Chapter 3: Aircraft Fundamentals

Lecture

I. Introduction

Time: 3 Minutes
Slide: 1–2
Lecture/Discussion

A. CCTPs may work in the aircraft environment as a part of the course of his or her duties, either permanently or as assigned.
   1. CCTPs must be familiar with both rotor-wing (helicopter) and fixed-wing (airplane) operations.
   2. In an aircraft environment, aircraft safety and aircraft operations always come before patient care.
      a. Concept often difficult for some providers to understand
      b. Essential to successful completion of mission

II. The Air Medical Role

Time: 9 Minutes
Slides: 3–7
Lecture/Discussion

A. Three organizational models for air transport programs dominate current practice and include:
   1. Hospital-based air programs where many hospitals share responsibility and costs of service
   2. Public service agencies where government agencies use air transport program outside medical setting while also serving the needs of critically injured and ill patients
   3. Private services that primarily offer interfacility transfers, but may also offer emergency scene responses
      a. Recently gained attention and growing because of ability to meet needs of health care systems

B. The basic concepts of an air medical service are to:
   1. Rapidly transport CCTPs to a patient
   2. Stabilize the patient's condition
   3. Transport patient to a tertiary care center as rapidly as possible
      a. Critically ill or injured patients who would have negative outcome with prolonged transport benefit most from air transport.

C. CCTPs must weigh benefit of air transport to patient versus risk.
   1. Evaluate patient and assess for effects of altitude and other forces that can adversely alter conditions en route.

a. Example: Cardiac patients with activity-sensing pacemakers may encounter severe complication if pacemaker malfunctions because of flight vibrations
2. Consider adverse effects of air transport on employees in relation to adverse reactions to aircraft humidity, noise, and vibrations, resulting in possible dehydration, hearing loss, and fatigue, respectively.

D. Air medical transports require risk-benefit assessment.
1. Often contraindicated in following circumstances:
   a. Severe anemia
   b. Hemoglobinopathy
   c. Myocardial infarction (MI) within 10 days or complications in 5 days before flight, with exception of patient with acute MI being flown to catheterization lab
   d. Uncontrolled arrhythmia
   e. Pregnancies past 24 weeks' gestation
   f. Recent eye surgery affecting the globe
   g. Nonacute hypovolemia
2. Requires special considerations when undertaken during risky circumstances, such as flying at lower altitude than usual to optimize patient outcome
3. Requires consideration of other factors, such as:
   a. Terrain
   b. Weather
   c. Geographic location of closest facility
   d. Transport crew capabilities

E. Despite drawbacks, air medical transport has demonstrated the following benefits:
1. Decreased mortality rates
2. Access to more specialized tertiary care facilities
3. Rapid access into health care system, especially for patients living in inaccessible areas

III. Communications

Time: 20 Minutes
Slides: 8–20
Lecture/Discussion

A. CAMTS
1. Program dedicated to ensuring high quality patient care and safety within ground, rotor-wing, and fixed-wing services
2. Communication standards established to help improve overall safety of most critical care transport systems
   a. Most efforts focused on rotor-wing and fixed-wing divisions because proper communication procedures within cockpit critical to ensuring safety of both patients and crew

B. Sterile cockpit
1. Term used by pilot in command to describe atmosphere during takeoffs, landings, and any other critical phase of flight
2. No communication allowed that could distract pilot in command unless related to safety of flight
3. Air carrier standards dictate its enforcement at all altitudes less than 10,000 feet.

        a. Because most helicopters fly between 2,000–5,000 feet, pilot in command determines sterile cockpit times, but always includes takeoff, approach, and landing
    4. Communications with operation centers and dispatchers should be observed during sterile cockpit times.
        a. Rule of thumb—communications to operation centers should be relayed:
            i. Prior to lift-off
            ii. After aircraft reaches cruising altitude
            iii. Or until pilot declares nonsterile cockpit
    5. Should also be observed while communicating with patients during flight
        a. Pilot may use option of "isolating" crew
C. Issues that may occur during flight that require landing short of the original destination
    1. Mechanical issues force pilot in command to seek closest airport.
    2. Patient's condition deteriorates and requires medical attention.
        a. Patient taken inside for advanced medical care unavailable in aircraft
    3. Potential mechanical malfunctions require crew to be alert.
        a. Smoke in patient care area
        b. Smell of abnormal odors
        c. Unusual vibrations
        d. Abnormal sounds
        e. Fluids leaking into patient bulkhead
    4. "Emergency" to ATC should immediately result in sterile cockpit.
D. Instrument flight rules versus visual flight rules
    1. Visual flight rules (VFR)
        a. Mode of flight used when weather conditions are good (good visibility, minimal cloud cover)
        b. Permitted in many areas without being in contact with ATC
            i. In populated areas pilot must be in contact with ATC even when flying VFR.
    2. Instrument flight rules (IFR)
        a. Mode of flight used when minimum cloud clearance and visibility requirements cannot be met.
        b. Pilot must rely on instruments inside cockpit to maintain control and navigation of aircraft.
        c. Pilot needs ATC clearance prior to takeoff and must maintain contact with ATC during flight to ensure proper distance from other air traffic.
        d. Rarely conducted by rotor-wing programs because pilots who perform certified-IFR approaches need to be able to land safely and legally during IFR weather
            i. Rotor-wing air medical craft often land at hospitals and unimproved landing zones.
            ii. Few programs that conduct rotor-wing IFR require two pilots.
        e. Routinely operated by fixed-wing aircraft who use FAA-certified approaches at airports for takeoff and landing, usually require two pilots
E. Flight following
    1. Critical care transport initiated upon communication center's receipt of request for service from authorized agency and accepts or declines mission
        a. Decision based on relevant factors (weather, terrain, nature of injury or illness)
        b. Decision often based on new patient information to avoid influencing pilots' decision
    2. ATC legally mandated to be in contact with the aircraft flying IFR to ensure it maintains safe distance from other IFR aircraft.

