



# Is mechanism of injury alone a useful predictor of major trauma?

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Trauma

## Summary

**Introduction:** The Review of Trauma and Emergency Services in Victoria -1999 left unresolved the predictive value of mechanism of injury in pre-hospital trauma triage guidelines. Ethics approval was granted. The objective of this study is to determine if mechanism of injury alone is a useful predictor of major trauma in pre-hospital trauma triage.

**Methods:** A retrospective cohort study was undertaken of all Victorian ambulance trauma Patient Care Records (PCRs) for 2002. PCRs where patients were physiologically stable, had no significant pattern of injury, but had a significant mechanism of injury were identified and compared with the State Trauma Registry to determine those patients who sustained hospital defined major trauma.

**Results:** There were 4571 incidents of mechanism of injury only, of which 62% were males, median age was 28 years. Two criteria had statistically significant results. A fall from greater than 5 m ( $n = 52$ ) of whom 5 (RR 10.86, CI 4.47 to 26.42,  $P < 0.0001$ ) sustained major trauma and a patient trapped greater than 30 min ( $n = 36$ ) of whom 3 (RR 9.0, CI 2.92 to 27.70,  $P = 0003$ ) sustained major trauma. The overall results are not clinically significant.

**Conclusion:** This study suggests that individual mechanism of injury criteria have no clinical or operational significance in pre-hospital trauma triage of patients who have an absence of physiological distress and no significant pattern of injury. These results add to the knowledge base of trauma presentation in the pre-hospital setting, especially in Australia, and are the baseline for further studies.

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## Introduction

Following the report of the Victorian Ministerial Task Force on Trauma and Emergency Services (VMTFTES) in 1999, two significant pre-hospital care questions

remained unresolved.<sup>4</sup> The first, is mechanism of injury alone a useful predictor in pre-hospital trauma triage? And secondly, what is the appropriate triage strategy for patients who deteriorate severely at the scene or during transport? This study set out to answer the first question.

The presence of any one of the physiological or anatomical abnormalities included in the pre-hospital potential major trauma criteria for the purpose of primary triage is less contentious. Triage in physiologically stable trauma patients where only mechanistic criteria are present has a high potential for over triage, however, a degree of over triage is unavoidable and necessary to consistently detect potentially serious injuries.

However, the presence of only high risk mechanism of injury or co-morbid factors placing the patient at risk of potential major trauma is controversial and potentially disruptive to the efficiency of a state-wide trauma system. "This group of patients should be triaged to a designated trauma service for assessment but whether this needs to be a Major Trauma Service (MTS) or other trauma service will remain at the discretion of the attending ambulance officer".<sup>4</sup> Validation of the predictive value of the mechanistic criteria alone has been limited in Victoria and Australia whilst the international literature varies considerably.

A review of all Emergency Medical Service (EMS) trauma data has not been previously attempted in Victoria or nationally, this is probably due to none of the Australian states or territories having, at the time of the study, an electronic data capture and data repository for complete EMS clinical data. The review of trauma data from the Victorian State Trauma Outcome Registry and Monitoring Group (VSTORM) is restricted as the dataset contains only those patients who have sustained major trauma, a subset of the total trauma incidents.

Only five international studies have previously reviewed the ability of the mechanism of injury to provide the only criteria to predict hospital defined major trauma or for trauma team activation. All these studies, had less than 1000 patients with mechanism of injury alone, did not include all age groups, did not report the outcome in the same manner, and at best had only two criteria that could be compared across all studies.<sup>3,5,6,10,12</sup> These studies collectively suggest that the mechanism of injury criteria alone are not useful predictors of hospital defined major trauma or useful for trauma team activation.

Ethics approval for the project was obtained from the Monash University Standing Committee for Ethics in Research on Humans and the Victorian Department of Human Services Ethics Committee.

