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Prehospital triage of trauma patients using the Random Forest computer algorithm

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ABSTRACT

Background: Overtriage not only wastes resources but also displaces the patient from their community and causes delay of treatment for the more seriously injured. This study aimed to validate the Random Forest computer model (RFM) as means of better triaging trauma patients to level 1 trauma centers.

Methods: Adult trauma patients with "medium activation" presenting via helicopter to a level 1 trauma center from May 2007 to May 2009 were included. The "medium activation" trauma patient is alert and hemodynamically stable on scene but has either subnormal vital signs or accumulation of risk factors that may indicate a potentially serious injury. Variables included in the RFM analysis were demographics, mechanism of injury, prehospital fluid, medications, vitals, and disposition. Statistical analysis was performed via the Random Forest algorithm to compare our institutional triage rate to rates determined by the RFM.

Results: A total of 1653 patients were included in this study, of which 496 were used in the testing set of the RFM. In our testing set, 33.8% of patients brought to our level 1 trauma center could have been managed at a level 3 trauma center, and 88% of patients who required a level 1 trauma center were identified correctly. In the testing set, there was an overtriage rate of 66%, whereas using the RFM, we decreased the overtriage rate to 42% ($P < 0.001$). There was an undertriage rate of 8.3%.

The RFM predicted patient disposition with a sensitivity of 89%, specificity of 42%, negative predictive value of 92%, and positive predictive value of 34%.

Conclusions: Although prospective validation is required, it appears that computer modeling potentially could be used to guide triage decisions, allowing both more accurate triage and more efficient use of the trauma system.

1. Introduction

Effective triage of trauma patients is critical for efficient utilization of trauma system resources. Overtriage results in the delay of treatment for the more seriously injured, an excessive burden on the trauma center and its staff, an inappropriate use of expensive and limited resources, and the unnecessary displacement of patients from their communities [1].

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The quality of prehospital care impacts patient outcome [2–4]. This includes not only appropriate management, resuscitation, and rapid transport to a hospital but also transport to the hospital best suited to manage particular injuries. Established in 1999, the accepted overtriage rate of 50% has been reevaluated but never successfully reduced [3]. This high rate of overtriage has led to a crowding of level 1 regional trauma centers across the nation at the cost of using expensive and dangerous transport and highly trained staff for patients who do not benefit medically [5]. Efficient resource management requires emergency medical service personnel to correctly triage patients to the appropriate trauma center.

Currently, triage is determined based on three domains: physiology, mechanism of injury, and anatomic location of injury. These domains are defined during the initial physical examination in the prehospital environment and recorded at intervals throughout the transport. None of these domains have been able to accurately predict major trauma, the need for trauma team activation, or the necessity of a level 1 trauma center, especially in the "medium activation" population [6–9].

The "medium activation" trauma patient is alert and hemodynamically stable on scene but has either subnormal vital signs or accumulation of risk factors that may indicate a potentially serious injury. The criterion used for this classification at our center is outlined in Table 1.

Computer models can be used to assist with medical decision making and are becoming more common in clinical use [10]. The Random Forest computer model (RFM) is an ensemble classifier that uses a combination of many decision trees. The decision trees are created using a labeled training set of data associated with each patient. As the RFM receives more information, it creates more trees to avoid overfitting, or the generation of a single decision tree that depends too much on irrelevant features. Class assignment in the testing set is determined by the number of votes from all trees. Each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. As trees become larger, the generalization error for forests converges to a limit. Advantages of RFM include its ability to manage large databases with multiple weak input variables, maintain effectiveness even with large amounts of missing data through accurate estimation, and generate an internal unbiased estimate of the generalization error as the forest building progresses [11]. These properties permit the RFM to function as a "learning algorithm."

This study aimed to create and validate the RFM as a tool to triage minimally injured trauma patients away from level 1 trauma centers using prehospital variables.

2. Materials and methods

Adult trauma patients with "medium activation" presenting via helicopter to a level 1 trauma center within a three-tiered triage system from May 2007 to May 2009 were included. Transferred patients, patients with burns as a major complaint, and patients aged <18 y were excluded. Patients who arrived with the "highest activation," classified as top tier in our triage system, were not included in this analysis. Variables included in the RFM were demographics, mechanism of injury, prehospital fluid, medications, vitals, and disposition. The selection of patients for the study is displayed in Fig.

Prehospital data were collected from a handwritten "run sheet" used by Life Flight by either accessing the physical paper files or viewing a scanned portable document format of

Table 1 – Criteria for "highest activation" or "medium activation" at our level 1 trauma center.

Parameters	Highest activation	Medium activation
Physiologic criteria		
GCS	≤10	>10, ≤14
HR	>120	110–120
SBP	≤90	>90
Respiratory rate	<10, >29	Not specified
Intubated	Yes	No
Anatomic criteria		
Penetrating injury	Any to torso, groin, head, or neck	To extremity
Amputation	Proximal to ankle or wrist	None specified
Sensory deficit	Paraplegia and quadriplegia	None pecified
Hemorrhage	Uncontrolled external	None specified
Fracture	Pelvic and two or more long bones	None specified
Trauma with urns	≥20% body surface area	10%–20% body surface area
Risk factors		
Extrication	None specified	Any patient requiring extrication
Intrusion depth	None specified	Into a passenger space of a motor vehicle of >12 in
Ejection	None specified	From an enclosed vehicle or motorcycle >20 mph
Pregnancy	None specified	>20 wk
Death of occupants	None specified	In the same motor vehicle
Auto *versus* pedestrian	None specified	Any injury
Age	None specified	>65 y
Fall	None specified	>15 ft
Transfer	None specified	Receiving blood to maintain vital signs
Respiratory	None specified	Compromise/obstruction