        a. Pilot must also file flight plan, receive flight clearance, and maintain ATC.
    3. VFR monitoring is called flight following (radar advisory service) and provided by authorized ATC facility.
        a. Service consists of controller notifying aircraft about area traffic when controller is available to do so in advisory capacity.
            i. May be unavailable during peak workload times
        b. Pilot should maintain constant contact with other local traffic and ATC facilities in proximity of aircraft.
        c. Highly recommended (not mandatory) because it can assist pilot in avoiding collisions
    4. VFR in helicopter
        a. Contact usually maintained with one of two entities:
            i. ATC
            ii. EMS communications center
        b. Pilot in command deciding not to flight follow with ATC must maintain real-time radio contact with a communications center every 15 minutes
    5. Fixed-wing operations
        a. Without flight plan, pilot in command must make contact with ATC or communications center every 30 minutes
        b. Most operate on an FAA flight plan
        c. Most air transport agencies enforce either filing flight plan or regular contact with own communications center when in flight
    6. Ground unit patient transport
        a. Lapses in communication must not exceed 45 minutes
        b. CCTPs must provide updates of patient's condition and geographic location during check-in times
    7. In all cases, complete communications record should be kept for 30 days
        a. Communications center should be secured, available only to authorized personnel

F. Identifying flight and scene locations
    1. GPS technology is critical to helping flight-following center constantly track aircraft's movement, even when not in radio contact
        a. Several commercial flight-tracking programs available; useful during in-flight emergency
    2. Computer software that allows for physical address to be input and converted to GPS coordinates is also necessary
        a. Rotor-wing responders frequently use handheld GPS device to obtain coordinates for geographic location
            i. Extremely accurate if coordinates properly read and relayed
            ii. Two sets of coordinates needed to prevent inaccuracies

IV. Rotor-Wing Transport vs Fixed-Wing Transport

Time: 9 Minutes
Slides: 21–26
Lecture/Discussion

A. Rotor-wing transport
    1. Advantages include:

a. Vertical takeoff and landing allows helicopter access to areas inaccessible by ground vehicles and/or fixed-wing aircraft
b. Sustained speeds in excess of 150 mph
c. Able to operate at altitudes less than 2,000 feet
d. Able to move from point to point
e. Able to serve all types of population bases, from dense urban to extremely rural
    i. Relatively small number of helicopters can serve large population because of quick flight turnaround time

2. Disadvantages include:
    a. More restricted than fixed-wing aircraft regarding weather limitations (generally cannot fly IFR)
    b. Interior space limitations can make it difficult to perform complex procedures while CCTP is in aircraft
        i. Examples: patient may be inaccessible from waist down, or limitations may prevent intubation
    c. Helicopters are more expensive to own and operate than ground transport
        i. Average four times cost of ambulance
    d. Subject to weight limitations, which is more problematic in summer when air is less dense, decreasing lift capacity

B. Fixed-wing transport
1. Advantages include:
    a. Safer than rotor-wing transport because it uses established landing areas and flies at designated cruising altitudes that minimize collision risks
        i. Most are also IFR certified and use two-pilot crew
    b. Attains high speeds (250 to 600 mph)
    c. Ability to travel greater distances
    d. Ability to carry multiple patients
        i. Two patients on smaller aircraft to hundreds on larger military air medical aircraft
    f. Lack of weight limitations regarding patient size
    g. May carry multiple medical crew members and variety of equipment
2. Disadvantages include:
    a. High cost of obtaining aircraft for air medical purposes
        i. Many air medical providers contract with various executive aircraft services to provide aircraft as needed
        ii. Cost can exceed $10,000 or more for short-distance flights and $100,000 for international flights
        iii. Most fixed-wing services secure reimbursement from patients or insurance companies prior to initiating flight
    b. Must use maintained landing fields
    c. May face restrictions on runway length depending on aircraft's size of the aircraft
    d. Require hangers which increases overall operating costs

VI. Rotor-Wing Aircraft

Time: 9 Minutes
Slides: 27–32
Lecture/Discussion

A. Mission profiles for air medical helicopters
   1. Statistics:
      a. 54% of flights will be for interfacility transports (hospital to hospital)
      b. 33% for scene responses
      c. 13% for other types of events (eg, organ procurement and search-and-rescue operations)
   2. May perform wide variety of missions, including:
      a. Transport of sick and injured (majority)
      b. Search-and-rescue
      c. Law enforcement operations
B. Types of air medical helicopters
   1. Type of helicopter used depends on several factors, including:
      a. Patient load capacity
      b. Over-water operations
      c. Requirements for VFR or IFR flight
      d. Altitude of operations
      e. Economy or budget of program
      f. Geographic range of flights
   2. Program type also varies based on community need and include:
      a. Hospital based
      b. Community based
      c. Operated by local or state government program
         i. Examples: law enforcement, fire, county EMS, state government program
      d. Nonprofit
      e. For-profit
   3. Most programs use aircraft vendor which provides aircraft, pilots, required aircraft maintenance
      a. Air medical program must provide medical crew and medical equipment
      b. May save program money
      c. Vendors that operate several bases allows for sharing of maintenance personnel, maintenance facilities, check pilots, and spare aircraft.
      d. Vendor and program usually participate jointly in billing and share percentage of reimbursements
C. Single-engine versus twin-engine air medical helicopters
   1. Both have distinct advantages and disadvantages, so each program must determine which type of aircraft best fits its overall mission profile
      a. Factors to consider include:
         i. Types of missions flown
         ii. Space available to land aircraft
         iii. Required payload
         iv. Available money to operate program
   2. Advantages of single-engine aircraft compared with twin-engine aircraft include:
      a. Aircraft start-up times of 3 to 5 minutes for a single-engine aircraft compared with 8 to 10 minutes for a twin-engine aircraft
      b. Less downtime for maintenance
      c. Lower maintenance costs
      d. Lower operating costs
      e. Lower fuel requirements
      f. Smaller landing zones needed
   3. Advantages of twin-engine aircraft compared with single-engine aircraft include:

a. Two-patient capacity versus one-patient capacity in the single engine aircraft
b. Larger openings for patient loading and unloading
c. Larger patient care area
d. Dual engines in case one fails (especially useful for transport over water)
e. Greater lift capacity

