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Helicopter Emergency Medical Services Literature 2014 to 2016: Lessons and Perspectives, Part 2—Nontrauma Transports and General Issues

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HEMS Safety

Health care interventions of nearly all types, from antibiotics to hospitalization, entail risk. That risk is usually carried by patients alone, but there are risk categories (eg, care of violent patients or those with communicable disease) in which caregivers are also at risk. Aviation safety is the first priority of HEMS; thus, it is the opening topic in this part of the review.

Safety Remains the First Point in Discussing HEMS

It is nearly universal in the air medical transport literature in recent years for there to be some comment about the risk of HEMS. A typical study from the end of 2016 includes in its opening paragraph the following: "The human cost of HEMS is also well-documented, with more than 200 deaths from 1980 to 2008. HEMS flight crews have one of the most dangerous occupations in the USA, with more than 100 deaths per 100,000 employees (compared to 21 deaths per 100,000 police officers)."[1]

It is not within this review's scope to delve into the long and critically important history of aviation safety in HEMS. Neither is it the editorial purpose to frame the known risks of HEMS against those risks associated with ground EMS (GEMS), risks that are far less well characterized because in part of the lack of reliable GEMS safety data. These topics and other vital statistics of HEMS safety are covered in detail in a separate recently published textbook chapter by 1 of the authors (I.B.).[2]

Overall Accident and Fatality Rates

On the overall safety front, important contributions have been made in the analyses of HEMS accidents in the United Kingdom and the United States. A 2014 report[3] calculated that over a quarter century of UK HEMS operations, the fatal accident rate was .04 per 10,000 missions (with comparable rates from the United States and worldwide ranging from .04 to .23 per 10,000 missions).

In a 2016 study from the United States, Boyd and Macchiarella[4] reported a detailed analysis of the country's HEMS-related accidents from 1983 to 2014. Overall HEMS accident rates declined by 71% over those 3 decades, whereas the fraction of fatal accidents (36%-50%) and injury profile were unchanged over time.

Safety of Night HEMS Operations

The 2014 to 2016 HEMS safety studies from continental Europe included a focus on night flights, which have been traditionally eschewed by the region's HEMS operators because of safety concerns. A Dutch study[5] of 513 nighttime flights found 0 accidents; the authors concluded that nighttime operations should not be precluded by safety considerations. German data reported in 2016 identified a similar (0) incidence of nighttime crashes; the Germans made the case that if aviation operations are properly planned and conducted, then nighttime operations are safe.[6]

An Australian group assessing US data also focused on night operations, taking the course of assessing types of pilot experience. In a 2016 report that assessed 32 single-pilot nighttime fatal HEMS crashes between 1995 and 2013, the Australians found that pilot domain task experience (ie, HEMS-specific total flight hours' experience) was inversely correlated with the likelihood of a fatal accident.[7] In the Australians' analysis, the cutoffs for safety margin increase occurred at 2-, 4-, and 10-year experience levels.

Another assessment of US data (from Pennsylvania) found that operations at night (1900-0600) were associated with a higher risk of fatal crash or injury. In fact, night operation was the only parameter of the studied operational variables (eg, weather, impaired visibility, and aircraft model) found to have a significant association with a fatal crash or injury in this study.[8]

For-Profit HEMS Service Status and Safety

The US HEMS safety literature included some different topics with particular relevance to that country. Some of the more prominent ongoing HEMS debate in the US literature demonstrates unsettled safety issues such as those relating to profit motive. A thought-provoking report from a US group[9] found that human and pilot errors were significantly more common with commercial (for-profit) operations compared with public sector (nonprofit) operators. Subsequent controversy over the findings[10] has highlighted the need for further investigation of the thesis that profit motive has a positive, negative, or no association with safety.

Multiple-Diagnosis HEMS Topics

This section covers HEMS studies from 2014 to 2016 that addressed topics that cross diagnostic lines. The 2 general areas of discussion are cost-benefit analysis and airway management. Some further details on related information regarding specific patient groups are presented in subsequent sections addressing HEMS use for 2

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specific nontrauma patient populations: STEMI and iCVA.

Patient Safety Issues in HEMS Transport

Aviation safety being covered previously, there is another set of safety concerns related to HEMS transport. These concerns deal with the HEMS environment (eg, acceleration and altitude) and its potential for ill effects on transported patients. This section considers 2014 to 2016 publications in this arena.

In 2016, a University of Southern California pediatric transport group assessed acceleration forces in multiple axes during various phases of GEMS, HEMS, and airplane transport.[11] The accelerations measured for HEMS were no different than those observed in the other 2 transport modes.

One group of studies has continued to visit the long-known[12,13] question of altitude-related increases in endotracheal tube (ETT) cuff pressures. The 2014 to 2016 literature reaffirms that barometric changes associated with increased altitude have theoretical potential to increase cuff pressures to potentially dangerous levels. These high cuff pressures, potentially problematic for any patient but usually emphasized with pediatric cases (with smaller airways), have not been reported to cause actual patient-centered adverse outcomes.