The objective of the study was to undertake an analysis of trauma patients who have suffered mechanism of injury (MOI) only trauma and establish sensitivity, specificity, and predictive values for each of the MOI criteria as identified by the VMTFTES.<sup>4</sup> The major outcome was the number of patients who had MOI only trauma and whether they subsequently had hospital defined major trauma.

## Materials and methods

### Study design

A retrospective cohort study was undertaken of all trauma patients who were transported by Victorian emergency ambulances during 2002 that presented with mechanism of injury only.

### Population and setting

The study was conducted in Victoria, a south eastern state of Australia. Victoria covers approximately 227,590 km<sup>2</sup> with a population of approximately 4.9 million people during the study period (49% males and 51% females).<sup>2</sup> The Metropolitan Ambulance Service (MAS) provides the EMS for the greater Melbourne metropolitan area which covers roughly 7694 km<sup>2</sup> and a population of some 3.5 million people. Rural Ambulance Victoria (RAV) services the remaining 1.4 million people covering roughly 219,896 km<sup>2</sup> of Victoria.

The state of Victoria has both a single and dual level EMS response. The first level of EMS response is provided by an Ambulance Paramedic with varying levels of Advanced Life Support (ALS) skills. The second level of EMS response is the Mobile Intensive Care Ambulance (MICA) with a paramedic who has a broader range of ALS skills including intubation and a greater range of drugs at their disposal.

### Process

No electronic EMS clinical data repository was available in the Victorian EMS at the time of data collection. Consequently, each EMS Patient Care Record (PCR) for 2002 was manually retrieved. All trauma PCRs were reviewed, and then each individual trauma case was analysed to establish eligibility for inclusion into the study. Eligibility was determined using pre-set inclusion and exclusion criteria. All trauma patients transported by emergency ambulances in Victoria from the 1st January 2002

**Table 1** Mechanism of injury criteria

Mechanism criteria
MCA >60 km
Motor cyclist/cyclist
Patient in vehicle rollover
Pedestrian hit >30 km
Fall >5 m
Patient trapped >30 min
Death of other vehicle occupant
Patient ejected from vehicle
Explosion
Object falling from >5 m

to the 31st December 2002 were eligible for inclusion in the study.

Patient data was included for all patients who had sustained trauma through road traffic accidents, industrial incidents, burns/explosions, or trauma other than that listed in the exclusion criteria, were not in physiological distress, did not have a significant pattern of injury, but had a mechanism of injury considered to be "at high risk of having major trauma" and were transported by ambulance to hospital.<sup>4</sup> The MOI criteria used in this study are defined in the VMTFTES and also listed in Table 1, the major trauma criteria are defined in Fig. 1.<sup>4</sup> Patient data was excluded from the study if the patient was not involved in a trauma incident, was transported as a result of an inter-hospital transfer, was in physiological distress, had a significant pattern of injury, or the PCR had insufficient information to determine if the patient had sustained trauma and what type of trauma.

Each PCR was reviewed by a researcher to establish eligibility as pre-determined by the inclusion and exclusion criteria. The PCRs that met the inclusion criteria had specific data entered into a secure relational database (Microsoft Access™ Version 10 SR2, Redmond, Washington, U.S.A.) specifically written for the project. The dataset was then reviewed to ensure that only one PCR per patient per incident was in the data repository. The required data was then exported to a file for uploading into a statistical program.

The hospital defined major trauma criteria referenced in this study are derived from the VMTFTES report<sup>4</sup> and include:

- Death after injury.
- Admission to an Intensive Care Unit for more than 24 h, requiring mechanical ventilation.
- Urgent surgery for intra-cranial, intra-thoracic, or intra-abdominal injury, or for fixation of pelvic or spinal fractures.
- Injury Severity Score (ISS) >15.

- Serious injury to two or more body systems (excluding integumentary).

The ambulance dataset was initially linked to VSTORM data by matching of unique identifiers in both datasets. As there was data missing from required linking fields in both datasets it was decided to undertake the final linking process manually. This involved checking a list of all major trauma patients from VSTORM ( $n = 1096$ ) against a list of EMS data ( $n = 4571$ ).

