

CHAPTER 2

Air medical services

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Introduction

Air medical transport includes scene transport (typically direct to tertiary care), interhospital transfer of high-acuity patients, and long-distance repatriation. Although most of the direct interactions between ground EMS and air medical services providers occur as a result of scene responses, the medical director must also consider the generally larger role that emergency interhospital air transport plays in the local and regional system of care. In both cases it is imperative to have a well-integrated and aligned system plan for air medical services.

The primary objective of air medical transport is to give patients who are not proximate to advanced or critical care the same chance of survival as patients to whom care is immediately available. The role of air medical transport in time-dependent disease such as traumatic brain injury, cardiac emergencies, stroke, sepsis, and major trauma continues to evolve. The historical role of air medical transport in trauma “medevac,” developed in the military, has transformed from primary “time critical” to “care critical” in which the use of a unique vehicle, team, and technology not tied to roads extends the reach of tertiary care by bringing specialized care not generally available from EMS directly to the patient with subsequent transport to tertiary specialist care. The geographic reach of air medical transport simultaneously decreases time to advanced resuscitation and needed procedural intervention and decreases the out-of-hospital time for a potentially unstable patient. The extent of the reach is profound, with studies both within the US and internationally highlighting a 1:6 ratio of helicopter EMS (HEMS) to ground ambulance in an urban US state, to a 1:50 ratio in the Western Cape of South Africa [1,2]. In essence, the evolving air medical transport model supports both the rural safety net and regionalization through delivering the care and technology of the tertiary center direct to the patient, whether on scene or in a community hospital. The goal is to improve cost-effectiveness and outcomes for patients and the emergency care system.

History to current situation

Air transport of injured patients is documented to have occurred by fixed-wing aircraft as early as 1915, approximately 12 years after the Wright brothers’ first flight. The US Army Air Corps initiated the first regular use of medical aviation in 1926, using a converted airplane to transport patients from Nicaragua to an Army hospital in Panama, 150 miles away. The routine use of air medical transport from hospital to hospital dates to World War II, as does the first use of scene evacuation of US soldiers from the site of injury, in what was then Burma [3].

Although the helicopter was developed during World War II, it was not routinely used for patient transport until the Korean War, and even then not by design but in response to road travel conditions that prevented transport by ground ambulance. Injured soldiers were strapped to stretchers outside the aircraft with the intervention limited to rapid evacuation to a field hospital rather than en route stabilization [4]. Air medical evacuation fully matured in the Vietnam War with over 800,000 injured soldiers cared for rapidly by field medics followed by a “dust-off” helicopter evacuation. Mortality decreased to the lowest rate of any major sustained conflict to that time. The forward operating medical units were then connected by specialized fixed-wing aircraft to bring injured soldiers to more centralized definitive care and later to specialized hospitals. The combination of rapid intervention near the battle zone, followed by rapid transport to a forward surgical hospital, and a continued chain of transport to specialized medical centers, is now the standard of care for military operations. From Iraq or Afghanistan, wounded US soldiers arrive via a flying hospital to centralized care, such as Ramsden, Germany, within 12–18 hours of injury. The greatly increased lethality of improvised explosive devices has dramatically changed the battlefield and increased the death to injury ratio; nearly 100% of these types of blast injuries would have been lethal in previous wars (Table 2.1).

The 1996 Accidental Death and Disability white paper [5] brought home the potential use of helicopter evacuation in a

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Table 2.1 Sequential survival improvement in US war experience

	Deaths per 100 injured
Revolutionary War (1776)	75
US Civil War (1861)	50 (first system of care)
World War I (1917)	8.5 (Thomas splint)
World War II (1941)	4.5
Korean War (1950)	2.5
Vietnam War (1964)	<1 (58,000 deaths)
Persian Gulf War (1990)	<0.5
Operation Enduring Freedom Afghanistan 2001–2012 [76]	<0.015

Source: US Army and US Army Military History Institute.

formalized trauma system. The paper detailed a lack of coordinated response to injury, including the observation that “helicopter ambulances have not been adapted to civilian peacetime needs.” Building from this landmark paper in 1970, Dr R. Adams Cowley partnered with the Maryland State Police and obtained a National Highway Traffic Safety Administration grant to purchase a Bell Jet Ranger helicopter to transport injured trauma patients directly from injury scenes to the newly created shock-trauma unit at the University of Maryland Hospital, the first civilian unit of its kind.

In 1972 the first hospital-based helicopter program was initiated at St Anthony’s Hospital in Denver, Colorado. The primary goal of this program was to provide interhospital transport of critically ill patients, linking community hospitals with tertiary care, but scene medevac response was also incorporated into operations. In parallel with the evolution of specialized trauma centers, by 1978 almost 20 new helicopter services had been initiated across the United States, primarily operated by individual trauma centers.

Each subsequent decade since then has seen a doubling of the US medical helicopter fleet [6,7]. Growth has continued steadily in the United States and around the world, with a second era of rapid growth from the late 1990s and more recently in the period from 2003 in which the number of helicopters in the US has more than doubled, in large part due to improved reimbursement from Medicare and unaligned regulatory oversight between the federal Department of Transportation and state EMS and health agencies [7]. Each rapid rise in helicopter deployment has tragically been associated with an increase in the number of fatalities.

