hazard since the dawn of human flight and to this day represents an area of robust research into its complex nature. It was understood very early in human flight that pilot's had difficulty maintaining safe orientation of an aircraft in the absence of a visible horizon. Advances in awareness and aircraft instrumentation, such as the Sperry artificial horizon, allowed for safer pilot operations and fewer spatial disorientation accidents.

While the artificial horizon was a key development in advancing the capability of aircraft operations spatial disorientation accidents continued to be a significant aviation safety concern accounting for approximately 16-20% of all fatal accidents. This led our aerospace physiology and medicine colleagues to seek out a better understanding of the human sensory system and its role in errors of orientation when piloting an aircraft. We now have a better understanding of

the combined contribution of the visual and vestibular systems and the factors in flight that lead to inaccurate pilot interpretation of sensory cues.

While the incidence of aircraft accidents secondary to spatial disorientation has decreased steadily over the years, the problem persists. Our most recent spatial disorientation study at CAMI shows that approximately 10% of Part 91 general aviation fixed wing accidents between 2003 and 2021 involved spatial disorientation as the primary cause after NTSB final evaluation. As has previously been reported in prior studies over 90% of these accidents unfortunately are fatal to the pilot, passengers or even individuals on the ground.

The office of aerospace medicine is addressing the hazard of spatial disorientation in the following ways:

I. Aerospace Medical Certification

While any human engaged in piloting in aircraft in environmental conditions of diminished visibility is at-risk for spatial disorientation, it is important that the medical evaluation of pilots with potential underlying acute or chronic conditions of the inner ear or vision are identified and managed effectively to ensure aviation safety.

In 2023, the office of aerospace medicine updated the AME guide with aerospace medical disposition tables for the following conditions affecting the inner ear:

- Acoustic Neuroma
- Benign Paroxysmal Positional Vertigo
- Labyrinthitis
- Meniere’s Disease
- Motion Sickness
- Perilymph Fistula
- Persistent Postural Perceptual Dizziness
- Superior Semicircular Canal Dehiscence Syndrome

II. Human Factors Research

The human factors research division at CAMI continues to study potentially contributing factors to spatial disorientation accidents including the global cognitive impact of fatigue as well as the specific performance impairment of medications or substances.

A new retrospective accident study conducted by CAMI’s Human Factor’s Research Division evaluated the incidence of positive post-mortem toxicology for potentially impairing medications and substances in general aviation spatial disorientation fatalities. Approximately one-third of the accidents in the study included a positive toxicology finding from CAMI’s toxicology laboratory.

Future areas of research in spatial disorientation include a need to better understand how pilot’s cognitively prioritize tasks when operating their aircraft in diminished visual conditions or while performing maneuvers conducive to spatial disorientation. Many spatial disorientation accidents

include errors in decision-making and the inadequate use of available weather information. Research focused on a better understanding of how a pilot utilizes and processes information when making decisions is another example of the increased focus on cognition in the field of spatial disorientation research.

III. Airman Education

Ample evidence supports the positive impact of pilot training and experience in the prevention and mitigation of spatial disorientation accidents.

At CAMI, our Airman Education program is developing a comprehensive spatial disorientation practical training program for pilots utilizing our two GATS-II full motion aircraft simulators and airman education physiology team.

This full-day course includes didactic classroom presentations on the topics of inner ear and visual physiology, SD accident case-studies, fatigue and the impact of potentially impairing medications or substances. The practical element of this course includes pilot participation in operationally relevant spatial disorientation flight scenarios utilizing the GATS-II full motion simulator(s).

Dr. Sigmon is a Medical Officer and Regional Flight Surgeon (International/Military/Federal) in the Aerospace Medical Education Division at CAMI (AAM-400).

<<back to top

Medical Certification Policy Updates

By Judith Frazier, MD, MBA

The Policy and Standards branch continues to focus on helping Aviation Medical Examiners (AMEs) more easily obtain the information needed to make a medical certification decision. This version highlights policy changes and updates published between June 2024 and October 2024. The full list of changes is hyperlinked in the Archives and Updates section of the AME Guide.

Psychiatry/Behavioral Health

Anxiety, Depression and Related Conditions– updated to remind AMEs to list/identify in block 60 which diagnosis are being use for Fast Track. Added single page with all the conditions/diagnosis which can be used for this program.