The PCR documentation was the sole source of data for this study, therefore, we were reliant on the quality of the information written by paramedics about the patient's incident and management. The need for high quality data capture from the PCR was also paramount. A quality analysis of the PCR documentation was undertaken simultaneously during the data collection process and has been reported elsewhere.<sup>13</sup>

Descriptive statistics were used to summarise the demographic data. Additional statistical tests include relative risk (RR), sensitivity, specificity, and positive predictive value. For these additional statistics patients in each mechanism criteria were compared to all other patients who had mechanism of injury alone. All tests are two tailed unless otherwise stated. The results are considered statistically significance if the  $P$  value is  $<0.05$ , all confidence intervals (CI) are 95%.

## Results

Victorian EMS transported 4571 patients classed as MOI only in the 12-month period from 1st January to 31st December 2002. This amounts to approximately 8.6% of the total trauma incidents ( $n = 53,039$ ) for that time period. The MAS attended approximately 69% of the total trauma incidents whilst RAV attended to approximately 31%.

The gender distribution was 62.5% males, 37.3% females, there were missing data for the remaining 0.2%. The mean age was 32.3 years with a standard deviation of 16.81 years. The median age was 28 years (range from 1 month to 97 years). There were 9.8% of patients who were less than 15 years of age with 11% of patients greater than 55 years of age. The age information is based on the actual age when there was a date of birth to calculate the age or an approximate age when there was no date of birth.

Forty-five patients who had mechanism of injury only were subsequently found to have hospital defined major trauma, see Table 2 for the distribution. A summary of the mechanism of injury criteria is shown in Fig. 2.

