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Using Triage Systems in Emergency Medicine is Crucial for Mass Incidents

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ABSTRACT

In an expected mass casualty incident (MCI), victims are usually overwhelmed by local medical system. Triage systems can be traced back to the needs of war in order to get the best results for the majority of the victims. In peacetime the triage systems are used to reallocate the limited medical resources to the victims of MCI. There are several kinds of triage systems in different countries, including the Simple Triage and Rapid Treatment (START), Sort, Assess, Life-saving interventions, Treatment and/or Transport (SALT), Sacco Triage Method (STM), Careflight triage and Triage Sieve (TS). The START system is the most common one and is commonly used in the United States of America. The SALT was developed by a work group of the Centers for Disease Control and Prevention (CDC) using scientific approach. STM is a triage algorithm created for a limited resource environment. In addition, the other triage systems also show their effectiveness in the management of the victims in MCI. Nevertheless, the data of thethes popular triage tools are based on simulated tests, and there is no proof of the validity and reliability of the triage systems. It is therefore important to assess the applicability, reliability, sensitivity and specificity of the current triage tools in the real MCI situation. Also, since different countries employ different triage tools, there is a need for cooperation in order to enhance the management of mass casualty incidents.

KEYWORDS: Mass Incident, Triage Systems, Emergency Medical Resources Allocation.

1. Introduction

The term “triage” has it’s origin from the French verb “trier”. Triage was originally practiced in 1792 by a military surgeon of Napoleon’s Imperial Guard, Baron Larrey, to divide the wounded into two groups: 1) Those who could be physically returned to battle; has early 2) been twentieth Those adopted century who rapidly [2]. required in Currently, more the triage extensive emergency can medical department be treatment. in described [1] the as [2] United the It Kingdom, process United of States arranging

of patients America and and Europe since their needs in the order that they should be treated so as to save the most lives in the context of a battle field or a disaster situation [3]. The objectives of triage are to determine which of the victims have potentially fatal injuries, to direct the victims to a particular area already designated for their management and to provide therapeutic intervention the as victims necessary should [4]. be In triaged peacetime, as MCI quickly demands and that effectively as possible. For instance, in 2001 the World Trade Center was assaulted and fell and with it incidents came given the limited knowledge resources of and how long to transport deal times with [4] such [5].

Disaster and MCI, which were earlier discussed as rare occurrences, gained importance owing to Terrorism including the Oklahoma City bombing, London bombings and Sandy Hook Elementary School shooting [6]. effective Terrorism triage related to mass save casualties as and many other lives MCI as need possible. an However, most of triage methods are used for trauma triage only and not for MCI triage in the real life. Furthermore, these systems are not suitable for the pre-hospital setting where clinical parameters are assessed [2] [7]. Therefore, the objectives of this review are to define MCI, to identify different triage systems used in MCI and to evaluate their effectiveness.

2. The New Characteristics of MCI

MCI refer to mass casualty situation that emergency medical services resources in terms of personnel and equipment are over MCIs taxed happen in very as rapidly far and as very the visibly, number leading and to complexity many of victims the [8]. casualties The are management concerned. of The vast majority of MCIs in is the different course with of the MCIs conventional may facility's be resources blunt, [9]. penetrating The and/or patterns burn of injuries. injuries Patients that may patients also present present with with also terrorism any be and combination the the of result mortality blunt, of rate penetrating man-made from and/or disasters it burn and alone injuries natural has to disasters increased the [11]. since paramedics The the [10]. intentional year They events 2007 may are [12]. defined Terrorism as risk In is 2016 not France only experienced limited terrorism to in geographical the events city but of also Nice; to more sporting, than religious 400 and people other were similar injured massive gatherings. while 86 people lost their lives over a distance of about 1. 1 miles in the incident [13]. In 2017, an earthquake of Richter 8. 0 struck in Sichuan China which resulted to the death of more than 20 people and more than 400 people were injured in the disaster [14].In the very recent days, over 500 victims suddenly appeared in the Las Vegas shooting. In face of plenty of trauma victims generated by MCIs, reasonable triage systems are urgely demanded to overwhelm the response capabilities with limited medi- cal resources [1].