VII. Fixed-Wing Aircraft

Time: 2 Minutes

Slide: 33

Lecture/Discussion

A. Mission profiles for air medical fixed-wing aircraft
   1. Typically used for flights of 200 nautical miles (300 miles) or greater
      a. Sometimes used for shorter distances as in rural, mountainous states where severe weather prohibits helicopters from flying
   2. More commonly used for international transports
      a. Military
B. Types of air medical fixed-wing aircraft
   1. Two main types are propeller driven (turbo prop) and jet aircraft
      a. Turbo prop aircraft jet engine and propellers
   2. Can be single- or multiengine
   3. Type of aircraft utilized depends on transport needs
      a. Some models more spacious than others

VIII. Air Medical Efficacy

Time: 11 Minutes

Slides: 34–40

Lecture/Discussion

A. Benefits of air medical transport
   1. Provides communities access to trauma centers
      a. Declining trend in availability of community hospital emergency departments
         i. From over 5,000 in 1992 to approximately 4,600 in 2002
         ii. Level I trauma centers maintain 95% bed capacity, requiring frequent diversions of patients to comparable facilities
      b. Air medical transport provides 65% of US population access to Level I trauma center within 60 minutes
      c. Half US population has access to 10 Level I or II trauma centers within 60 minutes
   2. Means difference between life and death in some regions
      a. Examples: places in Alaska, Canada, Central and South America, Africa, Asia, or Australia
   3. Provides specialty care to patients who require it
      a. Patients receiving multiple drips (nitroglycerin, dopamine, amiodarone, heparin)
      b. Patients (often same patient) needing continuous sedation and neuromuscular blockade, necessitating patient transfer to a ventilator by skilled flight crew

4. Provides specialty care to patients living in nonurban settings who require transport over longer distances than in past
5. Significantly reduces treatment times in following specialty care situations:
    a. Incident-to-catheterization lab time for patients with acute MI
    b. Incident-to-operation room time for surgical patients
    c. Incident-to-thrombolytic time for patients with acute MI and stroke
6. Reduces time to reach treatment when patients bypass emergency department and are directly admitted at receiving facility
    a. Many flight teams have preestablished protocols for direct admission of certain types of patients, allowing them to receive specialized care immediately upon arrival
    b. Flight crew's protocols may allow higher level of care than ground transport crew's protocols
7. Allows flight team to retrieve a patient, receive transfer of care, and transfer following local protocols
    a. Specialty resource centers have critical care ground transfer units available to assist flight team if weather prevents aircraft from flying, but this can cause complications
8. Allows transport of mass-casualty patient to outlying hospitals instead of overwhelmed local hospitals where ambulatory patients flock

B. Hazards of air medical transport
1. Use requires risk–benefit analysis as adding helicopter into chaotic rescue scene increases risk to responders and patients, even when established safety measures are followed
    a. Impossible to control amount of debris blown about or to totally eliminate hazards associated with main rotors and tail rotors
        i. Exception: fully enclosed tail rotors
2. Consider only patients who are critically injured or seriously ill after carefully considering all transport options
    a. Some patients will clearly benefit from speed and advanced skill
    b. Other patients could be transported by ground more quickly, with less potential danger

C. Financial implications of air medical transport
1. Cost varies greatly depending on region, distance flown, care provided, and other factors.
    a. 2000 Annual Transport Statistics and Fees Survey notes average cost ranges from $2,600 to $6,200 per flight.
    b. 2002 Medicare report found average cost of air medical transport via helicopter was between $5,000 and $10,000.
        i. Required Medicare to increase reimbursement rates
    c. Medicare reported 58% increase in number of flights reimbursed in 2004 versus 2001
        i. Operational costs per helicopter average $1 million per year.
2. Reimbursement requires justification for use.
    a. Medicare established criteria that justify use of air medical transport.
    b. Many flight programs routinely list all applicable justifications for air transport within medical report to facilitate insurance reimbursement.
3. Payment options for programs vary.
    a. Many services choose to send patients by fixed-wing aircraft for flights exceeding 100 nautical miles.

            i. Helicopter transport is 400% more expensive than fixed-wing transport for flights over 101 nautical miles.
    b. Some air medical helicopter programs do not charge and are instead funded by taxes or donations.
    c. Other air medical services offer membership program allowing people to pay annual subscriber fee for their household, covering the cost of air medical transport during that period.

D. Determining air medical transport suitability
1. When considering whether to use air medical transport, requesting EMS provider or physician must avoid three critical errors:
    a. Requesting air medical transport for a patient when a more suitable means of transport is clearly indicated
    b. Requesting air medical transport when the patient could arrive at receiving facility more quickly by ground transport
    c. Requesting air medical transport for a patient when cardiac arrest is ongoing or imminent
2. In most situations, air medical transport compares unfavorably to ground transport on basis of safety, cost, and availability
    a. Costs at least four to five times more than ground transport over same distance
    b. One air medical aircraft may serve population of 500,000, whereas 20 or more ambulances may serve same population
3. Another consideration is level of care that can be given
    a. Some states use paramedic as highest level of ground provider
    b. Registered nurses are usually highest level of provider for flight programs
        i. Allows higher level of care (balloon pumps, certain critical medications, IV infusions of nonparamedic approved medications)
4. Other considerations
    a. Traffic, construction, weather
        i. Thirty nautical miles (34.5 miles) or 30-minute transport considered minimum for which air medical transport is quicker than ground transport
    b. Patient condition
        i. Patients who require extended extrication time or have limited accessibility may benefit from air medical transport
        ii. Other patients may benefit from flight team's advanced care giving skills (rapid-sequence intubation, chest tube placement, blood administration)

