Resource Utilization in Helicopter Transport of Head-Injured Children

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Disclosures

• Nothing relevant to disclose.
Background/History

• Helicopter medical transport introduced in Korean War and increased in Vietnam War

• Introduced into civilian medical transport in the 1970s
  – Numbers have increased in each decade

• First ACH transport by helicopter in 1985
  – 1,100 helicopter flights per year
  – 200 fixed-wing flights per year

1. History of Medevac. https://www.mercyflight.org/content/pages/medevac
Resource Utilization

• Medical helicopter transport has been shown to improve survival

• Studies suggest overuse of helicopter transport
  – One study demonstrated that 33% of children air-transported to a major U.S. medical center were discharged from the ED

• Studies addressing the use of the helicopter in neurotrauma patients have been published in recent years, but further work is still needed
  – Much of the present literature regarding helicopter transfer for neurotrauma echoes the data published on air transfer for general trauma

Brown et al, 2016
Missios et al, 2011
Vercruysse et al, 2015
Walcott et al, 2011
Eckstein et al, 2002
Resource Utilization

• Numerous factors contribute to decision to transport by air: severity of illness, weather, commuter traffic, rural vs. municipal location, etc.

• Costs range widely from state to state but there are some fixed costs:
  • Liftoff fee
  • Mileage fee

• Costs may range from about $15,000-$50,000 depending on region and indication

• Insurance may or may not cover all of these costs
Hypothesis / Purpose

- Helicopter transport of children with head injuries is overutilized
- Identify factors associated with appropriate use of air transport
Study Design

• Identify patients transported to ACH from another facility by helicopter
  – The decision to transport by helicopter from the scene involves numerous difficult to account for variables
  – Factors involved in the decision to transport by helicopter from other facilities are better documented
  – Most patients transported by helicopter to ACH come from other facilities

• Identify patient factors associated with appropriate use of helicopter transport
Methods

• We reviewed the ACH trauma database and identified all patient transferred by air from another facility to ACH from February 2009 – December 2012
• Patients were included if they had a traumatic head injury for which neurosurgery was consulted
• Patients excluded if another body region sustained severe injury which by itself could have warranted transport by air
• Air transport was deemed appropriate if one or more of the following occurred:
  – Surgical intervention for head injury (eg craniectomy)
  – Procedure for head injury (eg ICP monitor insertion)
  – Death
• A logistic regression model was used to identify factors associated with appropriate helicopter transport
Results

- 373 patients met inclusion criteria in the study
- 116 patients (31.1%) had a procedure at bedside, surgery or procedure in the OR, or died as a result of the head injury
- 257 patients (68.9%) had no intervention for their head injury and survived
Results

452 patients transferred by air with subsequent neurosurgery consultation

79 patients excluded from study

373 patients were included for analysis

257 patients had no neurosurgical intervention

0 patients died

116 patients had neurosurgical intervention

28 had a procedure at the Bedside
70 had a procedure in the OR
18 had no procedure

26 patients died
Univariate Analysis

Associated with appropriate use of helicopter
- GCS (p<0.0001)
- Intubation (p<0.0001)
- Mass effect (p<0.0001)
- Skull fractures (p<0.0001)

Not associated with appropriate use of helicopter
- Age
- Gender
- Race
- Epidural hematoma
- Other intracranial hemorrhage
## Multivariate Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidural hematoma</td>
<td>3.20</td>
<td>(1.19, 8.62)</td>
<td>0.0214</td>
</tr>
<tr>
<td>Mass effect/midline shift</td>
<td>5.16</td>
<td>(2.06, 12.90)</td>
<td>0.0005</td>
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<tr>
<td>Edema</td>
<td>5.31</td>
<td>(2.14, 13.19)</td>
<td>0.0003</td>
</tr>
<tr>
<td>GCS</td>
<td>[Reference]</td>
<td></td>
<td>&lt;0.0001</td>
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<tr>
<td>Mild (13-15)</td>
<td>1.00</td>
<td>[Reference]</td>
<td></td>
</tr>
<tr>
<td>Moderate (9-12)</td>
<td>1.70</td>
<td>(0.41, 7.02)</td>
<td></td>
</tr>
<tr>
<td>Severe (3-8)</td>
<td>34.32</td>
<td>(6.95, 165.34)</td>
<td></td>
</tr>
<tr>
<td>Open depressed skull fracture</td>
<td>46.0</td>
<td>(7.62, 277.54)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Results

• Factors associated with appropriate transport included clinical and radiographic findings:
  • GCS 3-8
  • Open-depressed skull fractures
  • Mass effect/midline shift/herniation on head CT
  • Cerebral edema/loss of gray-white differentiation on head CT
  • Epidural hematoma (EDH)

• Factors not associated with reasonable transport included:
  • Age, race, gender, intubation, GCS 9-12, GCS 13-15, other skull fractures, other intracranial hemorrhage (without above findings)
Results

• Average cost difference between air and ground transport was $20,000
• Cost for the 257 inappropriate air transports was $5.1 million
Conclusions

• Near 70% of the patients transferred by helicopter survived without neurosurgical intervention

• GCS ≤ 8, mass effect and/or edema on head CT, EDH, and open depressed skull fracture all predicted need for helicopter transport

• Findings not predicting need for intervention include GCS > 8, simple skull fractures, demographic information including age
Summary

• Decisions to transport by air should be based on:
  – Neurological condition of the patient
  – Findings likely indicating need for surgery regardless of neurological condition of the patient (open depressed skull fracture, EDH, mass effect)
Limitations

• Retrospective study
• Does not account for travel time / distance
• Definition of “appropriate” use of air transport
Future Directions

- $P(\text{Reasonable transfer}) = \frac{1}{1+lp}$

- $lp = \exp(-1.6656 - 0.0378 \times \text{Age} - 0.1656 \times \begin{cases} 1 & \text{Gender = Male} \\ 0 & \text{Gender = Female} \end{cases} + 0.2729 \times \begin{cases} 1 & \text{Race = Black} \\ 0 & \text{Race = Non-Black} \end{cases} - 0.4724 \times \begin{cases} 1 & \text{Race = Hispanic} \\ 0 & \text{Race = Non-Hispanic} \end{cases} - 0.5528 \times \begin{cases} 1 & \text{Race = Other} \\ 0 & \text{Race = Non-Other} \end{cases})$
Future Directions

Points

GCS

moderate
mild severe

Mass effect, midline shift, or herniation

Edema, loss of gray white matter, or hypoxic ischemic appearance

Epidural

Open and Depressed Skull Fracture

Total Points

Linear Predictor

Reasonable Transfer
Future Directions

• Develop a scoring system that can be used by referring physicians
• Test our scoring system on an independent patient population
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  – Eylem Öcal, MD
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References