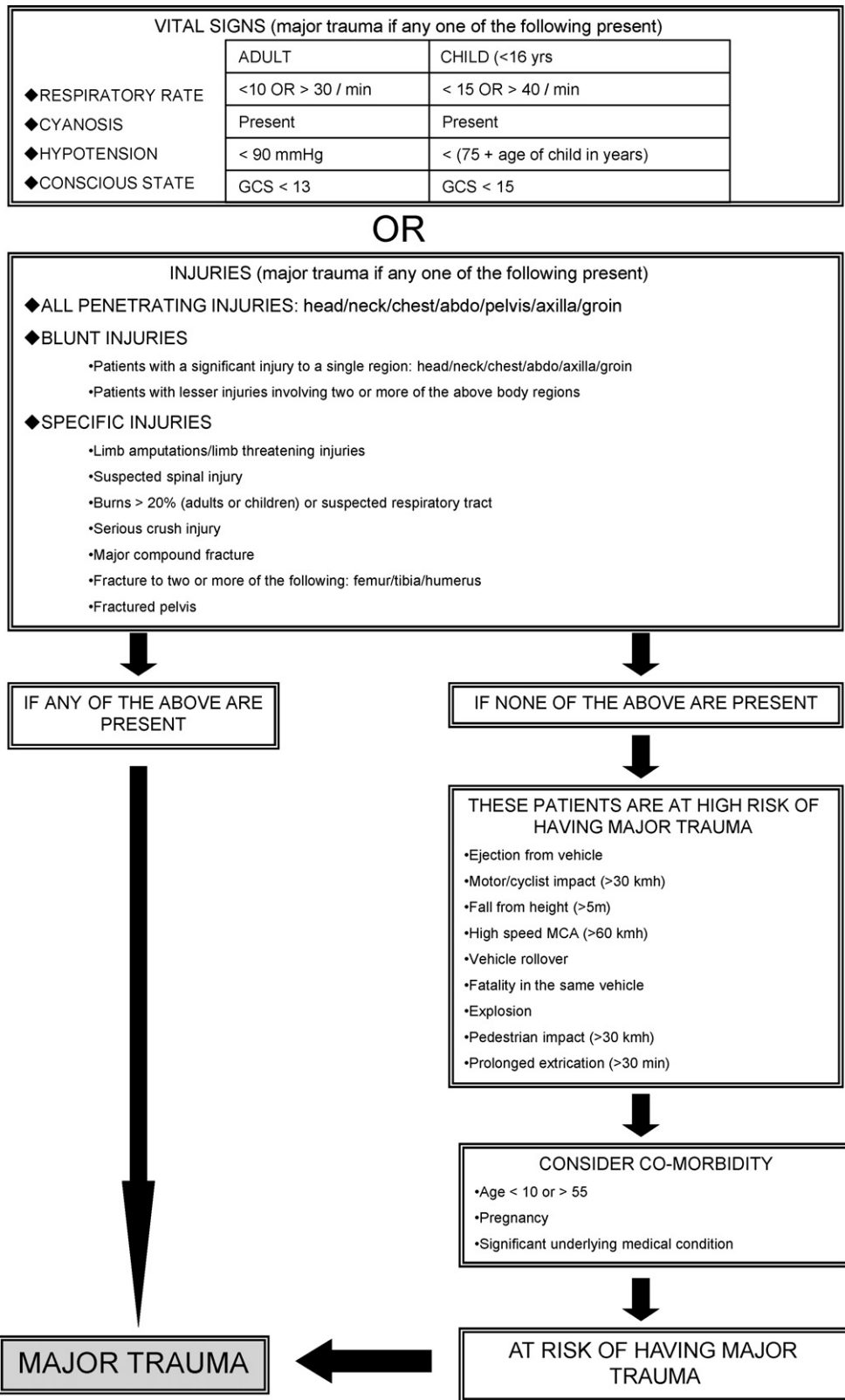
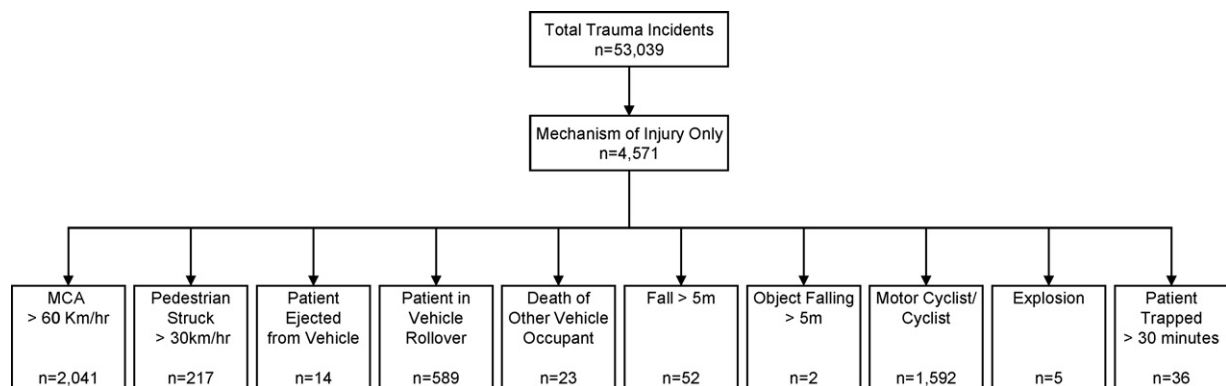


Figure 1 Victorian pre-hospital major trauma criteria. Copyright: Pre-hospital and Disaster Medicine.