3. Triage Algorithms in MCI

The medical objective of triage in MCI is to recognize the possible life threatening injury, and to give the patient the right management. Hence, the triage systems used in the context of MCI should enable the identification of the critical injury in a short

time frame and in a chaotic environment without a detailed assessment. There are several existing triage systems for mass casualty used in many countries. In general, these triage systems sort patients into 4 or 5 categories based on the basic physiological parameters. The data set used for categorization in the existing triage systems are walking, respiratory rate, heart rate and level of consciousness [15]. But the methods of these triage systems are different and therefore the outcomes of the triage systems of MCI also vary.

3.1. Simple Triage and Rapid Treatment (START) and Relative Triage Tools

The most widely used triage system in the United States is the Simple Triage and Rapid Treatment (START) system which was initially developed by Hoag Memorial Hospital together with the Newport Beach, California fire department. The purpose of START is to maximize the outcome for the majority of the victims. Based on the parameters such as walk, respire, perfuse and mental status, the START system classifies the patients into 4 categories with different color codes: immediate (red)—these are patients with treatable but life threatening injury; delayed (yellow)—injury that is treatable but not life threatening; minor (green)—injury that is not severe and expectant (black)—injury that is fatal or the patient is dead. The steps of START described are in presented the in following Figure five 1 steps and as described by Gustafsson et al The first step involves asking the patients to walk few steps to a certain area that has been predetermined. According to the level of ambulation, the patients are classified as "minor" with green color and these patients will be reassessed after the treatment of patient with life threatening injuries. Second, spontaneous respiration is examined. If the patient still do not have spotaneous breathing after airway is positioned, low priority is identified and he/she is labeled as "expectant" and considers as unsalvageable. Otherwise, spo- taneous breathing is appreciated with or without position airway, the triage will continue to check the respiratory rate (RR). If RR > 30/min, the patient is re- garded as immediate (red). If RR < 30/min, then perfusion is evaluated by radial pulse or capillary refill. If radial pulse is not present or capillary refill time is greater than two seconds, the victim is considered red or immediate. Last, mental status is evaluated. This requires immediate treatment of the victim if he or she is unable to follow commands. The patient who is able to follow commands is classified as delayed and given a yellow label.Triage is an initial part of medical management in MCI. Since first introduced

in 1980s, the START system is proved to be an effective triage system applied in medical management in MCI. conducted a study to evaluated the efficacy of START triage to predict mortality in an MCI [17]. They randomly se- lected trauma patients and analyzed 355 victims by START triage. The result suggested that 75.77% of "delayed" patients were survival. What is more, they labeled victims with tabulated scores of 1, 2 and 3 and the mortalities of victims were 50%, 28% and 21% respectively. This comprehensive analysis implied that START triage can predict likelyhood of mortality effectively. proved that the START system could improve the efficacy of triage in non- medical members even through a "last-minute" training [18]. Compared with non-START group, the accuracy of triage in START group was significantly in- creased, while the evaluation time was decreased. On the contrast, Kahn et al. found an opposite result in their study [19]. The performance of START system was assessed in a train crush. This study indicated that the outcome of START

was poor in evaluating 148 victims. Among these victims, 79 were over-triaged and 3 were under-triaged by START. It was thought this may be because of failure of the triage tool itself. Use of START did ensure that almost all patients received at least as much care as was needed, but incorporated a significant amount of over-triage which may be wasteful of potentially limited resources.

