February 29, 2014

TraumaHawk

Improving Treatment for Crash Victims Using Photos and a Smartphone App

Phase 1 FINAL REPORT

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INTRODUCTION

Photographic documentation of crashed vehicles at the scene can be used to improve triage of crash victims. A U.S. expert panel developed field triage rules to determine the likelihood of occupants sustaining serious injuries based on vehicle damage that would require transport to a trauma center (Sasser et al., 2011). The use of photographs for assessing vehicle damage and occupant compartment intrusion as it correlates to increased injury severity has been validated (Davidson et al., 2014). Providing trauma staff with crash scene photos remotely could assist them in predicting injuries. This would allow trauma care providers to assess the appropriate transport, as well as develop mental models of treatment options prior to patient arrival at the emergency department (ED).

Crash-scene medical response has improved tremendously in the past 20-30 years. This is in part due to the increasing number of paramedics who now have advanced life support (ALS) training that allows independence in the field. However, while this advanced training provides a more streamlined field treatment protocol, it also means that paramedics focused on treating crash victims may not have time to communicate with trauma centers regarding crash injury mechanisms. As a result, trauma centers may not learn about severe trauma patients until just a few minutes before they arrive. The information transmitted by the TraumaHawk app allows interpretation of injury mechanisms from crash scene photos at the trauma center, providing clues about the type and severity of injury.

With strategic crash scene photo documentation, trained trauma professionals can assess the severity and patterns of injury based on exterior crush and occupant intrusion. Intrusion increases the force experienced by vehicle occupants, which translates into a higher level of injury severity (Tencer et al., 2005; Assal et al., 2002; Mandell et al., 2010). First responders have the unique opportunity to assess the damaged vehicle at the crash scene, but often the mechanism of injury is limited or not even relayed to ED trauma staff.

To integrate photographic and scene information, an app called TraumaHawk was created to capture images of crash vehicles and send them electronically to the trauma center. If efficiently implemented, it provides the potential advantage of increasing lead-time for preparation at the trauma center through the crash scene photos. Ideally, the result is better treatment outcomes for crash victims.

The objective of this analysis was to examine if the extra lead-time granted by the TraumaHawk app could improve trauma team activation time over the current conventional communication method.

METHODS

Background and TraumaHawk Development

Development of the TraumaHawk app was a team collaboration involving law enforcement from the Iowa State Patrol, first responders, ALS paramedics, trauma doctors, nurses and app developers. Involving all parties was crucial in ensuring that both the app and reporting process would be intuitive and practical for all users. Figure A1 displays several screen shots from the TraumaHawk app. The design allows on-scene personnel to create a report in about one minute and transmit it electronically to the ED. The app alerts trauma staff to the exact location of the crash, and its distance from the trauma center. The report displays a series of relevant photos of the vehicles involved in the crash, and allows for added contextual information. Icons are used to help first responders easily select each specific photo to document the exterior and interior of the crashed vehicles. The few images captured allow assessment of steering wheel deformation, A-pillar compromise, roof crush and other intrusions into the occupant compartment of the vehicle that are correlated with increased injury severity (Tencer et al., 2005; Assal et al., 2002; Mandell et al., 2010).

Figure A1a

TraumaHawk User Procedures

To create a report, law enforcement or a first responder (for this project we used state troopers) clicks on the App (Figure A1a) and then clicks “New Report” on the first screen (Figure A1b).

Figure A1b

Within the new report, the user is asked to state the type of crash (frontal, side, rollover, or rear-end); meanwhile, GPS location is also automatically logged together how far the crash is from the Level 1 Trauma Center (Figure A1c).