With the continued regionalization of tertiary centers, the advent of critical access hospitals in rural communities, and the extension of HEMS in rural areas, the numbers of air medical services programs continues to grow. By the end of 2012, the ADAMS database project identified 302 air medical programs in the United States operating 946 dedicated rotorcraft from 776 bases, and 314 dedicated fixed-wing aircraft operating from 171 bases [8]. While the overall numbers are smaller, the rate of growth in Canada and Europe is similar to the US, with more

rapid expansion in Eastern Europe, the Middle East, China, India, and Brazil.

Based on data from the 2011 National EMS Assessment and the Government Accountability Office, collectively, air medical transport represents approximately 2% of all ambulance transports in the United States [9,10]. Although individual HEMS programs’ mission profiles vary widely by provider, on average (in the United States), a full-capability HEMS program will perform 54% interhospital transports, 33% scene runs, and 13% “other” mission types (e.g. neonatal, pediatric, transplant related) [7,11]. Growth is expected to continue in the years ahead due to other structural changes in the health care system, especially affecting rural areas.

Factors affecting this growth include the following.

- Closure of hospital emergency departments, which have declined in number from just over 5,000 in 1992 to approximately 3760 in 2011, a trend that is expected to continue [12,13,14,15].
- A reduction in the number of Level I and Level II trauma centers from 600 in 2008 to 445 in 2011, a trend that is likely to continue despite the addition of new trauma centers in new growth urban centers [11,16,17].
- Reduction in the availability of specialist care in rural areas, particularly neurosurgeons.
- The continued concentration of specialist care into hub-and-spoke systems [18].
- Closure of rural hospitals due to financial pressures, conversion to critical access status, or decertification of critical access status [19,20].
- Emergency department closures and hospital overcrowding with increasing capacity issues for critical care and specialty beds often causing hospitals to divert EMS patients [11].

These structural changes in health care systems are particularly problematic in rural areas with the least resources and infrastructure. A 2005 study identified that while 84% of all US residents have access to Level I or II trauma centers within 60 minutes, 27% of these residents require HEMS transport to achieve timely access. More problematic is that 42.8 million Americans live in rural areas without timely access to specialist care [16]. The most current update from the Centers for Disease Control illustrates some progress, with close to 90% of the population now within 60 minutes of a trauma center, in part due to the addition of medical helicopters in previously unserved areas [21,22].

Unfortunately, while 19% of the US population resides in rural areas, 55% of fatal motor vehicle crashes occur in rural areas, a rate nearly double that of similar accidents in suburban or urban areas [23]. Despite the gains of modern EMS, “highway fatalities are a major epidemic in this country; and most occur on rural roads involving rural residents. Only one-fifth of the nation’s population lives in rural areas, yet two-fifths of the vehicle miles traveled and three-fifths of all fatal crashes occur there” [24].

Outcomes

While there are unanswered questions about HEMS' cost-effectiveness, there is a body of evidence addressing HEMS' potential effects in a variety of situations [25,26,27]. It is important to try to identify those cases in which benefit is most likely to occur, so that resources may be wisely used. Though classic evidence from decades ago has been bolstered by more recent demonstrations of HEMS cost-effectiveness, HEMS will likely continue to be perceived, correctly or not, as costly [1,28,29]. At a minimum, HEMS constitutes a high-visibility allocation of resources. Because few would argue that HEMS benefit is always predicated solely on time and logistics, any consideration of HEMS outcomes evidence touches on the broader subject of advanced levels of care in the prehospital setting. The HEMS crews' extended practice scope offers circumstances well suited for assessing high-level ALS care and its potential benefits. For example, major analysis of prehospital intubation has provided important insight into, and unintended demonstration of, HEMS' salutary effect on outcome [30,31,32]. Other investigation suggests advanced airway skills and hemodynamic management (such as fluid administration) combine to contribute to better HEMS-associated outcomes [33].

The idea of HEMS utilization to expedite care for patients with time-critical injury and illness is not new. A significant body of literature exists that demonstrates HEMS utility for secondary (interhospital) transport of trauma patients. Loss of HEMS availability has been recognized as a potentially important factor causing increased trauma mortality in patients presenting to non-Level I centers [34]. Additionally, emphasis has grown in the use of HEMS to expedite care for patients with time-critical medical problems. As for trauma patients, HEMS has been used to extend the reach of hospitals capable of delivering advanced time-sensitive care for acute myocardial infarction and stroke [35,36]. With careful attention to training, some regions have successfully incorporated HEMS activation by scene ground EMS providers, for selected patients with acute coronary or stroke syndromes [37,38].

Helicopter EMS has also been suggested to potentially improve outcomes for selected patients with other diagnoses, ranging from ill neonates to high-risk pregnant patients and cases of ruptured abdominal aortic aneurysms [39,40,41]. While numbers of these patient populations tend to preclude robust outcomes analysis in retrospective studies, the occasional utility of HEMS for these types of patients is acknowledged by accepted consensus-based air medical transport guidelines [42].

Possible HEMS benefits to systems

Whether the EMS region is dealing with increased interhospital transports as a result of implementation of "inclusive" trauma systems or more frequent HEMS use for cardiac or stroke patients, air medical transport clearly has a vital role in

regionalization of care [35,43,44]. Patient-centered thinking should be paramount, but there are other "system-based" logistic and economic considerations to HEMS utility.