For pediatric 8 victim the years with breath. jump of additional Wallis START age five and 3461... patients system based rescue Carley children with To study is on breaths and compared severe date, offers created the to 4 observed injuries; the some for and were seconds START try pediatric that the practical asked important children efficiency and some system. to triage both authors application to measures in of activities the of The stimulate tools START suggested of assign of the jump that overall 5. through learn jump respiration including and that jump 363 jump age are START 5 correct the it and START in START START jump these simulated START. group not in seconds. assessment and the simulated this uses children in and START two pediatric Claudius of necessarily 2014 Thus, train exercises. was simulated study, short 55 the MCI with jumpSTART tools tools patients. conducted 1 required [22]. oneself this 85. practices educational Baez EMS increased same has a in performed had The MCI to in Thirty-three for Although study 7%. can intervention and practitioners in 4% approach been pulse poorly a average Simulations the pre-clinical suggested its help 34 the that col- Also, with the vs. as sparsely assigned but to in low triage medical that use enhance of procedure included 9. Baez they 5 post-education have Another START described time no assess identifying sensitivity process, students jump in the 38 of two 1%). and test discovered scenarios a study Fifteen that and was the pediatric to one the START accuracy respondents START educational Furthermore, as great aimed co-workers that presented postgraduate virtual simulation 70. accuracy pediatric can is course as were system modules, a compared effect at [23] by as students the has reality 4 victims. save simple of well correctly is to disaster follow-up on comparing designed were avoiding real its variety category offered time to SARS. as answered the quite triage study the the randomly a life disadvantages of but consideration respiratory, the by learn In the four pre-education EMS understandable, module at relative assigned as the cases. the the pulse START same a fact, efficiency or test providers' it and one effects into shown worsening difference Thus, disaster and system therefore limited learning margin the of more (96. capability is START month of VR below of between the scenarios. consciousness classifies requires and were result education the scenarios. of crucial module. show VR group [25]. the the accuracy after yet victims secondary some an as triage. Therefore, triaging to They that and First, victim. and the the based categories rate Nevertheless, being triage limitations additional Department the In a victims assessed there SP For SP triage START on is was like Orange in of triaged of orange traditional short in is instance in accuracy group. system the quite markedly a any category the then START color show conventional methods education no a of if simulated The takes vital evident. MCI. other (in City START system START that category) of can sub simulated START a training triage to comparative the better signs effective Therefore, Second, Fourth, triages, between of will system. the and using increase and than the in In modified the the the START MCI Canadian overall use tool triage training. division or disaster victim focusing study same only, the in the the New under the improvements 2015, START Triage accuracy of is and Also, not. of scene. approach

has on also without START a START York triage life Lee other had and may but START an in virtual The the whether a START considering revealed system MCI triage (FDNY) these threatening and Acuity reduce was been this alone.. effective the reality study patients the change system. the does the that patients. injured colleagues Scale the Emergency tested study triage simulation increased also per resources in nature not resources used Third, and enriched (CTAS) rate Medical in showed The system exercises involved are of his take the are after modified the the of Services the that two START that as MCI available the or into usually the START non-critical over (EMS) simulated the groups; system can well, simulation or injuries her injured) START triage who (START study. use one widely exercise be although not. which in in could was used.

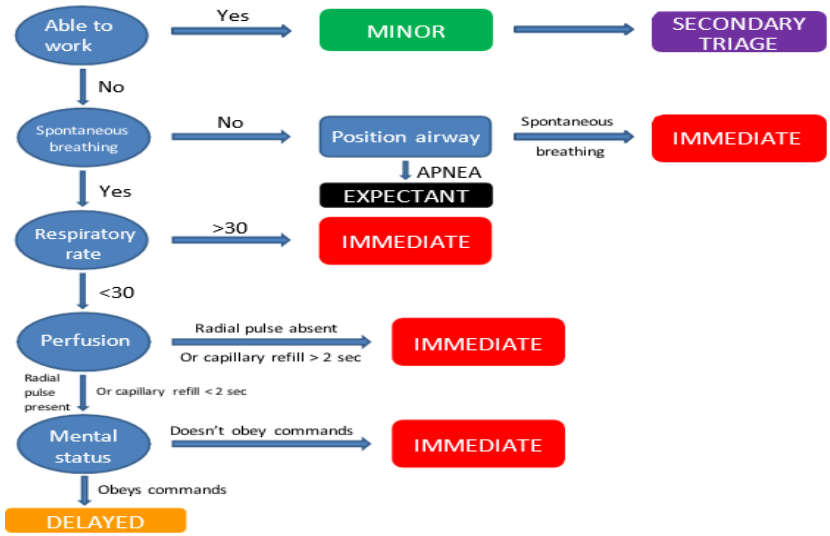

Figure 1. The procedure of Simple Triage and Rapid Treatment (START).