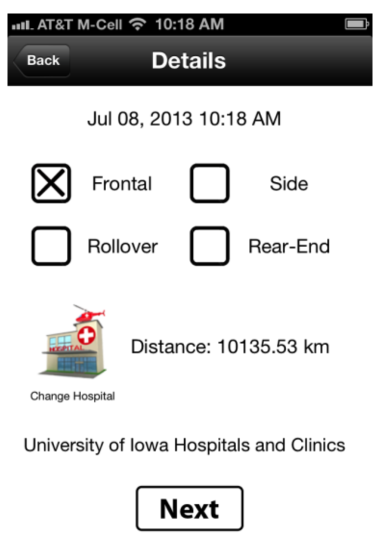


Figure A1c

As can be seen in Figure 1d, the user is then guided as to what areas of the automobile should be photographed. The six (6) areas chosen by the research team were selected based on the work by Davidson et al. (2014) that demonstrated these particular regions are most predictive of injury severity. Figure A1e shows the screen that pops up when the “Driver’s Side” option is selected in Figure A1d.

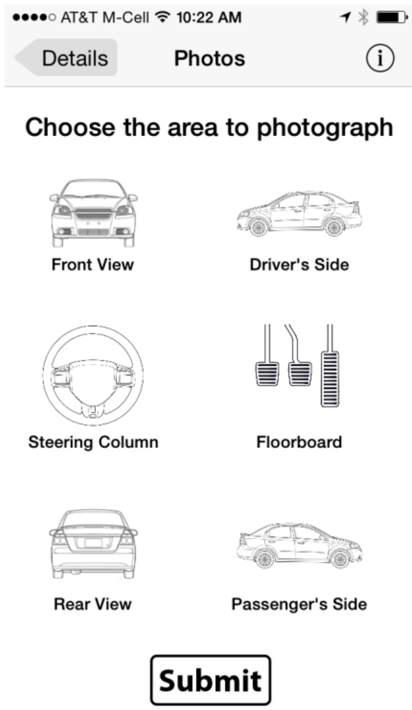


Figure A1d

The user is asked to provide three pictures of the driver’s side that together create a full side view of the vehicle, as well as 45º angled views at both corners of the damaged plane (Figure A1e). If the user is unclear as to where the pictures should be taken, he/she can click on “Help” and view example photos of how to capture the damaged side of the vehicle. Figure A1e is an example of photos taken at a TraumaHawk alert crash that illustrate the result of a high-speed near-side impact that met the intrusion rule for transport of the front right passenger to the trauma center. Officers are also allowed to include additional textual information on the crash.

Finally, users have the ability to ‘sanitize’ each image by using their fingers to smudge out crash victim faces (if present) and vehicle license plates to ensure confidentiality and protect the privacy of crash victims.

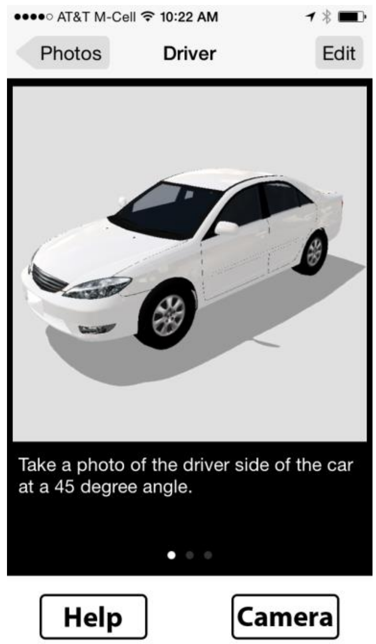
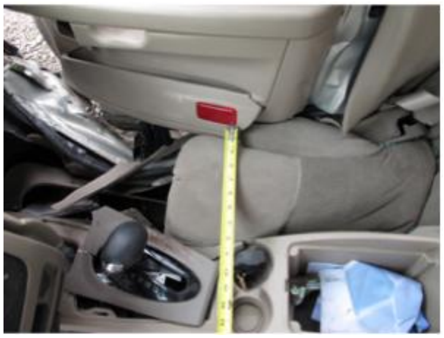

●●●●○ AT&T M-Cell 10:22 AM
Photos
Driver
Edit
Take a photo of the driver side of the car at a 45 degree angle.
Help
Camera