Extension of advanced care throughout a region

Some of the above-mentioned benefits to patients also apply as advantages to regions and EMS systems. For example, HEMS may facilitate an EMS system's ability to provide for early ALS in isolated or difficult-to-reach areas that would otherwise be poorly covered [45]. Analysis of the economics of covering a widespread region using a small number of aircraft, compared to a large number of ground vehicles dispersed in such fashion as to assure equivalent response times, is complex. Preliminary analysis has suggested that air medical transport is actually no more expensive than the multiple ground unit alternative [1].

Helicopter EMS may offer benefits even to patients already at smaller hospitals. This is most likely true in rural settings where local facilities may be staffed by individuals with relatively little experience with managing trauma or other critical illnesses. In trauma, for instance, the lack of ready availability of surgical subspecialists is translating to an increasing inability of non-Level I centers to care for injured patients [46]. The skills available among an air medical crew, including airway management, are sometimes called upon at small rural hospitals to help stabilize trauma patients prior to transfer.

Provision of ALS "back-up" for parts of an EMS system with limited ALS coverage

In addition to providing ALS-level care to geographically remote areas, HEMS can offer a means for relatively isolated areas to get patients to tertiary care centers without necessitating removal of scarce ground ALS resources from the region. At least one paper has specifically identified that one major reason why rural areas use HEMS is that they perceive that they are unable to cope with losing their limited ground ALS coverage for what can be a 5-hour round trip [47].

Use of air medical services for patients with non-critical illness or injury may not always be in the best interest of the system as a whole. However, some rural and frontier regions have come to rely on air transport as a means to assure they will not lose ALS coverage for hours every time a patient requires ALS-level transport to a distant receiving hospital. As an added benefit, the use of helicopters for longer-distance transports of critical patients can reduce the risks associated with prolonged lights-and-siren ground EMS transports [48].

Minimization of transport times and direct transport to specialized centers

The use of AMS for some transports, and its resultant streamlining of out-of-hospital times, can benefit EMS systems as well as individual patients. Examples of such benefits include faster turnaround and greater availability for transport. The overall reduction of transport time should also be viewed as a system benefit.

One purpose of the EMS regional authority is to provide the optimal system intended to get patients where they need to be. In many cases, this will be the closest facility; in such circumstances ground transport will usually be a preferable alternative. However, some patient populations may benefit in selected cases from direct transport to specialized centers for trauma, cardiac, stroke, pediatrics, or other diagnoses. While decisions as to exactly which patients need to go directly to “Level I” care are sometimes difficult, the fact remains that there are data suggesting that for some cases, HEMS direct transport to high-level care increases a regional system’s ability to improve its patients’ morbidity and mortality [36,44,49,50].

Transport flexibility in overloaded hospital systems

The helicopter offers advantages of being flexible with respect to receiving center; not much time is lost in changing the receiving hospital destination if it is close by, and the helicopter’s speed and range can bring distant hospitals into play if local facilities are overloaded. Though the obvious benefit to this (for EMS systems) relates to unusual circumstances such as disasters [51,52], the current environment of hospital and ED overcrowding renders the receiving hospital flexibility of HEMS a potentially useful thing.

With the advent of increasing problems due to ambulance diversion, the transport flexibility provided by HEMS has additional advantages. Since ambulance diversion problems can result in a given ground EMS unit being out of service for an extended period (i.e. while it is performing a longer-distance transport) [53], the aircraft may be able to “back up” the ambulance by either performing the transport or being available while ground EMS is out of service. With increasing evidence demonstrating that trauma mortality rates increase when trauma centers’ EDs are on diversion [54], the HEMS unit can serve as a life-saving method for “decompressing” the overtaxed ED. In fact, the utility of HEMS to distribute the patient load, already noted for its potential value in disaster and mass casualty incidents, may be applicable in some areas’ Level I trauma centers on an increasingly frequent basis [23]. The loss of availability of rotor-wing transport has been recognized as a potential mediator of increased mortality due to decreased capability to execute interhospital transports [55].

Integration

Although an effective air medical services (AMS) system is now often assumed to be part of emergency care, from the outset, integration of air services into the larger EMS system has been problematic. Like hospital emergency departments, AMS represents a relatively scarce resource with a significant capital cost for infrastructure and maintaining readiness. A recent study indicates that fixed costs are on average 84% of total AMS provider costs. As with the provision of all ambulance service in the

United States, costs are generally allocated per patient transport. The cost of AMS is expensive in comparison with ground ambulance transport, generally by a factor of 4–10 times. Hence integration and appropriateness of use are essential determinates for local system effectiveness [56].

Further complicating the picture is the CMS 2002 national ambulance fee schedule which has driven much of the growth due to a significant increase in helicopter reimbursement concurrent with a much lower relative value units (RVU) for ill-defined ground specialty care transport. This has led in many areas to a loss of ground critical care capacity and an increase in helicopter capacity [57].

Total cost of care from onset of injury or illness to discharge, however, is more important in the overall health care system. Consequently, it is often a mistake to make an isolated comparison and equate the lower charge with cost-effectiveness and the higher charge with cost-prohibitiveness [58]. The challenge for the medical director, faced with uncertainty in an emergency patient, is to align and integrate the air medical services resource into the entire emergency care system in order to maximize outcome and cost-effectiveness benefit.

