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Original article

Performance of a prehospital trauma diversion system in Hong Kong, China

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ABSTRACT

Purpose: To evaluate the performance of a prehospital trauma diversion system in Hong Kong, China.
Methods: A retrospective analysis of prospectively collected data in the trauma registry of Queen Mary Hospital, Hong Kong from 1 January 2009 to 31 December 2013 was done. All adult patients aged 18 years or above, either primarily or secondarily diverted to Queen Mary Hospital according to the trauma patient diversion protocol, were recruited. Need for trauma center level of care was based on a consensus-based criterion standard published in 2014. Performance of the protocol in terms of over-diversion and under-diversion was determined.
Results: A total of 209 patients were included for analysis. About 30% of the patients required trauma center level of care. The most common reason was the need for vascular, neurologic, abdominal, thoracic, pelvic, spine or limb-conserving surgery within 24 h of presentation. The over-diversion rate and under-diversion rate were 69.6% and 19.7% respectively.
Conclusion: The trauma patient diversion protocol currently in use in Hong Kong is not accurate enough. Further revision and refinement is needed.

1. Introduction

Despite the fact that trauma has become a major public health problem in China, there are many deficiencies in the delivery of trauma care. A robust trauma system in China is still lacking.[1] Being a metropolis in China with over 7 million population, Hong Kong (HK) follows the principles of regionalization of trauma care used in western countries. Primary trauma diversion (PTD) is the process of transferring an injured patient from the scene of injury directly to a designated trauma center. If the trauma patient, for any reason, is initially taken to a non-designated hospital but found to meet the trauma team activation criteria there, he or she would then be diverted to the designated hospital, i.e. secondary trauma diversion (STD). On HK Island, Queen Mary Hospital (QMH), a designated trauma center, is linked with Ruttonjee Hospital (RH). The population served by both hospitals is about 0.6 million. Based on the trauma patient diversion protocol (TPDP, Table 1) which is applicable to the whole territory of HK, the ambulance crew would transfer a patient with injury sustained in the catchment area of RH to either QMH (PTD), or RH (STD). STD refers to a trauma patient who is first taken to RH and transferred to QMH for treatment subsequently. Both hospitals have the same trauma team activation criteria.

A pivotal factor that determines the success of trauma diversion is appropriate patient selection by the prehospital personnel. In HK, the selection process rests on the ambulance officer in charge, whose training is equivalent to emergency medical technician standard. For non-arrested trauma patients not requiring emergent airway or breathing intervention, if they fulfill any of the physiological or anatomical criteria of the TPDP, they would be taken to the designated hospital for treatment. This protocol is based on the "field triage guidelines" published by the American College of Surgeons Committee on Trauma and the Centers for Disease Control and Prevention.[2] The major differences between the two are the lack of mechanism of injury criterion and the special patient or system consideration criterion in the TPDP. The difference is probably related to the training received by the local ambulance crew. Whether it is the TPDP or the field triage guidelines, the aim is to identify patients who would benefit from trauma center level of care (TCLC) for diversion.

The objective of this study was to determine the performance of the TPDP regarding under- and over-diversion by a consensus-based criterion standard. This standard was developed in

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Table 1
Trauma patient diversion protocol criteria.

Go to the nearest hospital if:	In cardiac arrest or airway and/or breathing cannot be managed
Go to trauma center if one or more anatomical criterion is met:	Flail chest
	Lower limb fracture of 2 thighs, or 1 thigh and 1 lower leg, or 2 lower legs, or 1 or 2 thigh(s) and 1 or 2 lower leg(s)
	Amputation proximal to wrist or ankle
	Penetrating trauma to head, neck, or torso
	Limb paralysis
	Pelvic fracture
	Burn of 2nd degree or more and involved 20% body surface area or more
Go to trauma center if one or more physiological criterion is met:	Glasgow coma score <14, or
	Not alert by APVU
	Systolic blood pressure <90 mmHg or capillary refill >2 s
	Respiratory rate <10 or >29 per minute

response to the lack of standard indication for trauma center need. It is hoped that the findings from this study can provide evidence-based data to other metropolises in China that are developing their trauma system.