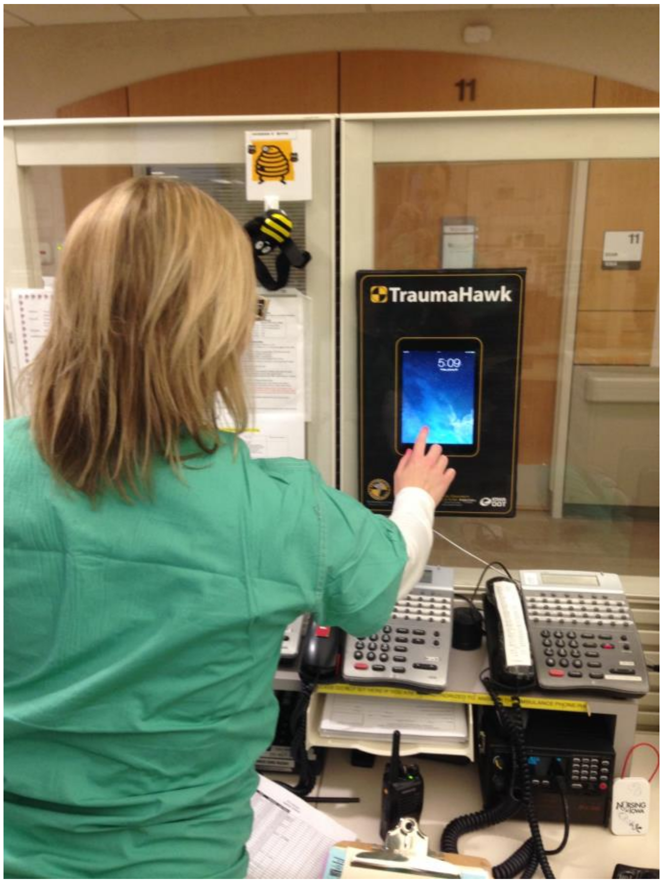
Figure A1e



Example images from a TraumaHawk crash file

TraumaHawk in the Emergency Department

Once a report has been submitted, it is electronically transmitted to the ED trauma center where the patient will be transported and displayed as an iPad® text alert; a signature auditory alarm alerts staff at the charge nurse's station that a report has been delivered.



A copy of the report is also sent to the research team via secure e-mail. The iPad report is then viewed by the ED charge nurse, who alerts the ED staff physician of the TraumaHawk notification. The ED physician reviews the

TraumaHawk report and shares the photos with the Trauma team to assess crash severity, the potential for traumatic injuries, how best to activate the trauma team most efficiently. A flow diagram of the overall process is presented in Figure 1.

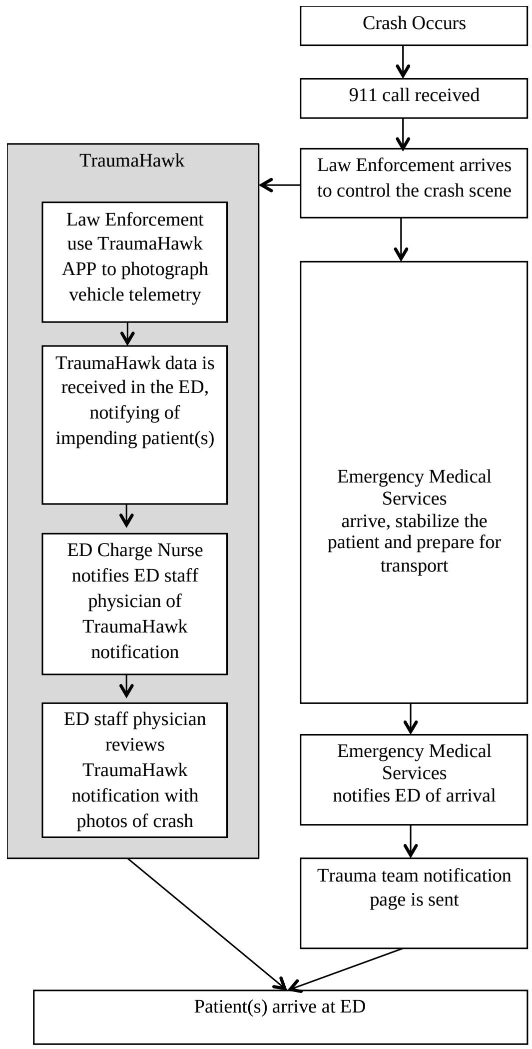


Figure 1. TraumaHawk flow diagram from crash to ED arrival

TraumaHawk cases are received at the University of Iowa's Level 1 Trauma Center with over 600 adult and pediatric trauma beds. At this Trauma Center, in order for a trauma notification to be sent, a patient must meet certain CDC Field Triage of Injured Patients criteria. Paramedics utilize such triage rules examining the physiological criteria and visually apparent traumatic injuries to assess whether a patient qualifies for notification (Sasser, et al., 2011). A patient may also be considered a trauma notification for certain levels of crush and intrusion for a high-risk automobile crash. A high-risk automobile crash is defined as:

1. Component intrusion greater than 12 inches at the occupant's site that includes the roof; or greater than 18 inches of crush at any location.

2. Patient is ejected (partial or complete) from the automobile, or
3. A death occurred in same passenger compartment, or
4. Vehicle telemetry data are consistent with a high risk of injury

In October 2013, 15 phones with the TraumaHawk App were distributed mainly to law enforcement (Iowa State Patrol), along with county and city-based ambulance services. In the first few months of deployment, we observed that the State Patrol and/or law enforcement were generally in the best position to complete and transmit the TraumaHawk reports at the crash scene. After providing first aid and traffic control, the on-scene patrol officer has a short window in which to capture a report once the paramedics arrive to help manage the scene. The paramedics are frequently too busy with patient care priorities to pause and document the scene. However, on ambulances that carried a three-member crew, the designated driver was able to take pictures and submit a report. It should be noted, however, that each crash can have a different order of first responders to a crash scene. Depending on the crash location, law enforcement may be one of the last parties to arrive.

Trauma Alert Times and Trauma Registry Data Collection

For TraumaHawk cases received from October 2013–August 2014, electronic medical records and trauma notification pages were examined to document the time and content of trauma notification pages and the actual time of patient arrival. Time of the TraumaHawk alert cases were identified and recorded. The difference between traditional paging and TraumaHawk lead-times was calculated in minutes. A paired *t*-test was used to determine if the mean lead-times for the Paging and TraumaHawk alerts differed significantly.

To examine how TraumaHawk motor vehicle crashes (MVC) differed from all MVCs seen at the Trauma Center over the study period, hospital-based trauma registry data were abstracted for all MVCs (ICD-9 CM E-codes =E810.0-E825.7) from October 2013 through June 2014, and then analyzed. Trauma notifications were excluded if the crash involved a motorcycle or moped, all-terrain vehicle, or snowmobile that did not include a collision with a passenger vehicle; if patients were not brought directly to the Trauma Center (transferred from an outside hospital to trauma center); or if they were not brought via ground or air ambulance. Differences in proportions of TraumaHawk vs. other MVCs were compared using Pearson chi-square test and differences in means were examined using a Student's *t*-test.

RESULTS

From October 2013 through August 2014, 35 TraumaHawk reports were received of which 32 met the criteria for a trauma team notification. During this time, 319 eligible MVC were seen at the Trauma Center, of which 10.0% (n=32) had TraumaHawk reports.

TraumaHawk-reported patients had an average injury severity score (ISS) of 6.4 (standard deviation=11.4), 50% (n=16) were male, their mean length of hospital stay was 5.6 days (standard deviation=7.9), and the majority (93.8%, n=30) arrived by ground ambulance. These characteristics did not differ between TraumaHawk and Non-TraumaHawk (see Table 1).

Table 1. Patient, Emergency Department and Hospital Stay Characteristics by Presence of TraumaHawk Photos

	TraumaHawk				
	Yes	(%)	No	(%)	p-value
Age, years (mean, std)	30.8	(19.4)	38.6	(20.0)	0.0365
Male	16	(50.0)	153	(53.5)	0.7070
Arrival Mode					
Air ambulance	2	(6.3)	55	(19.2)	0.1797[1]
Ground ambulance	30	(93.8)	230	(80.4)	
Police	0		1	(0.4)	
Injury Characteristics					
ISS	6.4	(11.4)	8.0	(10.5)	0.5020
Max AIS	1.7	(1.3)	2.0	(1.2)	0.1721
ED GCS	14.6	(1.3)	14.3	(2.7)	0.2256
TRISS	0.97	(0.07)	0.95	(0.16)	0.2383
Admitted to Hospital	8	(25.0)	128	(44.8)	0.0325
Length of stay, days (mean, std)	5.6	(7.9)	5.2	(8.3)	0.8811
Died	0		7	(2.5)	0.9999[1]

[1] Fisher's exact test

TraumaHawk patients were less likely to be admitted (25.0% vs. 44.8%, p=0.0325) and were, on average, younger than non-TraumaHawk patients (30.8 vs. 38.6 years, p=0.0365).