This is often not a simple challenge. As noted in a 2007 national white paper:

Integrated air medical resources are an essential component of contemporary EMS systems. Today, financial pressures, insurance issues, changing federal regulations, and competition all are forcing changes, consolidation, and in many cases reduced services or closure of emergency departments, trauma centers, hospitals, and specialty physicians. These factors have contributed to the increased use of AMS to move patients to specialty centers, particularly from outlying areas. As with EMS in general, there has been a general lack of overall system planning and design to guide the development and implementation of needed AMS. Mechanisms that might provide such guidance, such as state EMS or health regulations, certificate of need (CON) processes, and federal aviation and healthcare regulations, sometimes conflict with one another, providing a jumble of uncoordinated hurdles to AMS providers [15].

The 2006 Institute of Medicine (IOM) report on EMS, *Emergency Medical Services at the Crossroads*, noted the challenges of federal and state regulatory jurisdiction, and calls for the integration of air medical services into regionalized EMS systems. This concept was solidified in a 2007 consensus document from the NAEMSP, the National Association of State EMS Officials, and the Association of Air Medical Services. It suggests a course of action for integration of air services to become reality [59]. Medical directors must prospectively and retrospectively manage the medical oversight and integration of air medical services. The consensus paper identifies seven principles essential to effectively integrating such providers into the prehospital and hospital emergency care system.

- States must assume regulatory oversight of the medical aspects of air medical services that advertise services and/or operate in their states, including dispatch and communication coordination [11].

- Air medical services are essential elements of contemporary EMS systems [15].
- EMS systems should strive to ensure that every patient having an emergent condition has access to air medical and ground critical care transport with transport type dictated by case-specific objective evaluation of distance, circumstances, and the logistics of transport [16,21].
- Air and critical care medical transport represent particular expertise in the delivery of acute emergency care, often with non-physicians practicing near a physician's scope-of-practice level. As such, clinical care provided by non-physicians should be overseen by physicians who practice and have expertise in emergency, critical care, and critical care transport medicine [60,61].
- All medical transport systems should use the national consensus medical guidelines for both dispatch and postmission use review [42].
- Air medical services should operate at a level consistent with the standards developed by the Commission on Accreditation of Medical Transport Systems (CAMTS) [62].
- Air medical transport providers should operate at the highest levels of safety possible, and they should implement and maintain comprehensive risk management and safety systems management programs [63].

As noted in Table 2.2, there is no ready correlation between the number of helicopters in a state and the land mass and population. Further, the number of helicopters is unrelated to improvements in reduction of motor vehicle fatalities [64]. More problematic, the 20% growth rate is unevenly distributed and growth since 2003 has predominantly occurred in areas already served by HEMS [65]. While there is no accepted calculation for the "right" number of helicopters to serve a population or provide geographic coverage, only two policy-level studies have been undertaken in the US to examine coverage, appropriate use, system design, and cost benefits [66,67].

With ambulance reimbursement tied to patient transport, there is a significant incentive for supply to drive demand. As the current organization of the HEMS system is more tied to market forces than health care planning, physician medical directors need to pay close attention to appropriate use decisions in the face of clinical uncertainty. A 2009 study in Arizona found a combination of high rates of discharge from the ED following flight concurrent with high probability of survival and low Revised Trauma Score (RTS) [68].

Without thoughtful and consistent integration, helicopters can become the "medical centerfold" in a system, increasing the costs of care without improving outcomes. Although historically "transport was treatment," the evolving model requires careful consideration of value added at each provider level. As with all medical interventions, an effective system recognizes that EMS and air medical transport are medical interventions and must be "physician proscriptive events." Essential elements of medical oversight include the following.

Table 2.2 2005–2012 summary of helicopter assets by state (www.adamsairmed.org)

State	Helicopters 2005	Helicopters 2012	Population	Square miles
AL	9	16	4,779,736	52,423
AK	32	33	710,231	656,425
AR	12	13	2,915,918	53,182
AZ	50	56	6,392,017	114,006
CA	72	97	37,253,956	163,707
CO	10	16	5,029,196	104,100
CT	2	2	3,574,097	5,544
DE	5	6	897,934	2,489
FL	44	43	18,801,310	65,758
GA	19	27	9,687,653	59,441
HI	6	4	1,360,301	10,932
ID	10	8	1,567,582	83,574
IA	9	11	3,046,355	56,276
IL	19	26	12,830,632	57,918
IN	15	20	6,483,802	36,420
KS	10	12	2,583,118	82,282
KY	20	30	4,339,367	40,411
LA	9	14	4,533,372	51,843
MA	4	4	6,547,629	10,555
MD	18	18	5,773,552	12,407
ME	2	2	1,328,361	35,387
MI	12	12	9,883,640	96,810
MN	12	17	5,303,925	86,943
MO	30	33	8,988,927	69,709
MS	5	10	2,967,297	48,434
MT	4	5	989,415	147,046
NC	13	22	9,535,483	53,821
ND	2	3	672,591	70,704
NE	6	6	1,826,341	77,358
NH	2	3	1,316,470	9,351
NJ	5	13	8,791,894	8,722
NM	10	10	2,059,179	121,593
NV	6	8	2,700,551	110,567
NY	28	32	19,378,102	54,475
OH	28	40	11,536,504	44,828
OK	14	19	3,751,351	69,903
OR	4	9	3,831,074	98,386
PA	37	47	12,072,379	46,058
RI	0	0	1,052,567	1,545
SC	8	8	4,625,364	32,007
SD	4	5	814,180	77,121
TN	24	31	6,346,105	42,146
TX	61	75	25,145,561	268,601
UT	8	12	2,763,885	84,904
VA	21	23	8,001,024	42,769
VT	0	0	625,741	9,615
WA	10	10	6,724,540	71,303
WI	12	13	5,686,986	65,503
WV	5	11	1,852,994	24,231
WY	1	3	563,626	97,818
DC	3	4	601,723	68
Totals	753	946	308,745,538	3,787,419

Source: 2005–2012 Summary of Helicopter Assets by State (www.adamsairmed.org)

- Patient selection/dispatch criteria guiding the use of air medical services, to include explicit criteria such as the NAEMSP

guidelines with requirements for providers to measure and report compliance.