E. Other justifications for air transport
1. Ground EMS unit may be overwhelmed by severity of patient's injuries and need expertise of flight crew
    a. Ground crews and smaller community hospitals may wait for helicopter crew to perform advanced procedures such as rapid-sequence intubation
    b. Medical flight team viewed as "safety net" by community

F. Transport of patients in cardiac arrest
1. Most air medical providers do not routinely transport patients in active cardiac arrest for the following reasons:
    a. It is against federal air regulations for passengers or crew onboard an aircraft to not be restrained in seatbelts during takeoffs and landings or as requested by the pilot
        i. Providing effective CPR in the aircraft often requires the medical crew to be unbuckled

   b. CPR is often futile, with fewer than 5% to 8% of all patients who receive CPR being resuscitated
      i. Use of air medical transport for patient in cardiac arrest generally viewed as poor use of resources
   c. CPR generally requires minimum of three providers to be effective
      i. Rotor-wing aircraft typically carry only two medical providers, limiting effectiveness of resuscitation
   d. CCTP must realize a patient may arrest in flight and be prepared to handle situation

IX. Triage of Air Medical Transport Patients

Time: 6 Minutes
Slides: 41–44
Lecture/Discussion

A. Overtriage in the field
   1. Review of pediatric trauma patients transported by helicopter reveals trend toward overtriage
      a. Ohio study found nearly 70% of pediatric trauma patients transported by air were discharged from the emergency department
      b. Children's National Medical Center in Washington, DC study found 85% of pediatric trauma patients did not require air medical transport
      c. Los Angeles, CA study found 33% patient discharged home from emergency department
   2. Many of overtriaged cases involved appropriate use of air transport, however
      a. 37% of patients had multiple injuries
      b. 14% were intubated in emergency department
      c. 18% were admitted to intensive care unit
      d. 4% were taken directly to operating room
   3. Prehospital personnel require better training to curtail trend toward overtriage
   4. Patient statistics
      a. Estimated 10% or fewer of all patients (pediatric and adult) sent to hospitals require multiple interventions
      b. More than 90% of patients transported by rotor-wing or fixed-wing aircraft require multiple interventions
         i. Patient acuity is much higher in air medical industry because triage is performed by experienced providers prior to the initiation of air medical transport

B. Undertriage in the field is also a problem.
   1. Some trauma physicians state that overtriage rate of 25% is acceptable to ensure those patients who most desperately need care are not overlooked
      a. Actual undertriage rate may actually be as low as 10%
      b. Most trauma surgeons agree that discharge rate from emergency department of less than 10% indicates undertriage

C. Air medical use criteria
   1. Determining the appropriateness of using air medical transport from one facility to another involves following guidelines
      a. Contraindications and relative contraindications may make it inappropriate

2. Current HEMS criteria use both mechanism of injury and physiologic parameters to determine which patients might benefit most from transport in helicopters.
   a. Strictly basing need on mechanism of injury no longer clinically accepted practice because it has resulted in
      i. Needless trauma team activations
      ii. Emergent transports of stable patients
   b. New models use both mechanism of injury and physiologic parameters to triage patients
3. HEMS providers should have frequent discussions with local trauma team about criteria used to triage patients
4. HEMS should also implement formal system to track “time to discharge” on all patients flown
   a. Air medical services with high overtriage rates should educate local providers about triage criteria

X. Air Medical Crashes

Time: 6 Minutes
Slides: 45–48
Lecture/Discussion

A. Number of air medical crashes has increased over years with increased number of air medical providers
   1. Flight statistics
      a. 770 helicopters in United States are dedicated to air medical service
      b. Patient transports are increasing at rate of 5% per year
      c. Flight hours in the United States between 1998 and 1999 increased by 12%
B. Causes of air medical crashes
   1. NTSB has found that aircraft crashes are never caused by one single event, but a series of factors
      a. “One bad decision often leads to another. As the string of bad decisions grows, it reduces the number of subsequent alternatives for continued safe flight” (FAA Advisory Circular Number 60-22)
   2. Crash statistics
      a. 55% of crashes occur during scene flights, but scene flights account for only 35% of HEMS missions
      b. 40% percent of flights occur at night, but account for more than 60% of crashes
   3. NTSB has identified four major factors contributing to HEMS crashes:
      a. Human error (68% of crashes)
      b. Weather (30% of crashes)
      c. Mechanical failure (25% of crashes)
      d. Controlled flight into terrain (20% of crashes)
   4. Weather poses single greatest hazard to HEMS operations per NTSB conclusions
      a. Main contributing factor in crashes linked to human error
      b. Involves encounters with unpredicted instrument meteorological conditions (IMC) during flight
         i. Examples: cloudiness, low visibility
   5. Mechanical failure has become less of a factor as helicopters become more reliable
      a. In last 15 years, number of such crashes has decreased by almost 10%

6. HEMS one of most dangerous forms of helicopter aviation with some of highest line-of-duty death rates for EMS providers, second to motor vehicle collisions
    a. Only 30% of all HEMS accidents in past 10 years occurred on patient-related missions
    b. Remaining 70% occurred during:
        i. Maintenance flights
        ii. Check flights
        iii. Relocation
        iv. Public relations flights