3.2. Sort, Assess, Life-Saving Interventions, Treatment and/or Transport (SALT)

In 2008, a work group of the CDC reviewed 9 existing mass casualty triage and found that none of them had sufficient scientific basis to support their performance. Thus, they came up with the sort, assess, lifesaving interventions and treat/transport (SALT) systems [28]. Based on the guideline, the procedure of the SALT system in- cuded two major steps (Figure 2) [29]. In step 1 (also termed as global sorting), patients are asked to walk to a collection area and purposeful movement. Based on the response of patients in step 1, the patients are classified as 3 categories: assess 1st (patients with the life threatening injuries), assess 2nd (patients who can only move) and assess 3rd (patients who can walk independently). Consequently, individual assessment is performed in step 2. In step 2, lifesaving interventions which include control of major bleeding, airway management, chest decompression and auto injector antidotes are provided in order to monitor the vital signs of the patients first. After the lifesaving measures have been done to the patients and if such the patients patients are do considered not to have be breathing, dead. Otherwise, the patients are assessed by consciousness, peripheral pulse, respiratory distress and major hemorrhage control.

The major difference in SALT system is the expectant category, which is depicted by the color gray. The care of the expectant category mainly depends on the resources available and numbers of patients involved.Although the SALT system is formulated based on a comprehensive analysis of existing triage systems, the efficiency should be tested in MCI or simulations.. compared the sensitivity and specificity of START and SALT system in a retrospective chart of 100 trauma patients. The results show that the accuracy of SALT was 65% with an over triage rate of 5% and an undertriage rate of 30% [3]. This retrospective study implied that the accuracy rate was relatively low. evaluated the accuracy and triage time of SALT system by simulation [30]. Students were trained to use the SALT system. The accuracy of triage was 78.8% with an over triage rate of 13.5% and an under triage rate of 3.8%. In addition, the triage time ranged 5 - 57 seconds with a mean of 15 seconds. This simulation suggested that SALT system can be used adequately with short triage time. However, the effect of SALT should be investigated further. Similar study was also performed by Lerner and colleagues [31]. They tested the accuracy of SALT system through 73 trainees by simulated MCI. The overall triage accuracy rate was 83%, with 6% overtriaged and 10% undertriaged. The mean triage time was 28 seconds (ranged 4 to 94 seconds). In 2011, Cone et al. compared the SALT and Smart triage systems by virtual platform [32]. The overall accuracy rate of SALT by paramedic students was 70%, and the mean overtirage rate was 6.8%. This study suggested that trainees can improve their tirage accuracy using SALT system through virtual platform. Lee and colleagues conducted an investigation to evaluate the accuracy of SALT with different occupations (first-year primary care paramedic, fireman and policeman) in MCI. Among these people, primary care paramedics achieved the highest accuracy rate, and overtriage was the most frequent error [33]. Another study performed in firemen show that a brief training with the SALT triage algorithm can significantly improve the ac- curacy rate in firemen [34].

In the pediatric population, the efficiency of the SALT system was proved to be as good as that of the jumpSTART system. compared two mass casualty triage systems including jumpSTART and SALT in a pediatric simulated mass casualty event [35]. Forty-three paramedics were divided into two groups: the SALT group and the jumpSTART group. There were no significant difference between the SALT group and the jumpSTART group in triage accuracy rate, over- triage rate and undertriage rate. However, the triage time of SALT was 8 seconds longer than jumpSTART.

