Trauma System Adoption of Advanced Automatic Collision Notification (AACN)

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Advanced Automotive Collision Notification (AACN)

• Goals
  – Transmit crash data from vehicle at time of crash to alert Emergency Response system to:
    • Occurrence and location of crash
      – Reduce response times
    • Predict likelihood of serious injury
      – Assist with dispatch decisions regarding level of response
    • Assist with field triage decisions
      – Additional info for EMS in deciding on level of trauma center
      – Decrease time to trauma center
      – Decrease mortality and morbidity

CIREN - Crash Injury Research and Engineering Network
nhtsa.dot.gov or HIPRC.org
Presentation Outline

- Need to integrate AACN into trauma systems
- Current EMS dispatch for MVC and Survey of EMS dispatcher views on AACN integration
- Validation of Pre-Hospital Trauma Triage Criteria for Motor Vehicle Collisions
- Predicting Severe Injury Using Vehicle Collision Data
- Prediction of Injury Severity using Crash Data Recorder variables
- Next steps: Integration of AACN into EMS dispatch

Getting from Crash to Trauma Center

- Identification of crash location
- Notification of 911 PSAP
- Appropriate EMS and Rescue response
  - Getting the right people there
- Field Triage decision
  - Getting the right patient to the right hospital
- Care and transport
- Report to trauma team
If you are severely injured, care at a Level I trauma center lowers the risk of death by 25%.

McKenzie, Rivara, Jurkovich... NEJM, 2006

Research conducted at Harborview Injury Prevention and Research Center

Current Need for Crash Notification Systems and GPS locations – CIREN case studies

- Driver found after 8 days, departed roadway down into roadside ravine
- Survived with critical injuries after very long treatment at the trauma center
- Would have benefited greatly from initial EMS response

Need for Crash Notification Systems for Notification and GPS locations – CIREN case studies

An elderly couple struck a tree late evening and rotated into ditch out of site

- Couple not found until next morning and passenger had died and driver was critically injured
- Injuries appeared survivable if EMS response was initiated
Current EMS MVC dispatch

- Key Questions
  - Is anyone trapped in the car? (RESHVY)
  - Is the car off the road or difficult to access? (RESHVY)
  - Does the accident involve a commercial truck, building, train, or other heavy equipment? (RESHVY)
  - Is the car on all four wheels? (RESHVY)

Current EMS Dispatch

- Is this a high risk location? (Freeway, Bridge) (MED7F)
- Is there any smoke or flames? (MED F)
- Is anyone under water in the vehicle? (RESWA)
- Is everyone up and walking around? Yes (BLS/PD) No (ALS/PD)

Survey of Regional PSAPs

- Recognize value of AACN for exact GPS location of crash, more important for rural than urban
- Do not want to receive raw CDR data, would prefer a scale which predicts:
  - Need for extrication
  - Risk of Severe Injury
- Concern about false positive activations
- Concern about integration with current CAD systems, Do not want a separate system
Optimizing the System

Background
NHTSA/CDC AACN Work

• In 2006, the CDC Field Triage Decision Scheme was revised to include the use of vehicle telemetry.

http://www.cdc.gov/fieldtriage/
How does the current triage algorithm perform in real life?

- Multicenter review of EMS data from 7 regions in the Western US
- 122,345 injured patients transported by EMS over a 3 year period, 34.5% met at least one trauma triage criteria, 5.8% had an ISS>=16
- Overall sensitivity 85.8%, specificity 68.7%
- Approximately 1,000 patients were undertriaged and they tended to be older, 47% falls, 30% MVCs

Newgard et al, JACS, 2011

Each Step adds to Sensitivity
Summary/Conclusions

- Step 3 is a valuable component of the overall triage tool, adding to sensitivity with minimal reduction in specificity.
- Strongest predictors for ISS > 15 were death in the vehicle and steering rim collapse.
- Step 3 may be improved by AACN prediction algorithms.
- Elderly are susceptible to undertriage.

AACN Prediction Models

- Review previously published models
  - GM
  - URGENCY
- Describe research project designed to develop new models
  - Exclusion of patient specific data (age, gender)
  - Evaluation of CDR only variables
The GM Model

- NASS-CDS 1999-2008
- Planar, non-rollover crash events, model year >=2000, airbag deployment or delta v >= 15mph
- Vehicle level analysis, 32% missing delta v, imputation done but not presented
- Variables: crash direction, delta V, belt use multiple vs single impacts, vehicle type, Age > 55, gender
- Sensitivity 40%, Specificity 98% for probability threshold of 20% for ISS>15

Kononen et al, Accident Analysis and Prevention, 2011

URGENCY

- Occupant rather than vehicle level analysis, Age 16+ only
- Cases with missing data excluded
- Variables: crash direction, delta V, belt use multiple vs. single impacts, maximum intrusion, ejection, narrow impact, rollover, age
- Separate models for each crash direction but same variables
- Endpoint 10% probability threshold, MAIS 3+

Augenstein, 2005

Predicting Severe Injury Using Vehicle Collision Data

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J Trauma Acute Care Surgery 74(1): 190-194, 2012
Objectives