C. Making the industry safer
1. Several solutions have been proposed to reduce number of air medical crashes, including:
    a. Crew resource management training for all flight team members mandated
        i. All new flight team members are required to attend initial training
        ii. Most programs offer annual refresher training
    b. Information sharing between competing agencies to prevent helicopter shopping
        i. Medical providers should share decisions to decline certain missions based on safety issues with surrounding air medical services, even when in direct competition with them
    c. Full support by air medical program business administration and aircraft vendor when decision made to decline a mission
    d. Joint agency training between air medical providers and different agencies to facilitate cooperation among various parties involved in transport decision
        i. Includes other area HEMS programs, EMS agencies, fire departments, hospital providers
        ii. Involves aircraft familiarization, landing zone requirements, flight activation criteria, flight request training
    e. Advanced technology to increase safety of flight operations, when possible
        i. Example: night vision goggles
    f. Flight-tracking software to assist with real time tracking of aircraft at all times
        i. Helps locate aircraft that crashes or loses radio contact
        ii. May also include ground-proximity warning systems and obstacle detection and alerting systems on aircraft
    g. Weather display and alerting systems installed in aircraft to give pilots real time weather data and warnings
    h. Cockpit voice recording and flight data recorders for rotor-wing aircraft
        i. Enables investigators to better analyze factors that lead to crash or near-crash situation

XI. Crew Resource Management

Time: 5 Minutes
Slides: 49–51
Lecture/Discussion

A. Development of crew resource management a result of several events:
1. Implementation of cockpit voice recorders and flight recorders in 1960s to1970s revealed that more than 80% of crashes involved human error
    a. Primarily related to crew's inability to respond appropriately to situations

2. 1977 KLM/Pan Am crash on Tenerife, Canary Islands in which two 747s collided on runway
    a. Deadliest crash in aviation history
    b. Primarily due to unclear communication between KLM pilot and control tower regarding takeoff
3. NASA held 1979 workshop focusing on ways to improve air safety
    a. Developed new procedure called crew resource management defined as:
        i. "Using all available resources—information, equipment, and people—to achieve safe and efficient flight operations."
4. Groundbreaking idea that challenged previous assumptions that pilot was in control
    a. Encouraged flight crews to speak up when they did not agree with pilot
    b. Encouraged pilots to listen and take into account flight crew input
    c. Expected aviation industry to accept that human-to-human interactions are an integral part of any team performance
5. Today, ICAO requires crew resource management for airlines in 185 countries
    a. Study by University of Texas Human Factors Research Project found that commercial airline flights experience average of four threats per flight
        i. Most threats or errors caught through crew resource management without detrimental consequences

B. Crew resource management focuses on cognitive and interpersonal skills needed to successfully complete the flight:
1. Cognitive skills consider mental processes needed to:
    a. Maintain situational awareness
    b. Make decisions
    c. Solve problems
2. Interpersonal skills focus on:
    a. Individual and group behavior
    b. Communication
    c. Teamwork

C. Crew resource management does not imply that all decisions are made by committee without considering rank
1. Amount of participation by subordinate crew members depends on situation
2. Medical crew member's role in crew resource management focuses on passive monitoring
    a. Do not provide flight instructions to pilot or participate in technical decisions regarding operation
    b. May intervene if level of skill being displayed by pilot falls below safe standard
        i. Examples: aircraft on imminent collision course with radio tower, or nearby air traffic
3. Decision to accept mission is one area of crew resource management in which all crew members should hold equal empowerment is the decision
    a. Use of "three to go, one to say no" rule
        i. Also called 51% rule
        ii. Gives every crew member power to decline flight
        iii. If any crew member does not feel comfortable with mission it should be aborted

D. Human factors contributing to error can be classified into three types:
1. Skill deficiency may cause following errors:
    a. Losing control of aircraft on runway
    b. Flying at improper speed
    c. Not following standard operating procedures in event of an emergency

2. Errors in perception involve:
    a. Spatial disorientation (covered in Chapter 4)
    b. Somatogravic illusion
    c. Mistakes in judgment regarding distance, altitude, or airspeed
    d. Perception errors occurring during nighttime landings or landings that involve reduced visibility
3. Errors in decision making may include failure to:
    a. Choose appropriate emergency procedure
    b. Take corrective action when aircraft is flying below minimum altitude

XII. Air Medical Safety

Time: 14 Minutes
Slides: 52–60
Lecture/Discussion

A. Air medical transport has inherent hazards
1. Air medical providers encounter a complex myriad of hazards, including:
    a. Launching rapidly after request (most rotor-wing must launch within 5 minutes of request) places stress on flight crew to become airborne
    b. Landing at chaotic scenes in hasty landing zone
    c. Treating patients with catastrophic injuries or illnesses that sometimes exceed abilities of ground medical personnel
    d. Operating in physically demanding aircraft environment
        i. Can induce heat illness, dehydration, motion sickness, physical and mental exhaustion after extended operations

B. Risk factors
1. Retrospective studies regarding air medical crashes conducted by NTSB, FAA, and AMPA indicate the following areas within HEMS operations need improvement:
    a. Weather forecasting
    b. Flight operations during instrument meteorological conditions
    c. Personnel training
    d. Design standards
    e. Crashworthiness
    f. Operations management
2. Other areas of HEMS operations identified as risk factors for air medical personnel include:
    a. Unprepared landing sites
    b. Complacency
    c. Additional stress of responding and caring for critical patients
3. Safety reports indicate that the following problems warrant improvement:
    a. Poor communication with air traffic control
    b. Collision with ground objects
4. Time-critical nature of the job is another risk factor:
    a. Rapid launch makes leisurely preflight inspection or rechecking or weather impossible
        i. Most program policies have all flight crew members perform quick walk-around aircraft prior to initial start up (three sets of eyes better than one)

5. Helicopter Air Ambulance Task Force has created the following recommended safety measures:
    a. Stricter weather guidelines
    b. Night vision goggles
    c. Instrument-rated pilots and aircraft
    d. Dual pilots
    e. Enhanced pilot minimum qualifications
    f. Better usage criteria