- Communications/integration of the AMS resource within the EMS system, to include a clear and consistent method for requesting a helicopter enhanced by regional protocols for early or simultaneous HEMS response.
- The provision of rapid information to the requestor regarding availability and estimated time of arrival in order to optimize field and interhospital care and transport. Comparing provider ETAs with actual arrival times is an essential system performance measure [61].
- Communication with HEMS center, EMS personnel at the scene, and emergency personnel who are establishing the landing zone. This should be available while responding to the scene and include stand-down criteria for the HEMS service.
- Regional education provided by the air medical service to all EMS agencies in their jurisdictions regarding the service, when and how to use it, and the management of scene safety.
- Determination of scene versus interhospital transport: the goal of an EMS system should be to transport patients requiring time-sensitive care directly to a regionally agreed tertiary destination. EMS providers must be given authority, with posttransport quality review, to initiate direct transport in order to optimize the effectiveness of time-dependent care.
- Measurement of time to definitive care as well as potential overtriage rates. Air medical services providers should participate in regional and state quality and performance reviews, including measuring the percentage of patients discharged in less than 12 or 24 hours after air medical transport, percentage with stable vital signs and low trauma scores, and those patients not requiring time-critical intervention.

Operations

As air medical services by nature cross geographic and health care catchment boundaries, physician medical directors, and physicians interfacing or providing system oversight, must be able to simultaneously understand and manage the system, not just the individual patient. Team composition and relevant scope of practice for critical care, performance characteristics of all modes of transport, selection and management of vehicles, mobile medical technology, various mission profiles, best practices in risk and safety strategies, and regulation including local, state, and federal level are all essential to a designed system. While ambulances, helicopters, and fixed-wing aircraft appear similar, team composition, scope of practice, available medical therapies and technologies, medical oversight, clinical and operational performance capability, quality, safety, and charges for services vary widely.

Clinical operations

The majority of HEMS programs fly with a crew of two medical providers (93%), with a small number using either one (3%) or three (4%) medical providers. The most common medical crew configuration is one flight nurse and one flight paramedic (67%). Less commonly used configurations are flight nurse/flight nurse (8%), flight nurse/flight physician (5%), flight paramedic/flight paramedic (5%), flight paramedic only (<2%), and flight nurse only (<1%).

A handful of programs limit their care solely to specialized interhospital transport, such as neonatal and pediatrics, and do not use personnel with prehospital training. The majority of programs that perform any scene response have a crew that includes either a flight paramedic or a flight nurse who has been cross-trained as a paramedic. Some air medical programs use supplemental staff with unique clinical skills on specific transports of patients with special medical needs. Depending on the space and lift capabilities of the particular aircraft, they may either take the place of one of the regular crew members or come on board as a third caregiver. Some examples of personnel who may be used in this fashion include perfusionists, respiratory therapists, neonatal transport nurses, pediatric transport nurses, and intensivists.

Vehicles/mode of transport

The decision to transport via rotor-wing or fixed-wing aircraft depends on a number of factors including disease diagnosis, destination, speed, distance, and weather. Helicopter flights tend to be for shorter-distance, more time-dependent emergency missions, whereas fixed-wing flights tend to be longer distance.

Helicopters

Recently, air medical services have transitioned to smaller single-engine visual flight rules (VFR; constant visual reference of the ground) aircraft [69]. Less than 10% of the current US helicopter fleet operates with instrument flight rules (IFR), which is the standard for commercial airlines. Primarily this is a cost-driven decision as the increase in the number of aircraft has resulted in fewer patients per aircraft. While all helicopters are weight and range limited, smaller aircraft and cabin size are important considerations in the availability of specific in-flight therapy and availability of specialty medical equipment. The flight radius of a light- to medium-sized rotor-wing aircraft used for medical transports is 50–175 miles, with a 100–155 kph speed. Monitoring of actual response times and longer distance flights is essential in medical oversight due to the potential need for refueling with a patient on board, which is a time and safety consideration.

Fixed-wing aircraft

These aircraft have increased range when compared with helicopters, including speed (200–300 kph) with 500 mile to transoceanic range. Launch time is generally longer than the 5–10 minute launch time for most rotor-wing aircraft, and both legs

of transport require ground ambulance transfer. This negates speed and may present additional patient risk regarding dislodged invasive medical equipment such as airways or indwelling central catheters.

Although fixed-wing aircraft have limited usefulness in truly emergency, time-dependent medical flights, they may play a role in certain emergency situations that would normally be handled by helicopter. Fixed-wing aircraft are more all-weather capable, IFR, and have deicing capability which is virtually absent outside of large military helicopters.

Space

Unlike some large military helicopters that can accommodate six or more patients, space is often quite limited in the aircraft used for civilian HEMS operations. Access to the patient is highly variable, depending not only on the model of aircraft, but also on the configuration of the medical interior of each individual aircraft.