- Create a NASS dataset comparable to that used by GM with multiple imputation for missing data
- Evaluate all the collision variables used in previously reported models (excluding age and gender) to determine optimal algorithms for prediction of ISS>15 at Step 0 and Step 3
- Evaluate a secondary model including only variables currently captured by AACN systems
- Separate model for rollover collisions
- Recreate previously reported models for comparison using this dataset and assess performance at Step 0 and Step 3

Comparison of Models

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>UW NON-ROLLOVER</th>
<th>UW NON-ROLLOVER-ABBREVIATED</th>
<th>UW ROLLOVER</th>
<th>ONSTAR</th>
<th>URGENCY</th>
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<tbody>
<tr>
<td>Delta V</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>(Delta V)^2</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (Delta V)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDOF</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seatbelt use</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle body type</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Events</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle curb weight</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum intrusion^a</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Narrow impact^a</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger ejection^a</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rollover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger age</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Passenger gender</td>
<td></td>
<td></td>
<td>✓</td>
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</tr>
</tbody>
</table>

Summary

- UW model was comparable in sensitivity and specificity to GM model at both Step 0 and Step 3
- UW abbreviated model was comparable as well with a slight decrease in PPV
- These models have the advantage of not requiring contact with the vehicle to determine patient characteristics.
- With all models NPV was high thus minimizing risk of undertriage, overtriage may still be a concern.
Predicting Severe Injury or Need for Extrication using EDR-derived variables

What is an EDR?

Methods

- EDR data obtained from NHTSA and merged with NASS data set (2002-2010)
- Summary variables created from EDR files
- Sample randomly divided into a prediction and validation set
- All variables tested using step forward logistic regression to determine optimal models to predict ISS >15 or entrapment
- 40% files missing delta v and speed, usable n=742

9/18/2015
EDR derived variables

- airbag deployment
- driver belt status
- passenger belt status
- time for driver pretensioner activation
- driver seat track position
- passenger airbag suppression switch position
- maximum pre-crash delta V (within 600 ms of impact)
- maximum pre-crash vehicle speed (over 5 seconds before impact)
- pre-crash vehicle speed 1 second before impact
- maximum pre-crash engine speed (rpm) (over 5 seconds before impact)
- pre-crash engine speed 1 second before impact
- maximum pre-crash throttle percentage (over 5 seconds before impact)
- pre-crash throttle percentage 1 second before impact
- maximum pre-crash vehicle speed (over 5 seconds before impact)
- brake switch circuit on (over 5 seconds before impact)
- brake switch circuit on 1 second before impact
- time for first stage air bag deployment (ms)
- time for second stage airbag deployment
- time for first + second stage airbag deployment

Note delta v also assessed as a polynomial variable

Prediction of ISS>=15

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>OR 95% C.I.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max DV</td>
<td>0.714</td>
<td>(0.610, 0.839)</td>
<td>0.0056</td>
</tr>
<tr>
<td>Max DV squared</td>
<td>1.010</td>
<td>(1.006, 1.018)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Max DV cubed</td>
<td>1.000</td>
<td>(1.000, 1.000)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Driver belted</td>
<td>0.590</td>
<td>(0.356, 0.977)</td>
<td>0.0404</td>
</tr>
<tr>
<td>Braking 1 second prior</td>
<td>0.528</td>
<td>(0.318, 0.876)</td>
<td>0.0135</td>
</tr>
</tbody>
</table>

Prediction of ISS > =15

Reflects 20% Predicted probability threshold
**Prediction of Entrapment**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>OR 95% C.I.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max DV</td>
<td>0.890</td>
<td>(0.820, 0.965)</td>
<td>0.0050</td>
</tr>
<tr>
<td>Max DV squared</td>
<td>1.005</td>
<td>(1.002, 1.008)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Max DV cubed</td>
<td>1.000</td>
<td>(1.000, 1.000)</td>
<td>0.0013</td>
</tr>
<tr>
<td>Max speed</td>
<td>1.017</td>
<td>(1.009, 1.024)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>RPM 1 second prior</td>
<td>1.000</td>
<td>(1.000, 1.000)</td>
<td>0.0119</td>
</tr>
</tbody>
</table>

Reflects 20% Predicted probability threshold

**Summary**

- EDR data alone can generate useful models to predict injury severity and potential need for extrication
- Probability threshold may vary based on need to minimize undertriage without excessive overtriage
- Development of a scale to predict these outcomes may be more useful to facilitate decisions at PSAP (Step 0) and by EMS providers (Step 3)
Feedback from Trauma care providers

- Trauma center will be in contact with paramedics once on scene to assess Step 1, 2 and 3.
- More training to assess Step 3, Intrusion criteria with addition of scale based on telematic data
- Transmission of photographs of damaged vehicle useful to assess Step 3.

Integration of AACN into PSAPs

- Numerous vendors provide 911 systems
  - Seattle region prepared to integrate and test AACN
- On issue to address: AACN data sent to 911 (PSAP) could become publically available
  - AACN could have data that could incriminate and needs to be protected
    - Solution:
      - Direct only severity rank, GPS, vehicle model, number of occupants, etc to 911
      - Direct sensitive data to EMS, trauma centers as medical records protected under Federal laws
Future Direction

Next steps

- Ongoing collaboration with King County EMS to test data transmission and integration into CAD systems
- Finalize injury prediction algorithms and develop scoring system with input from EMS leadership