C. FAA guidelines
1. All aircraft fall under one or both of the following guidelines set forth by the FAA:
    a. Title 14 Code of Federal Regulations (CFR) Part 91
        i. Governs operation of all aircraft within the U.S., including waters within three nautical miles of coast
        ii. Includes all aircraft
        iii. Includes general aviation (private) aircraft (less restrictive rules)
    b. Title 14 Code of Federal Regulations (CFR) Part 135
        i. Governs operations of all commuter or on-demand commercial operations
        ii. Stricter than guidelines for 14 CFR Part 91
        iii. Apply to almost all air medical operators
2. Differences between two sets of guidelines include:
    a. Minimum weather conditions in which aircraft is allowed to operate
        i. 14 CFR Part 91, “Basic VFR Weather Minimums,” states helicopters must remain clear of clouds when operating less than 1,200 above ground
        ii. 14 CFR Part 135 guidelines specify that HEMS aircraft must have weather minimum of at least 1,000 ceilings and 3 miles of visibility
        iii. Discrepancy causes potential major safety hazard
    b. If flight is unable to be flown under 14 CFR Part 135 weather minimums for the complete flight, the flight should not be attempted
        i. Review of 55 HEMS accidents from January 2002 to January 2005 found that 10 flights crashed while operating under 14 CFR Part 91 weather minimums
3. For purposes of the CCTP, only Part 135 is relevant as all commercial operators must abide by Part 135 regulations
    a. Only a few government operators can operate solely under Part 91
4. FAA also requires that air medical transport programs designate someone as operational control
    a. Term usually given to chief pilot or operational manager for an air medical program
    b. Denotes the person with ultimate authority to initiate, conduct, and terminate EMS mission

D. Weather-related issues
1. FAA states the following weather requirements in FAR Part 135, Section 135.201: Except when necessary for takeoff and landing, no person may operate under VFR
    a. An airplane:
        i. During the day, below 500 feet above the surface or less than 500 feet horizontally from any obstacle; or
        ii. At night, at an altitude less than 1,000 feet above the highest obstacle within a horizontal distance of 5 miles from the course intended to be flown or, in designated mountainous terrain, less than 2,000 feet above

the highest obstacle within a horizontal distance of 5 miles from the course intended to be flown; or

b. A helicopter:
   i. Over a congested area at an altitude less than 300 feet above the surface

2. CAMTS has established weather guidelines that exceed FAA requirements and have been accepted by many air medical providers; they consider several variables, including:
   a. Local area response
   b. Crosscountry response
   c. Nonmountainous and mountainous areas
   d. Day light, night with high light, and night with low light

E. Crew safety precautions
1. CAMTS strongly emphasizes need for adequate crew rest and ongoing safety precautions, both of which affect CCTPs and patients
2. CAMTS suggests the following standards for all CCTPs:
   a. Shifts longer than 24 hours are discouraged.
   b. Personnel should have at least 8 hours of rest before any shift longer than 12 hours.
   c. Personnel should not be on duty more than 16 hours within any 24-hour span.
   d. Crew members who must work longer than 16 hours must have the right to take an unscheduled break.
3. Other CAMTS requirements adopted for pilots include standards indicate that pilots must have the following:
   a. A minimum of 2,000 total flight time hours, with 1,500 of the hours in a helicopter
   b. 1,000 hours qualified as pilot-in-command time
   c. 200 hours of night flying
   d. A minimum of 500 hours of turbine time, with 1,000 hours encouraged
   e. 5 hours of geographic orientation with another pilot before accepting a mission alone

XIII. The Air Medical Crew

Time: 3 Minutes
Slides: 61–62
Lecture/Discussion

A. Being part of the air medical crew is competitive.
1. Consider the following challenges:
   a. Air medical personnel must have flight experience, but the only way to obtain it is to be part of the crew.
   b. Most air medical services routinely have between 10 and 50 qualified applicants for one flight position.
   c. Within the medical industry, a flight position is one of the most difficult to obtain.
2. Flight team members must be clinically competent and prepared to deal with a myriad of medical and traumatic emergencies.
   a. May be called to scene because of their clinical expertise, rather than simply for patient transport

b. Must be willing to obtain numerous advanced certifications to care for the most critical patients

B. Air medical crew configuration
1. Best crew configuration is the one that is able to offer the most optimal care to the patient.
    a. Many variations exist; none have been proven to be the best overall
2. Air medical transport improves mortality rates when HEMS crew capabilities exceed that of noncritical care ground personnel.
    a. Programs operating under physician-level standing protocols experience lower mortality rates.
    b. Programs that operate under aggressive protocols with advanced scope of practice have the best opportunity to improve patient outcome.
    c. Continued practice, experience, and education combined with aggressive medical protocols to lead to better patient outcomes
3. Most common configuration in air medical environment is flight nurse/flight paramedic
    a. Flight nurse well-experienced in critical care environment
    b. Flight paramedic well-adapted to airway management and emergency scene management
    c. Both proficient in dealing with comorbid or multitrauma patient
4. Other configurations include:
    a. Nurse/respiratory therapist configuration
        i. Offers advantages in airway management
    b. Nurse/nurse combination
        i. Controversial as nurses may not have necessary prehospital and airway management experiences
    c. Paramedic/paramedic combination
        i. Also controversial as does not provide advanced scope of practice provided by flight nurse
    d. Perfusionists may be added if air medical service transports patients on balloon pumps
    e. Physicians may be included in a few air medical transport teams
        i. However, increased scope of practice of flight team personnel has shown addition of physician onboard does not significantly increase patient survival

C. Air medical crew employment
1. Working on a rotor-wing or fixed-wing aircraft is demanding and requires personnel to be highly proficient in a myriad of prehospital and critical care skills.
    a. Flight crew personnel encounter critical patients on almost every mission.
2. The industry has minimums and recommendations for training flight nurses, flight paramedics, and flight respiratory therapists.
3. Individual states may require additional training.