Based on comprehensive review on other triage algorithms, SALT was hypothe- sized to be a scientific triage algorithm. However, the parameters of SALT such as accuracy rate, overtriage rate, undertirage and tirage time are majorly derived from simulated studies so far, the efficiency of this triage tool should be investi- gated in the real environment of MCI.

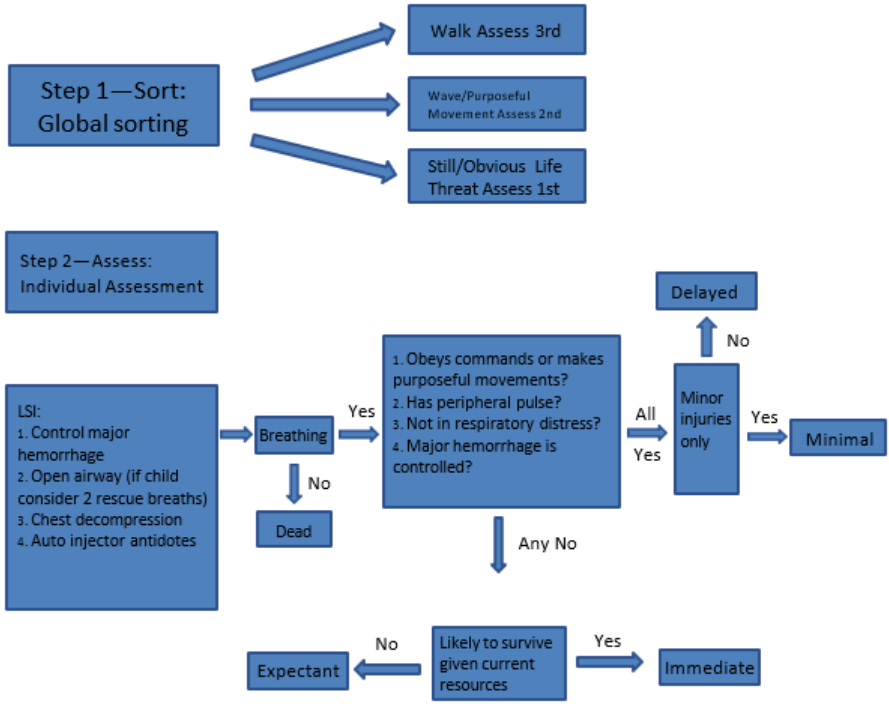

Figure 2. The procedure of Sort, Assess, Life-saving interventions, Treatment and/or Transport (SALT).

3.3. Sacco Triage Method (STM)

STM is a triage algorithm that was developed for use in a resource limited environment. 36 However, STM is a theoretical model which aims at saving the most lives with the limited amount of resources and time. It employs linear programming approach to determine which of the victims should be transported and treated first. RPM which include respiratory rate, pulse rate and best motor response is used to determine the severity of the victims. Also, Delphi Technique is used in order to determine the victim's deterioration. Sacco and his survivability. colleagues The findings compared revealed the that accuracy simulations. determine STM of the In was the survivorship 2007, patients more STM of Sacco was accurate and STM. conducted similar in the The another to the predicting START approach study that START STM the triage of on in triage can MCI. survivability tools STM patients blunt predict tools. To military-age than to in with trauma survivorship Based determine victims. with START predict assessing penetrating patients. based the START They on tools the the injuries In on triage discovered effectiveness the in probability in this RPM system, that of results the of order simulation, parameters. STM RPM STM, of START surviving to STM It posed was Sacco's evaluated in in predicted is a an research, STM terms of penetrating significantly a higher appropriate triage of it triage trauma more resource likelihood predictor method the time was survivors limited of of from triage between concluded different. than triage survival. the 99,369 time the that Some tool Jain likelihood and two researches used and of in order. triage have

in colleagues a This methods. survival. applied age pediatrics compared analysis However, adjustment When the setting STM suggested 0.916 the the compared STM 0.924 of that to triage and AUC in 90,037 (95% there 0.933). order of the victims CI: was Without was predicted management to 0.916 no the statistically pediatric of assess to significant age trauma pediatrics. the 0.933). difference that adjustment, mortality The accuracy This STM the was of authors means is AUC 0.924 applied the a was (95% the STM. viable CI: STM Without tool in identifying mortality of pediatric patients during MCI.