Weight

Unlike ground transport, all aircraft are weight and space sensitive. The weight of the medical equipment, the providers, and the patients must be considered prior to every call. The weight, size, and electrical requirements of medical equipment are performance limitations. Certain models of ventilators, intraaortic balloon pumps, extracorporeal membrane oxygenators, and other medical devices may be readily adapted for use in ground interhospital transport, but may be too bulky and heavy for use on a helicopter. With the increasing girth of the average American, the provision of air medical services becomes more challenging, and a plaintiff in a recent court case in Florida has challenged a HEMS decision to not fly a patient due to weight.

Auditory

Aircraft are inherently noisy working environments. All necessary medical history must be obtained before loading the patient, as conversation will be difficult in flight. Breath sounds must be evaluated before transport, as auscultation on board will not be fruitful without the use of an amplified electronic stethoscope wired into the aircraft intercom system.

Lighting

Lighting can be an additional challenge in providing medical care aboard a helicopter. Although the driver of an ambulance generally is unaffected by what goes on in the patient care area, the pilot of a helicopter can have his night vision affected by the light necessary to provide patient care. It is therefore necessary to illuminate the patient care area with less distracting red or blue lighting at night, or to pull a heavy curtain to separate the cockpit from the helicopter service area. Most of the medical helicopters in the US now operate using military night vision, requiring additional certification of interior aircraft lighting.

In the daytime, sunlight may make viewing of medical monitoring equipment difficult and can also affect the function of some medical equipment, such as the infrared sensor for certain end-tidal carbon dioxide monitors. Unlike ground ambulances, patients on helicopters may also develop “flicker seizures” by having sunlight shine directly through the moving rotor blades into their eyes, causing a strobelight-like stimulation and subsequent generalized seizure activity.

Electronic medical equipment

Electronic medical equipment must be evaluated for the effects of radiofrequency interference and electromagnetic interference before it can be used safely on an aircraft. The Federal Communications Commission limits use of any unapproved communication device. Medical equipment must be assessed for power requirements which may affect the aircraft and battery performance for transitioning patients to and from the aircraft. Physicians should be aware of what medical technology is available from any individual provider agency and have assurance that the equipment is regularly tested.

Regulations

Air medical services providers are regulated by both state and federal regulatory agencies, in addition to regional or local medical oversight. All aviation-specific issues are strictly in the purview of the Federal Aviation Administration (FAA), economic regulation is overseen by the federal Department of Transportation (prices, routes, and services), while medical issues are generally in the purview of a medical director and state laws and regulations. There is unfortunately a tremendous amount of gray territory in between. The complexity of regulation is beyond the scope of this chapter, but has been detailed by interested organizations [59]. In 2006, the IOM noted that “while the Federal Aviation Administration is responsible for safety inspections, helicopter licensure, and air traffic control, the committee recommends that states assume regulatory oversight of the medical aspects of air medical services, including communications, dispatch, and transport protocols” [11].

Federal preemption

Understanding the various jurisdictional purviews of these regulatory authorities is a challenge for medical directors in the best of circumstance, and the Airline Deregulation Act of 1978, which created federal preemption to state regulation of interstate commerce, increases the complexity. Specifically, the Act states:

(b) PREEMPTION.—(1) Except as provided in this subsection, a State, political subdivision of a State, or political authority of at least 2 States may not enact or enforce a law, regulation, or other provision having the force and effect of law related to a price, route, or service of an air carrier that may provide air transportation under this subpart [70].

As with the Emergency Medical Treatment and Active Labor Act (EMATLA), which is well known to emergency clinicians, the devil is in the details. Under preemption, air medical services providers have successfully overturned state regulatory efforts requiring aircraft-specific equipment, hospital destinations, certificate of need requirements, and CAMTS accreditation as a requirement for licensing. Although preemption continues to be debated, recent case law in many arenas other than air medical services has upheld the federal preemption position. The medical director must work to align the interests of patient care with often competing and conflicting regulatory and policy efforts.

Federal Aviation Regulations

The FAA solely governs aviation under Title 14 of the Federal Code. All air ambulances require air carrier certificate holders either directly responsible or contracted for aviation services. The two sections of the regulations that have the most bearing on air medical services are Part 91 General Operating and Flight Rules, which apply to all aircraft flying in the US, and Part 135 Air Carrier Certificates, Commuter and On-Demand Operations and Rules Governing Persons on Board Such Aircraft. These regulations basically govern such things as pilot rest and training, air space regulations, VFR/IFR, and aircraft maintenance. With the exception of public entities operating under Part 91, in order to provide air medical services, a Part 135 certificate holder must be present within the service. This can be a certificate holder that is contracted by a hospital or other entity to provide aviation services (“traditional model”), a hospital becoming a certificate holder and owning the aircraft and hiring aviation staff, or a Part 135 certificate holder with a preexisting aviation operation that hires its own medical personnel (“community model”). Note that the FAA Reauthorization in 2011 now requires that all air medical services with medical crew on board be conducted under Part 135.

A hospital may own an aircraft and contract with a Part 135 operator who takes responsibility for all operations of the aircraft. Over the past several years the FAA has increased scrutiny of Part 135 operations to assure that operational control, the accountability and responsibility of the aviation component of the service, rests solely with the certificate holder. It is essential that medical directors clearly understand the FAA’s definition of operational control because conflict between the air medical services mission (e.g. go/no go decisions, diversion of aircraft, medical equipment, etc.) and FAA requirements on the certificate holder must always defer to the certificate holder’s operational control.