XIV. Rotor-Wing Operations

Time: 12 Minutes
Slides: 63–70
Lecture/Discussion

A. Rotor-wing aircraft are generally operating at maximum capacity when they complete 1,000 flights or more per year.
    1. A service that completes 1,000 flights has likely has at least 1,500 requests for services
B. Standby
    1. State of readiness in case of potential request for response by rotor-wing provider
        a. Initiated by HEMS provider upon notification of potentially life-threatening emergency call
    2. When placed on standby, air medical crew performs following tasks:
        a. Check weather suitability
            i. May decline mission if weather does not meet FAA minimums discussed previously
        b. Gather necessary equipment
        c. Conduct preflight inspection on aircraft
        d. Obtain landing coordinates and appropriate radio frequencies
        e. Wait at aircraft until they are launched or cancelled
    3. Under auto-launch protocol, aircraft placed on standby launches en route to scene instead of waiting for formal launch request
        a. Common for responses that involve distances of greater than 30 nautical miles
        b. Often not practical given considerable cost and inherent hazards
    4. Some EMS make HEMS standby request automatically as part of dispatch protocol, depending on call's severity
        a. If scene location is greater than 30 miles, aircraft will usually launch
C. Establishing a helicopter landing zone
    1. Landing in a hastily created landing zone is one of the most dangerous aspects of rotor-wing air medical.
        a. Predesignated landing zones preassessed for hazards is the ideal situation
        b. Many fire departments and EMS agencies have established numerous landing zones throughout response areas
            i. Coordinates recorded and given to dispatch center
    2. Factors to consider for establishing landing zone:
        a. Should be at least 100′ x 100′
            i. Some programs require 60′ x 60′ during day; 100′ x 100′ during night
            ii. Landing surface does not have to be this wide, but site needs to be clear of any obstacles for at least 100′ x 100′
        b. Should be free of the following obstacles:
            i. Wire (no high-tension power lines within half a mile)
            ii. Towers (no television, radio, or cellular towers within half a mile)
            iii. Trees
            iv. Signs and poles
            v. Low-height ground obstacles (stumps, small trees, fence posts, mailboxes, rocks)
            vi. Buildings
            vii. Vehicles
            viii. People
            ix. Animals
            x. Loose debris (traffic barrels or trash)
        c. Should be a hard surface to facilitate moving stretcher to and from aircraft with fewer personnel
        d. Should have less than a 5° slope to avoid the danger of the blades coming in contact with an object or a person on a slope

    e. Should ideally be outlined by four markers, one on each corner of the landing zone
        i. Cones for daytime operations; lighted markers for nighttime operations
        ii. May also use vehicles to block off access to the area
        iii. When using emergency vehicles to block off zone, it is recommended that they have all of their emergency lights on assist aircraft
        iv. Do not use strobe lights or flammable lights (flares)
  3. Landing zone personnel should be taught proper hand signals to assist helicopter with landing

D. Precautions after landing the helicopter
  1. All landing zone personnel should wear eye and ear protection at all times to protect themselves from flying debris and the noise of the aircraft.
  2. Secure all loose items, including:
    a. Helmets
    b. Equipment
    c. Sheets from patient stretcher
  3. Never operate near tail rotor
    a. This is area of greatest hazard on aircraft; follow all precautions
    b. When paramedics, EMS, other medical personnel are loading patients, one member of the flight team (usually pilot) should stand between auxiliary personnel and tail rotor
    c. No personnel other than flight crew should be aft of aircraft's loading door
    d. No one should approach aircraft unless directed by flight crew
    e. Approach only from front right side of aircraft in full view of pilot.
    f. Realize that every aircraft is different in terms of blade dip
    g. Always follow pilot's directions

E. Hot loading, or loading patient into a helicopter while it is running sometimes necessary
  1. Factors related to hot loading include:
    a. Type of landing zone
    b. Type of helicopter
    c. Scene time
        i. May be necessary when there is no time to power-down and power-up helicopter, or question of being able to restart helicopter
  2. Requires observance of certain precautionary measures.
    a. Each service must follow specific, consistent hot load procedure that considers helicopter's design
    b. Discuss type of load before landing at scene
    c. Wear proper personal protective equipment
  3. Safeguards must be in place to ensure no one approaches tail rotor.
  4. Other considerations for hot loading include:
    a. Crew must determine safety of before performing
    b. Pilot and at least one other person must remain in helicopter during
    c. Helicopter must not be approached until crew member signals to do so
    d. Approach aircraft in crouched position
    e. On slope and if conditions permit, approach aircraft from downhill side
    f. Assisting ground personnel exit aircraft after patient is loaded

XVI. Aircraft Safety and Survival

Time: 14 Minutes
Slides: 71–79
Lecture/Discussion

A. Safety training
  1. All flight team members must have initial training on aircraft safety and survival and then undergo refresher training annually.
     a. Every flight team member must be familiar with different types of aircraft operated by program
     b. Flight team members should ideally also be familiar with different types of aircraft used by programs in nearby areas
     c. Hospital-based flight team members will routinely assist with aircraft loading and unloading on hospital's helipad
  2. A comprehensive safety training program needs to address following issues:
     a. Aircraft familiarity
     b. Behavioral characteristics of aircraft during hard landing sequence/crash landing
     c. Equipment storage
     d. Personal protective equipment
     e. Egress training

B. Daily safety briefings should be held at the beginning of each scheduled shift.
  1. Briefings should include:
     a. Daily plan
     b. Crew member duties
     c. Equipment and aircraft issues
     d. Weather expectations
     e. Emergency situations
  2. Pilot in command also briefs crew members on weather forecasts and determines if crew will be ready to respond or if a weather check is needed before making a "go or no go" transport decision

