Logistics of Air Medical Transport: When & Where Does Helicopter Transport Reduce Prehospital Time?

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Disclosures

No conflicts to disclose

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Background

- Trauma is a time-sensitive disease

- Helicopter EMS (HEMS) integrated into trauma systems

- HEMS can be faster than ground EMS (GEMS) under certain conditions
  - Long distance
  - High congestion
Background

• HEMS has added time of notification, response, patient preparation for flight

• Time benefit varies based on distance, traffic, & weather

• Unclear where & when this benefit emerges under varying conditions
Objective

Determine threshold distance where HEMS has shorter prehospital time than GEMS under varying traffic, weather, & geographic conditions.
Methods: Study Population

• PTOS 2000 – 2013

• Transported by HEMS or GEMS from scene

• Exclusions
  ▪ Not injured in PA
  ▪ Missing zip code
  ▪ Zip code/injury county mismatch
  ▪ Missing prehospital time
  ▪ Prehospital time >95%ile
Methods: Data Synthesis

• Distance
  ▪ Zip code centroid to trauma center
  ▪ HEMS: straight line distance
  ▪ GEMS: shortest driving distance by GIS

• Traffic → based on recorded 911 dispatch
  ▪ Peak traffic time: 6-10a & 3-7p M-F
  ▪ Off-peak traffic time: all other times
Methods: Data Synthesis

• Weather
  ▪ Daily weather archive obtained from NOAA for each day in study
  ▪ Transport weather assigned based on closest weather station
  ▪ Weather dichotomized as adverse vs. clear
  ▪ Adverse weather defined as presence of precipitation or fog
Methods: Analysis

• Primary outcome: Total prehospital time

• Linear regression
  ▪ Association prehospital time and transport distance
  ▪ Adjusted for need for extrication
  ▪ Interaction term: distance & transport mode
  ▪ Plotted fitted regression line & 95%CI
Methods: Analysis

• Threshold distance at which HEMS faster than GEMS identified where 95%CI no longer overlaps

• Traffic conditions
  ▪ HEMS vs. GEMS peak vs. GEMS off-peak

• Weather conditions
  ▪ Adverse vs. Clear

• Geographic area
  ▪ PA EMS regional council areas
Methods: Sensitivity Analysis

• Linear regression assumes linear relationship between outcome and covariates – may not be true

• Nonparametric regression performed
  ▪ No assumption of functional relationship between outcome and covariates
Results: Study population

PA Trauma Registry
N=427,934

- Missing Zip Code
  N=3,027

- Missing Time
  N=142,971

- Transfer
  N=572

- Non-PA
  N=54,917

  - Zip/County Mismatch
    N=69,077

  - Time Outliers
    N=12,203

  - Non-EMS Transport
    N=426

Study Population
N=144,741

- HEMS
  N=27,163

- GEMS
  N=117,578
## Results: Study population

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HEMS becomes faster at 7.7 miles from trauma center
Results: Traffic conditions

- Prehospital time (mins) vs. Distance (mi)
- Graph shows the relationship between distance and prehospital time for different traffic conditions:
  - HEMS
  - GEMS off-peak
  - GEMS peak
Results: Traffic conditions

HEMS faster at 7.9 miles in off-peak traffic
HEMS faster at 6.5 miles in peak traffic

Graph showing prehospital time (mins) vs. distance (mi) for HEMS, GEMS off-peak, and GEMS peak.
Results: Weather conditions

- Clear Weather
- Adverse Weather

Graph showing prehospital time (mins) vs. distance (mi) for ground and helicopter transport in clear and adverse weather conditions.
Results: Weather conditions

HEMS faster at 7.3 miles in clear weather
HEMS faster at 17.1 miles in adverse weather
Results: Geographic areas

- Chester County EMS
- Bucks County EHS
- Delaware EHS
- EHS Federation
- EMMCO West
- EMS Northeastern PA
- EMSI
- Eastern PA EMS
- Montgomery County EMS
- Philadelphia EMS
- Seven Mountains EMS
- Southern Alleghenies EMS

Prehospital time (mins) vs. Distance (mi)

- GEMS
- HEMS
Results: Geographic areas

HEMS faster at 5.4 miles in Chester Co.
HEMS faster at 35.3 miles in EMMCO West
Not faster in Philadelphia
Results: Geographic areas

Rural Threshold Distance: 18.5 ± 12.7
Urban Threshold Distance: 10.1 ± 2.0
Results: Sensitivity analysis

The graph shows the relationship between prehospital time (in minutes) and distance (in miles) for two different systems, GEMS and HEMS. The graph indicates that prehospital time increases with distance for both systems. The blue line represents GEMS, and the red line represents HEMS. The point at 7.5 miles shows a significant change in the trend for both systems, with GEMS experiencing a drop in time and HEMS showing a more gradual increase.
Summary

• Threshold distance where HEMS becomes faster ~8 miles from trauma center

• Moves ~1.5 miles closer to trauma center in peak traffic

• Moves ~10 miles farther from trauma center in adverse weather
Summary

• 6-fold variation in threshold distance across Pennsylvania EMS regions
  ▪ Trend toward farther threshold in rural areas

• Similar relationships between time and distance in sensitivity analysis
Limitations

• Crude categorization of traffic & weather

• Zip code centroids for distance

• Missing data

• Linear relationship assumptions

• 95%CI sensitive to sample size
Conclusions

• Threshold distance where HEMS faster is closer to trauma center during peak traffic

• Threshold distance moves farther during adverse weather

• Threshold distance varies significantly across regions

• These factors should be evaluated at local level to guide HEMS triage protocols