Another area of FAA scrutiny is the use of brokered aircraft in which there is no clear line of operational control in the marketing and sale of service. This has primarily been an issue in the fixed-wing arena whereby brokers market fixed-wing services without owning aircraft, employing pilots, or employing medical crews. Physicians arranging for transport need to be cognizant that all is not what it seems in many of these operations.

Quality, safety, and credentialing

Most states license air ambulances as ambulances, but states have no jurisdiction over the aviation aspects of the program. This misalignment is challenging as safety issues, especially with regard to medical helicopters, have been a profound factor. Although accident numbers are relatively small, the consequences of accidents are enormous, with most accidents incurring major or fatal injuries. The Federal Aviation Regulations are based on safety, but are limited and do not currently address all of the best practice recommendations from the National Transportation Safety Board (NTSB).

In addition to safety problems, including HEMS being on the NTSB “10 Most Wanted” list, air medical services quality is often opaque. Recent work by the American Academy of Pediatrics (AAP) and the Air Medical Physicians Association (AMPA) is in the early stages of establishing quality performance metrics. Table 2.3 highlights proposed national metrics illustrating both consensus and some divergence based on primarily adult patients versus neonatal and pediatric-specific transport and air medical services agency characteristics, with more information available at <https://ampa.org/>.

In addition to state licensing, provider agencies may voluntarily submit to external accreditation from CAMTS. Currently CAMTS has 21 participating organizations, and has accredited about 154 air medical and ground services. The newest standards may be found at www.camts.org.

Operational challenges

The EMS medical director should have insight into the environmental factors that can affect the ability of an air medical program to support ground EMS operations.

Weather and visibility

With certain limited exceptions, timely scene HEMS response requires the pilot to be able to fly to the scene under VFR. In most EMS helicopter operations, this requires at a minimum a visibility of at least 1 mile with a cloud ceiling of at least 500 feet. Many programs use higher minimums in the interest of maximizing safety and increasingly, especially hospital-based providers are incorporating IFR to increase safety and reliability. Current NTSB recommendations include instrument flight currency for all pilots as marginal weather with low visibility/night operations is the most common crash profile. Transition to instrument flight is a tremendous safety enhancement in the event the pilot inadvertently encounters changing weather and can no longer navigate by sight.

Emergency medical services providers should anticipate that rotor-wing aircraft will be grounded during periods of freezing precipitation. Rain itself generally does not prevent scene HEMS response as long as visibility minimums are met; however, freezing/frozen precipitation can accumulate on the rotor blades and cause the aircraft to lose lift.

Table 2.3 Combination of quality metrics consensus measures, Air Medical Physicians Association (AMPA) and American Academy of Pediatrics (AAP)

Measure	AMPA rank	AAP rank
Unplanned dislodgment of therapeutic devices	4.41	4.94
Verification of tracheal tube placement	4.51	4.90
Average mobilization time of the transport team		4.89
First attempt tracheal tube success	4.45	4.89
Rate of transport-related injuries (patient injuries or death rate)	4.06	4.88
Medication errors on transport	4.47	4.88
Ventilator use for patients with advanced airway	4.85	
Bedside time for ST-elevation myocardial infarction patients	4.85	
Medical equipment failure	4.14	4.77
Rate of CPR performed during transport		4.74
Rate of serious reportable events	4.40	4.73
Unintended neonatal hypothermia (on arrival to destination)	4.51	4.68
Waveform capnography for ventilated patients	4.60	
Definitive airway sans hypoxia/hypotension on first attempt	4.54	
Glucose check in patients with altered mental status	4.50	
Use of appropriate mode of transport	4.50	
Rate of transport-related crew injury		4.48
Rapid sequence intubation protocol compliance	4.47	4.46
Use of a standardized patient care hand-off		
Appropriate ventilator management	4.43	
Appropriate management of blood pressure in patients with aortic emergencies	4.41	
Tracheal tube position reconfirmed after movement of patient or deterioration	4.34	
Incidence of hypoxia during transport	4.25	
Management of hypertension in patients with hemorrhagic CVA	4.18	
ECG interpretation for STEMI patients	4.15	
Appropriate management of hemorrhagic shock	4.15	
Documentation of a glucose check for patients with CVA symptoms	4.01	
Adverse drug events during transport	4.08	
Reliable pain assessments and treatment	3.90	

Data are reported on a 1–5 Likert scale.

CPR, cardiopulmonary resuscitation; CVA, cerebrovascular accident; ECG, electrocardiogram; STEMI, ST-elevation myocardial infarction.

Ambient temperature

The ambient temperature can have a significant effect on the maximum weight that a helicopter is able to carry. The higher the temperature, the less dense the air, and consequently the harder the engines must push the rotor blades to achieve the same amount of lift. The effect of temperature on lift is magnified at high altitude, where the air density is already low. Each pilot, at the start of his or her work shift, calculates the maximum weight of fuel, cargo, and passenger weight the aircraft can carry on that day. In certain air medical operations, temperatures greater than 90°F may prohibit the transport of two patients or may limit the amount of fuel that is carried.