2. Methods

This study was a retrospective analysis of prospectively collected data in the trauma registry of QMH from 1 January 2009 to 31 December 2013. Trauma patients aged 18 years or above were recruited if their injury occurred in the catchment area of RH and based on the TPDP, they were transferred by ambulance to QMH or RH initially and then QMH subsequently. Patients who were not transferred to either QMH or RH by ambulance were excluded. Those who at the scene arrested or required emergent airway or breathing intervention as judged by the ambulance crew were also excluded, because the crew did not need the physiological or anatomical criteria on the TPDP to make the judgment. Two investigators reviewed the ambulance records to determine whether the ambulance crew complied with the TPDP and non-compliance cases were excluded. Data on patient demographics, injury profile and the need for TCLC were collected. The need assessment was based on a consensus-based criterion standard published in 2014.[3] The standard contains 10 indicators for the highest level of trauma care.

Descriptive statistics were used to describe the patients. Mann–Whitney test and Chi-squared test were used to compare continuous and categorical variables respectively. A p value < 0.05 was considered statistically significant. The 95% confidence interval (*CI*) was reported wherever appropriate. Performance of the TPDP was represented by the rates of over- and under-diversion. Over-diversion rate was represented by 1−positive predictive value i.e. (false positive)/<(true positive) + (false positive)>. Under-diversion was represented by 1−sensitivity i.e. (false negative)/<(true positive) + (false negative)>. Statistical analyses were done with SPSS 11.5 (SPSS Inc., Chicago, USA).

3. Results

A total of 318 patients fulfilled the inclusion criteria. Among them, 4 patients and 101 patients were excluded for incomplete records and non-compliance by the ambulance crew respectively; 3 patients were in cardiac arrest at scene and 1 needed emergency airway/breathing intervention at a nearby hospital. At last, 209 patients were recruited in the final analysis.

The median age of patients was 48 years. Male outnumbered female patients by almost 40%. A quarter was secondarily diverted from RH. Most were victims of blunt trauma. Only 5 patients suffered from a penetrating injury. The median injury severity score was 8. Mortality rate was low at 1%. About 30% of patients were judged requiring TCLC (Tables 2 and 3).

Of those requiring TCLC, the most common reason was the need for vascular, neurologic, abdominal, thoracic, pelvic, spine or limb-conserving surgery within 24 h of presentation (Table 4). There was significant difference between the group requiring and not requiring TCLC regarding mechanism of injury, injury severity score and mortality rate (Table 5). The over-diversion rate and under-diversion rate were 69.6% and 19.7% respectively (Table 6).

4. Discussion

There are multiple studies on the performance of the field triage guidelines. Comparison between these studies is often difficult because of the heterogeneity in definition of the need for TCLC. Injury severity score (ISS) is at present the most commonly used criterion for defining the need for TCLC. However, it has been found to be a suboptimal proxy for TCLC need.[4] The criteria used in this study are more comprehensive and should be better in reflecting resource needs. This is indirectly supported by the finding of significantly higher median ISS and mortality of the group requiring TCLC than the group that did not.

Two local studies investigated the performance of TPDP.[5,6] Both showed markedly different results regarding under-diversion (28.8% versus 40.5%) and over-diversion (44.8% versus 3.5%). The drawback in these studies is how under- or over-diversion is defined. In these studies, over-diversion was defined as diversion despite the fact that none of the TPDP criteria was met and vice versa for under-diversion. These definitions are better considered non-compliance by the ambulance crew. Their under- or over-diversion rate only reflected the performance of the ambulance crew, not that of the TPDP. With the TPDP in focus, it is more appropriate to define over-diversion as patients, those who should not have been diverted i.e. not requiring TCLC, are diverted because the TPDP criteria are met. Similarly, under-diversion means that

Table 2
Patient characteristics.

Parameters	Values
Age (years)	
Mean (SD)	50.7 (18.7)
Median	48
Range	19–95
Gender	
Male (*n*, %)	145 (69.4)
Female (*n*, %)	64 (30.6)
Diversion type	
Primary (*n*, %)	161 (77)
Secondary (*n*, %)	48 (23)