**Table 2** Mechanism of injury only and hospital defined major trauma

Mechanism criteria	N	Hospital defined major trauma	Major trauma (%)
MCA >60 km	2041	20	0.44
Motor cyclist/cyclist	1592	10	0.22
Patient in vehicle rollover	589	4	0.09
Pedestrian hit >30 km	217	3	0.07
Fall >5 m	52	5	0.11
Patient trapped >30 min	36	3	0.07
Death of other vehicle occupant	23	0	0.0
Patient ejected from vehicle	14	0	0.0
Explosion	5	0	0.0
Object falling from >5 m	2	0	0.0
Total	4571	45	0.98

**Figure 2** Total trauma incident and mechanism of injury only numbers.

### Mechanism of injury and predictability of major trauma

Only two of the ten criteria where patients had hospital defined major trauma provided statistically significant results. They were, patients falling from a height greater than 5 m, RR 10.86, CI 4.47–26.42,  $P < 0.0001$ , and patients trapped in a motor vehicle greater than 30 min, RR 9.0, CI 2.92–27.70,

$P = 0003$ . The major trauma predictability criteria for all mechanisms are listed in Table 3.

### Discussion

This study is the first in Australia, and one of few internationally, to use a complete state EMS dataset, and not data from a specific trauma registry, to

**Table 3** Mechanism of injury criteria and predictability of major trauma

Mechanism criteria	Total (n)	Major trauma (n)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	P value
MCA >60 km	2041	20	44	55	1	0.9023
Motor cyclist/cyclist	1592	10	22	65	1	0.1038
Patient in vehicle rollover	589	4	9	87	1	0.5614
Pedestrian hit >30 km	217	3	7	95	1	0.7977
Fall >5 m	52	5	11	99	10	<0.0001
Patient trapped >30 min	36	3	7	99	8	0.0003
Death of other vehicle occupant	23	0	0	99	0	0.5624
Patient ejected from vehicle	14	0	0	100	0	0.326
Explosion	5	0	0	100	0	0.0411
Object falling from >5 m	2	0	0	100	0	0.0006

investigate the characteristics of patients who have mechanism of injury only trauma over a 12-month period. Only two criteria demonstrated statistical significance, a fall greater than 5 m and a patient trapped in a vehicle greater than 30 min.

International studies often covered a small geographical area, normally a catchment area for a trauma centre or major local hospital, rarely included paediatric patients, and had much smaller mechanism of injury numbers than did this study.<sup>3,5,6,10,12</sup> The study by Ma et al. collected all EMS data for the state of Maryland, however, analysis was undertaken on only one of the five EMS regions and did not report MOI only outcomes.<sup>7</sup>

Of the international studies that investigated mechanism of injury only<sup>3,5,6,10,12</sup> none reported the same mechanisms, at best three of the international studies can be used to compare only two of the mechanisms, patient ejected from a vehicle and fall >4.6 m.<sup>3,6,12</sup> Even this is complicated by Bond et al.<sup>3</sup> who only reported positive predictive values for the criteria and not sensitivity and specificity as the other studies did. Three of the international studies reported vehicle intrusion or space violation,<sup>3,6,12</sup> this mechanism is recommended in the American College of Surgeons Resources for Optimal Care of the Injured Patient document,<sup>1</sup> however, this mechanism is not used in the Victorian EMS guidelines for potential major trauma.<sup>8</sup>

A study by Palanca et al. using data from the Royal Melbourne Hospital reported results for vehicle intrusion, it is interesting that this component is not part of the ambulance service mechanism criteria nor is it a required component on the PCR.<sup>9</sup> The vehicle diagram on the PCR does not provide sufficient data to accurately report on vehicle intrusion. Paramedics do receive instruction about the documentation of vehicle intrusion, however, little evidence of this information was seen when reviewing PCRs for the study.