C. Crashes and hard landing operations
  1. Unscheduled landing may be a normal landing that occurs at a point other than intended landing site; primarily due to either:
     a. Unexpected weather (IFR situations with a VFR-rated pilot or aircraft)
     b. Non–life-threatening mechanical problem with the aircraft
  2. Hard landing occurs when aircraft contacts ground harder than normal, possibly resulting in injury or aircraft damage; can result from any of the following:
     a. Engine failure
     b. Mechanical failure
     c. Wire strike
     d. Pilot error
     e. Incapacitated pilot
  3. Rescue aided by use of radios and emergency locator transmitters
     a. International mayday frequency of 121.5 MHz is always monitored by air traffic controllers, military agencies, search-and-rescue groups
     b. Emergency locator transmitter (ELT) on board
        i. FAA mandates for most aircraft operators
        ii. Activate with 4g of force in event of crash and transmit distress radio beacon to satellites
  4. To prepare for a crash or hard landing with some warning ahead of time:
     a. Shut off

   b. Elevate head of stretcher, if it contains patient, to 30° or per manufacturer's instructions
   c. Tighten seat belts and helmet straps
   d. Ensure freedom from entanglement hazards, such as communication system or monitor cables and cords
   e. Brace for impact, ideally maintaining one hand on aircraft door to maintain point of reference for exit post crash
5. The following rules should be practiced until they become instinctive:
   a. Never exit a crashed helicopter until the blades stop turning.
   b. After exiting helicopter, all crew members should meet at 12 o'clock position before attempting to rescue crew members or patients
      i. Individual safety comes first. If there is fire or debris at the 12 o'clock position, crew members should assemble at a safe location nearby.
   c. If pilot is incapacitated, crewmembers should be proficient in operating throttle, fuel, and battery switches to decrease the likelihood of fire and explosions
   d. In event of crash into water, crewmembers should place one hand on the ceiling of the aircraft to use as a reference point
      i. Follow your bubbles as they always lead to the surface
   e. Also use reference points in darkness and when smoke is present
6. Follow steps to deal with the aftermath of a hard landing
   a. Ensure all motion of aircraft has stopped before attempting to exit
      i. Slowly count to five after aircraft comes to complete stop
   b. Attempt immediate rescue of other flight team members.
   c. If immediate rescue not possible, proceed to safe distance at a predesignated location
   d. Treat injured persons and make plans for rescue attempt for those still inside
   e. Once aircraft has cooled and immediate fire threat resolved, develop plan of action
      i. Salvage survival gear or usable pieces of wreckage
7. Safety and survival after a crash increased by survival training programs that include minimum elements:
   a. Location and contents of the aircraft survival bag
   b. Directions for construction of a temporary shelter to protect crew members and patients from the elements.
      i. Evaluation of suitable location free from future dangers
      ii. Basic parts (roof, floor, walls)
      iii. Assembly of temporary shelter using limited resources
   c. Survival priorities using rule of 3s:
      i. 3 minutes without oxygen
      ii. 3 hours without shelter
      iii. 3 days without water
      iv. 3 weeks without food
   d. Unless help is immediately visible, stay within close vicinity of the aircraft to aid rescuers
8. Six important tips for increasing the survival odds:
   a. Conserve strength, fluid, and heat by moving as little as possible and as slowly as possible.
   b. Prepare emergency signals, make shelter, inventory supplies, and ration all food.
   c. Guard against infections and intestinal disorders.
   d. Do not travel in adverse weather if injured or confused.
   e. Stay with the downed aircraft.

    f. If you must travel, do not separate parties and mark your path, leave messages behind, and keep a log.
9. The ability to signal is vitally important in increasing survivability.
    a. Increase your visibility by staying near aircraft wreckage or moving to a nearby clearing or higher elevation.
10. Prevent dehydration
    a. Find potable water once shelter has been obtained.
    b. Use following guide:
        i. At temperatures below 100°F (38°C), drink 0.5 L of water every hour
        ii. At temperatures above 100°F (38°C), drink 1 L of water every hour
11. Decrease fear and panic through:
    a. Training
    b. Faith in your equipment
    c. Faith in the technical knowledge of the immediate superior
    d. Concentration on the task to accomplish
    e. Trust in providence/God
12. Immediately after crash, once you are in a safe area and have rescued all survivors, sit down and relax.
    a. Force yourself to take six slow deep breaths.
    b. Consider your situation and plan out exactly what you need to do.
    c. This process begins conservation of physical and mental resources, increasing survival chance by 50%!

D. Water ditching
1. Statistics from NTSB report
    a. Of the 63 pilots who died after crash water ditching, 78% died of drowning inside aircraft; only 20% died as a result of injuries or because of nonfatal incapacitation
    b. Approximately 30 to 40 general aviation ditchings occur annually in US coastal or inland waters
    c. Most crew members have less than 15 seconds' notice aircraft is going to ditch
2. Follow previously discussed crash procedures if ditching is imminent
3. Airplanes and helicopters act differently in water.
    a. Airplanes usually float for several minutes before sinking.
    b. Helicopters usually capsize because they are top-heavy
4. Once the aircraft makes contact with the water, follow four important steps to successfully egress the aircraft:
    a. Resist urge to exit aircraft immediately, but count to five to ensure all motion has stopped
    b. Identify and open exit using deliberate offset method
    c. Grab hold of familiar reference point in the direction of your exit
        i. Do not release belt until you have secure grip on reference point to avoid disorientation
        ii. Do not let go until you have found another reference point
    d. Once exit is open, keep hold on reference point, release seatbelt with other hand, and pull yourself through your exit.
        i. Do not kick as you exit the aircraft to avoid getting stuck in wires or debris.
        ii. If stuck, don't panic, try backing up and rotating
        iii. Be prepared to encounter aviation fuel in water, which can blind you.
        iv. Continually exhale as you ascend to surface to prevent barotrauma

v. Follow your bubbles to find surface or swim opposite of direction that causes pressure to build in your ears