Of the 32 TraumaHawk cases who were also trauma notifications, the actual mean time between the trauma team page and patient arrival was 12 minutes; with TraumaHawk, the advanced notice was received at the trauma center 26 minutes before patient arrival, more than doubling notification time ($p<0.001$). On average, the ED doctor saw patients 69 minutes after they sustained their injury. These times were significantly lower for TraumaHawk patients (56.7 minutes, standard deviation=23.3) than for non-TraumaHawk patients (70.2 minutes, standard deviation=43.8) (p=0.03). In addition, the trauma surgeon responded, on average, 66 minutes after the injury. TraumaHawk patients saw the trauma surgeon, on average, 58.1 minutes (standard deviation=22.1) after their injury vs. 67.3 minutes (standard deviation= 36.0) for non-TraumaHawk patients (p=0.07).

The TraumaHawk reports averaged six (6) (range 1-14) photos per report. In the 35 TraumaHawk reports, 88.6% included interior images of the driver area with a view of the steering column, and 80% showed a view of the driver floorboard. In all cases, the damage planes were documented.

DISCUSSION

Advanced warning and trauma page activation regarding an incoming crash allows ED personnel to allocate resources more efficiently. They are able to order the disposition of patients and allocate adequate staff to receive the incoming crash victims. The increased time afforded by a trauma alert also allows trauma surgeons and specialty services to adjust schedules accordingly (i.e., they might delay the start of a non-urgent scheduled procedure to provide time to assess the incoming trauma victim).

While all trauma staff receives a standardized report from the field, viewing the TraumaHawk images prior to a patient's arrival allowed an assessment of potential injury patterns and increased severity. This enabled the trauma team to prepare and plan for specific key treatment and specialties services (orthopedics, pediatrics, neurosurgeon, etc.). This added context was key, as evidenced by the shorter amount of time before patients were seen. While all patients undergo a standardized and very thorough exam after arrival, the photos and an understanding of occupant compartment intrusion patterns can help the team focus on particular parts of the exam where the data would indicate there is a high risk for injury. Conversely, having an understanding of crush patterns and how the presence of increased intrusion relates to the vehicle occupants injuries, minor crashes can also help relieve the concern regarding traumatic injuries. Assessment of low-speed crashes with no intrusion could also potentially avoid unnecessary trauma notifications, the need for invasive procedures and radiological images, and reduce concern when treating and releasing a patient from a crash.

In these primary data, TraumaHawk was shown to increase the advance time for trauma notification and preparedness at a trauma center for identified trauma patients. Because of the added context, patients were seen more quickly than non-TraumaHawk cases. Since the initial 15-phone deployment, we have increased the number of phones to 35 in state trooper vehicles, and more data will be available in the soon.

There are limitations to this study. First, TraumaHawk patient crashes tended to occur in closer proximity to the ED than did non-TraumaHawk patients; therefore we cannot say if the shorter time between patient injury and the ED/Trauma physician was perhaps due to the shorter distance traveled. Second, because there are only a small proportion of MVCs seen at the ED with TraumaHawk reports, our generalizability of the current results are limited; although, the characteristics of TraumaHawk patients and their injuries did not differ greatly from non-TraumaHawk patients.

CONCLUSIONS

TraumaHawk allowed the trauma team significantly more time to prepare for incoming crash victims than the conventional ambulance crew notification. This permitted trauma staff to assemble the most appropriate level of care by specialists, as well as to arrange other vital aspects of care such as scheduling of operating rooms earlier than with the conventional communication. Further research is needed on the effect of TraumaHawk on patient outcomes.

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