The patient with the mechanism of a fall greater than 5 m only has a 9.6% chance of having hospital defined major trauma. The international studies for a fall >4.6 m varied with their results, the proportion of patients with major trauma varied from 4% in the study by Knudson et al.<sup>5</sup> to 59% in the study by Long et al.,<sup>6</sup> with this study identifying 11% as having major trauma using the same criteria as the international studies. It is difficult to draw any real conclusion from these findings due to the wide variation in the results and the vast differences in the populations the patients were drawn from. Two international studies were conducted in the mid 1980's,<sup>5,6</sup> many changes in medical care and health promotion have taken place since these studies were undertaken so it is also difficult to make

comparisons on these grounds. The difference in EMS systems and health care systems may also make it difficult to accurately compare. The study by Bond et al. reported a predictability of hospital defined major trauma for patients with a fall >4.6 m of 14.3% whereas this study identified 9.6% as having major trauma using the same criteria as Bond et al. It is difficult to draw any real conclusion from this study due to the lack of actual mechanism of injury fall numbers in the study by Bond et al.<sup>3</sup>

The patient who is trapped in a vehicle greater than 30 min has an 8.3% chance of having hospital defined major trauma. The results for a patient with a prolonged extrication time again varied widely, the proportion of patients with major trauma was from 65% in the study by Simon et al.<sup>12</sup> to 73% in the study by Long et al.,<sup>6</sup> with this study identifying 6.7% of patients with hospital defined major trauma using the same criteria as the international studies. The study by Long et al.<sup>6</sup> must be considered in some isolation due to the age of the data and the changes that occurred in traffic rules, vehicle design, and health care between it and the study by Simon et al., some 10 years later. The study by Bond et al. reported the proportion of patients with major trauma as 40% for patients with a prolonged extrication time whereas we identified 8.3% of patients with major trauma using the same criteria as Bond et al.<sup>3</sup> The number of patients with a prolonged extrication time with mechanism of injury only is again not easily determined in the international studies due to the way in which the data are grouped and the lack of clarity of mechanism of injury only criteria.

The study results demonstrate that using mechanism of injury only criteria as a predictor of hospital defined major trauma is not justified. Even though two of the results were statistically significant the positive predictive value (PPV) was ten percent or less in both cases. For example, we interpret the fall results as, a person who had a fall greater than 5 m, is physically stable and has no significant pattern of injury, has a ten percent chance of sustaining hospital defined major trauma. Given that both criteria have a PPV of ten percent or less we suggest that MOI only has no use in pre-hospital trauma triage.

The findings from this study have guided the two EMS medical standards committees in their decision to remove the mechanism of injury only as a trauma triage guideline from the state endorsed clinical practice guidelines. The mechanism of injury criteria is still used as a triage tool in conjunction with physiological distress and significant pattern of injury. This study supports the findings of Shatney and Sensaki that using mechanism of injury only as a

criterion for trauma team activation is an inefficient use of scarce hospital resources. Of the total patients identified by Shatney and Sensaki 75% were discharged home from the emergency department, 26% were admitted to hospital, and only 0.17% required early surgery (less than 12 h).<sup>11</sup>

This study is subject to a number of limitations. Firstly, the data used in this study is based on the analyses of PCRs identified during a retrospective review covering a 12-month period. While the authors believe all available trauma PCRs were included in the study, the possibility exists that some PCRs may have been missed. Secondly, there were small major trauma numbers for some mechanism criteria and therefore, the findings may not be a true representation and should be interpreted with caution. Finally, as there was some required data missing from the PCRs, e.g. incident number, patient gender and age, we cannot be entirely sure that all ambulance data and state trauma registry data were linked successfully. These issues may have potentially limited the final dataset.

## Conclusions

In conclusion, data from this study confirms that individual mechanism of injury only criteria, that is, patients who are not physiologically distressed nor have a significant pattern of injury but have a mechanism of injury criteria present, are not good predictors of patients who will go on to have hospital defined major trauma. Consequently, individual mechanism of injury criteria have no clinical or operational significance in pre-hospital trauma triage of patients who have an absence of physiological distress and no significant pattern of injury. These results add to the knowledge base of trauma presentation in the pre-hospital setting, especially in Australia, and are the baseline for further studies and international comparisons.

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time and assistance involved with the data linking. We also acknowledge the research assistants who manually reviewed the Patient Care Records and entered the data into the study database.

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## Conflict of interest

There are no conflicts of interest.

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