Hazardous materials or infectious disease

Unlike ground ambulances, helicopter pilots and crews are enclosed in the same small air space occupied by the patient and are at risk for exposure to fumes or communicable disease. Patients who are contaminated with hazardous materials should not be transported by air, and each service should have a preestablished plan for managing highly infectious patients.

Ability to perform unusual and *ad hoc* activities

The nature of the helicopter lends itself to utility in unusual circumstances. Some of these circumstances are mentioned here. These occasional uses do not justify the expense of procuring HEMS, but if the assets are already available, then these deployments can be helpful and contribute to overall utility of the air medical resource. EMS medical directors should have an awareness of the special capabilities of the air medical services in their area.

Remote or difficult access areas

Helicopters can be of great assistance for patients who are difficult to reach or remove from remote areas even if clinically they do not require critical level intervention. Hikers and hunters may become ill or injured a great distance from a roadway. Rural roads may be inaccessible long after a big snowstorm. Island inhabitants may be inaccessible due to rough or frozen waters.

Search and aerial rescue

Helicopters can be used effectively to assist ground EMS in locating patients in unusual situations. Some examples would include an overturned boat with persons swept downstream, a severely crashed vehicle found on an isolated stretch of road at night with evidence of bleeding and no patient, or a young child or an Alzheimer's patient missing in cold weather. Hunters and hikers may call from the woods via cell phone to report a serious injury or illness but may be unable to provide an exact location. On occasion, these patients are only located by staying on the line and telling the 9-1-1 center when they hear the helicopter getting close to them. All helicopters are capable of performing visual searches, and those that perform nighttime scene responses have searchlights and night vision.

Hoist operations may be invaluable in dealing with a patient in a difficult access area where a landing zone cannot be established. Special equipment and training are required and currently, other than military, law enforcement, and fire/rescue providers, only Intermountain Healthcare LifeFlight in Salt Lake City provides this type of service. Hoisting is most often used to remove a patient from a dangerous, precarious, or time-critical situation, but on occasion may also be the only means of inserting rescuers to access the patient. Hoist operations are much more widely provided by HEMS internationally.

Aerial reconnaissance and lighting

Visualization of an incident scene from the air may provide important information as to the size of the event, the number of resources needed, and the best route for responding units to

gain access. In regional disasters such as flash flooding and earthquakes, aircraft can locate imperiled persons who are not yet patients, and can alert responding units to impassable roadways.

Most medevac helicopters have strong searchlights that can effectively illuminate an area the size of a football field. Although use of a helicopter searchlight is not a cost-effective method of routinely providing illumination, it can provide rapid, mobile visualization in critical situations. Beyond initially locating patients, the aircraft can provide lighting while rescuers access and provide initial care to patients who are scattered across a large incident, or are located in the water or in a difficult access area.

Mass casualty incidents

There are also instances in which HEMS flexibility has translated into myriad uses during disaster and mass casualty incidents [51,71]. In incidents with multiple injured patients, air medical transport can be used to distribute patients among appropriate trauma facilities to prevent any one center from becoming overwhelmed. Depending on the incident location, the strategy may be to fly the most seriously injured patients, or alternatively to drive the most critical to nearby trauma centers, while flying less critical but serious patients to more distant trauma facilities.

Mass gatherings

Mass gatherings of people present EMS systems with unique problems. Normal traffic patterns throughout an entire city or region may be disrupted significantly. In addition to challenges in accessing and transporting patients associated with the event itself, access to health care facilities in the area may be obstructed. These facilities may also be overwhelmed with ambulatory patients from the event. Air medical transport may play roles in removing patients from the event itself, allowing non-event patients to continue to access health care facilities in the area, and distributing patients to more distant hospitals when local facilities are overwhelmed.

Go teams

In the rare case where a medical expert or team needs to be transported to the patient, the speed and logistical capabilities of the helicopter may be useful [72]. Air medical programs may be able to support local EMS by transporting hospital-based physicians and other personnel who are specially trained and equipped for scene response. These responses typically involve incidents with protracted extrications in which there is concern that a field surgical procedure may be required. Such teams may also play a role in selected mass casualty incidents and disaster situations. "Go team" response requires much preplanning and coordination among local EMS, the sending hospital, and the air medical service. In addition to transporting people, helicopters have been occasionally used to rapidly transport vital supplies or drugs (e.g. prostaglandins to a neonate with a ductus-dependent lesion).

Conclusion

The successful integration of air medical transport into local EMS systems is dependent on effective preplanning and coordination at many different levels. Medical directors and EMS physicians play a pivotal role in ensuring that air services are used efficiently and effectively.

Despite the projected substantial decreases in health care spending, the need for air medical services will continue to grow and evolve. The US Department of Health and Human Services projects a four-fold increase in the number of persons 60 years and older in the next two decades. The trend is particularly noticeable in the United States, with a rapidly aging population, especially in rural areas [15]. The emergency medical needs of this population are reflected in the growing rates of trauma, as well as the increased occurrence of time-critical conditions such as heart attack, stroke, and non-trauma surgical emergencies (e.g. abdominal aneurysms and stomach/intestinal bleeding) [73]. Recent studies examining the response to elderly trauma patients have found that many of these patients do not currently reach trauma centers in a timely manner [74,75]. As medical science creates new ways to intervene in medical emergencies with technology that must be utilized within a narrow window of time, the need for air medical services to bring that technology to patients, or to bring patients to that technology, will continue to grow but must be carefully medically overseen to assure appropriate resource use in time-sensitive disease.

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