Three 2016 studies, all from the United States, reported opposite findings regarding ETT cuff pressures. One team[14] found that properly inflated adult (7.5 mm) ETT cuffs are not likely to be associated with dangerous cuff pressure increases below 8,000 feet above sea level. However, another group reported that potentially dangerous cuff pressure elevations occurred to equal degrees in all 3 of the tested ETT sizes (4.0, 6.0, and 8.0).[15] A third group, testing 3 sizes of ETTs (3.0, 4.0, and 6.0), also found potentially dangerous cuff pressure elevations at altitudes as low as 1,500 feet (with cuff pressures regularly surpassing 30 cm H_2O) and 2,800 feet (with cuff pressures regularly surpassing 50 cm H_2O) above mean sea level.[16]

Perhaps the best synthesis of real-world relevance with regard to ETT cuff pressures comes from Massachusetts. In 2016, these investigators reported that the main problem with regard to HEMS transport of post-ETI patients was that the pretransport cuff pressures were (on average) more than double the recommended levels.[17] Their recommendations to check ETT cuff pressures before and during transport to maintain optimal safety are consistent with the general consensus of the studies mentioned here.

Airway Management by HEMS Crews

Airway management and endotracheal intubation (ETI) are among the most important of all out-of-hospital interventions.[18] A detailed discussion of airway management and its risks and benefits are outside the scope of this review. However, given the importance of the subject, some relevant HEMS airway management studies from 2014 to present are noteworthy.

Although there are historic data showing nonphysician HEMS crew ETI success rates rivaling those achievable in the emergency department setting,[19] the most recent literature addressing HEMS ETI comes from air medical crews including physicians. In 2015, a multinational study (from 5 European countries and Australia)[20] showed similarly impressive ETI results; HEMS physicians' first-pass ETI success rate was 86%, and the overall ETI success rate was 98.8% with airways successfully established in 100% of patients.

Perhaps the most compelling evidence of HEMS bringing additional airway expertise to the patient comes from a 2015 Dutch study from another physician-staffed air medical crew.[21] In an unusual design, the researchers were able to assess HEMS versus GEMS ETI attempts in the same patients; GEMS crews were allowed to attempt ETI, and then if they failed HEMS crews would intervene. The same medications (administered within the same protocols) were used throughout the airway management attempts. The HEMS physicians' first-attempt ETI success rate of 84.5% was nearly twice that of the GEMS paramedics' first-attempt success rate of 46.5%.

HEMS crews' ETI success reports of recent years include pediatric patients. In 2015, an Australian group reported 100% intubation success rates by their paramedic-staffed HEMS crew, for both adult and pediatric patients.[22] In a 2016 Swiss study focusing solely on airway management in 425 children, Schmidt et al[23] reported a 95% first-pass ETI success rate, with a 98.6% overall ETI success rate. Another 2016 study from Switzerland[24] reported on HEMS physician airway management in 1,047 cases; they found a 96.4% rate of first-pass ETI success with an overall ETI success rate of 99.5%, with no requirement for surgical airways.

The airway success of HEMS crews is well-documented and is not presented here to imply that all HEMS crews have the same success or that GEMS crews do not have the capability to reach these levels of ETI success. However, the rates of airway management success in the HEMS literature are consistently high, and both airway and ventilatory management (with resultant impact on outcome) appear potentially better for HEMS compared with GEMS cases.[25,26]

Future directions for airway management in HEMS will need to include skills maintenance in an era of enlarging crews with more limited ETI training and practice opportunities. Comparisons of HEMS crew success rates with GEMS crew success rates may help determine when HEMS should be deployed. Furthermore, there needs to be a follow-up investigation to glean more information along the lines of a 2015 report from a rural US state (Mississippi)[27] that HEMS is needed to bring ETI skills for interfacility transports, particularly those from referring facilities staffed by physicians lacking ETI experience.

HEMS Costs and Benefits

If there is no benefit to HEMS transport, then the risk:benefit calculations cannot be favorable. Additionally, there are monetary cost issues. Despite classic reports[28] arguing that a region-based cost of HEMS is no higher than the cost of response time–equivalent GEMS critical care coverage, HEMS' concentration of resources translates into widespread perception (even among some HEMS advocates)[29] of air medical transport as being a high-cost option.

Recent years have seen consensus statements from organizations such as the National Association of EMS Physicians and the American College of Emergency Physicians reaffirming the position that appropriately used HEMS improves patient outcomes.[30] However, with increasing pressures on health care spending, risk:benefit and cost:benefit calculations are of critical importance.

In 2015, a Norwegian group,[31] noting their country's oft-cited report[32] of a HEMS benefit-to-cost ratio of 5.87, published an analysis promoting Norway's success in optimizing HEMS access. The group reported that Norway has achieved a national goal for 90% of the population to be reachable by HEMS within 45 minutes.[31]

Scandinavians' attention to costs and benefits has included assessment of the limits of transport distances (for interfacility missions) for which HEMS maintains cost-effectiveness over airplane transports. A Swedish financial analysis reported in 2014[33] found that HEMS retained cost-effectiveness over airplanes up to a range of 300 km (186 miles).

Another Swedish group reported on cost-effectiveness for HEMS use in STEMI. Schoos et al[34] analyzed STEMI transports arising from the islands comprising much of Sweden's coastal population centers and calculated that surface transport (by boat) was simply not an option if percutaneous