Attention-Deficit/Hyperactivity Disorder (ADHD) Disposition Table

- Clarified it is applicable for both pilots and ATCS
- Can accept if meets both Fast Track for ADHD AND Fast Track for Anxiety Depression and related conditions,
- Standard Track, clarify that separate tests must be ordered for BOTH amphetamines AND methylphenidate.

FAST TRACK PATHWAY Decision Tool for Current Deferred Cases for depression, anxiety, and related conditions available for AME use. Combines all required items for Fast Track in one place.

Neurology

CACI – Migraine and Chronic Headache Worksheet – revised to add additional medications.

Head Injury or Brain Injury Disposition Table – expanded guidance for brain injury 5 or more years ago (Row B1) or brain injury within the past 5 years (Row B2).

Brain Injury Decision Tool for the AME – new to use with Brain Injury dispo table.

Neurology – Section updated grouping all items attached to a condition in a single place (dispo table, CACI, AASI, status summary). Align entire section as a single search page.

Otolaryngology (ENT)

ENT – New Disposition tables for:

- Allergies or Anaphylaxis; (Allergic Rhinitis; Seasonal Allergic Rhinitis; Hay fever) Disposition Table.
- Sinus Conditions Dispositions Table.
- Speech Impediment - Stuttering, or Mechanical Conditions Disposition Table

Other Systems

Cardiology – **ECG/EKG** - AME Equipment and Medical Confidentiality, EKG/ECG equipment must be 12-lead.

Dermatology (Skin) – New Psoriasis Disposition Table, CACI – Psoriasis Worksheet and AASI – Psoriasis. Updated meds allowed for CACI

GI – **CACI -** Colitis Worksheet revised to add additional acceptable medications.

GU – Low Testosterone (Low T) Hypogonadism New Disposition Table, new CACI, new AASI, new Status Summary.

ID – Updated COVID-19 disposition table. AMEs no longer required to annotate uncomplicated, resolved COVID infection.

Musculoskeletal – Pectus Excavatum Disposition Table. (new)

Arthritis CACI – expanded to add additional medications.

Rheumatology – CACI - Arthritis Worksheet revised to add additional acceptable medications.

Miscellaneous

New page added for English Proficiency and Pilot Medical Certification. English language is not a medical requirement. Described what an AME should look for and if concerns, can opt to report to the FSDO.

Terminology update. **Aviation psychiatrist or Aviation psychologist** replaces term HIMS psychiatrist or HIMS psychologist.

Exam techniques – revised Item 35 Lungs and Chest; Item 39. Anus, Examination Techniques revised, and Item 41. G-U System, Examination Techniques Updates. Describes what part of exam is not required unless indicated by past medical history or symptoms. It may be performed at the discretion of the AME or applicant. Document findings in Item 60.

Pharmaceuticals

Pharmaceuticals – Weight Loss Management Medications and Pre-Diabetes. Expanded the acceptable meds for CACI to include tirzepatide (GIP + GLP-1 Agonist) Mounjaro or Zepbound

Biologics, Biosimilars, and Non-biologics – new page Expands acceptable medications for colitis, psoriasis, and arthritis.

Migraine Medication – new page. Expands acceptable medications including for CACI.

Over-the-Counter Medications Reference Guide (What Medications Can I Take and Still Be Safe to Fly) – added to AME guide

Vaccines – reduced required observation time after COVID vaccine to 24 hours if no symptoms.

Administrative Changes

Special Issuances – removed AASI Certificate Issuance Coversheet. This document is no longer needed.

Help us improve the AME guide! Send you comments or suggestions to: AMEGuide@FAA.gov. (This mailbox does not answer case questions.)

Dr. Frazier is the Manager of the Policy and Standards Branch in the Office of Aerospace Medicine (AAM-220).

<<back to top

Aviation Medical Examiner Information Links

For downloadable, printer friendly versions of this Bulletin click here.

Guide for Aviation Medical Examiners
Aviation Medical Examiner (AME) portal (GO AME)
AME Seminar Schedule & Registration
AME Online Training Information
AMCS Online Support
Regional Flight Surgeon Contact Info
Aeromedical Safety Brochures
Medical Certification Information
MedXPress Login & Help
AME Minute Playlist
Pilot Minute Playlist
CAMI Library Services
Designee Management System (DMS)

Sleep Apnea Information

OSA Protocol
OSA Information Brochure

<<back to top

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