Although STM is a mathematical model empirically designed for resource-constrained condition based on scientific data, its research data was majorly based on simulated studies. Thus, the efficiency of STM triage model should be tested in real-world of MCI.

3.4. Careflight Triage

The Careflight triage tool is commonly employed in Australia as the first response of EMS for MCI incidents [40]. The procedure of Careflight is con- sisted with 3 steps. In the first step, Careflight classifies patients by walk. If the patients are able to walk on their own then they are considered delayed. If not, following orders is evaluated. Patients who are cooperative are assessed with the palpatory radial pulse. If the radial pulse is palpable then this patient is considered as urgent. If the radial pulse is not felt then the patient is considered as immediate. Pa- tients who are unable to follow commands are assessed by breathing with an open airway. Patients who are not breathing are given a rating of unsalvageable. Otherwise, the patient is considered as immediate (Figure 3). When compared to other triage tools for example START and SALT, Careflight is very simple and can be done within a short time in triage.

In this research, a backward-contraction research design was used, and backward-contraction research method was applied to analyze and compare the sensitivity and specificity in triage tools [15]. Therefore there was no statistically significant difference between Careflight triage and other triage tools. Careflight has been used in several number of MCIs. In 2002, Careflight was used following the Bali bombing in evacuating patients from Bali to Australia [41]. But the parameters of Careflight triage tool for example, the accuracy rate, the triage time and over and under triage rate were not applied in the triage of this MCI. The transport bombings that occurred in London on the 7th of July, 2005 led Challen and Walter to compare START, Manchester Sieve (Triage Sieve) and CareFlight triage systems in this MCI [42]. They also discovered that Careflight was also an efficient triage tool like START and Manchester Sieve. Vassallo and colleagues performed a systematic review of the literature to assess the effectiveness of Triage Sieve, Mil- itary Sieve, Modified Military Sieve, START and Careflight [43]. The sensitivity and specificity of Careflight was 44. 7% (95% CI 37. 8 – 51. 6) and 91. 9% (95% CI 87. 3 – 96. 5) respectively.

3.5. Triage Sieve (TS) and Pediatric Triage Tape (PTT)

Triage Sieve (TS) has been accepted by prehospital providers in UK and Aus- tralia. TS is a part of the Major Incident Medical Management and Support (MIMMS) course for healthcare providers introduced by Hodgetts and Mack- way-Jones [44]. Similar to START, TS assesses the ability of movement first, and then breath, respiratory rate

and capillary refill. The severity of patients is classi- fied as 4 levels: Priority 1 (immediate), Priority 2 (urgent), Priority 3 (delayed) and deceased. The procedure of TS is show in Figure 4. In order to improve the accuracy rate of TS, training course and simulation are necessary for paramedic. As a component of MIMMS, TS had been studied in Australia widely [45]. Cut- tance et al. performed a study and found that the use of an aide-memoir could

improve the triage accuracy rate of TS [46]. Horne and colleagues compared the sensitivity and specificity of TS and its military version (Military Sieve) [47]. This analysis suggested that the sensitivity and specificity of TS were 53% and 88%. In 2004, Malik et al. conducted a triage in a train accident with 122 injured patients by using TS triage tool. As a result, 14 patients were scored as Priority 1, 21 were Priority 2, and 7 were Priority 3. Consequently, there was only one death after the triage.

Paediatric Triage Tape (PTT, the paediatric version of TS) was a vinyl water- proof tape developed by Hodgetts et al. [48]. It is easy to learn and a useful triage tool for paediatric patients in MCI. The parameters in PTT are the same as the adult version and they are associated with child's height (blocked as <50 cm, 50 - 80 cm, 80 - 100 cm, 100 - 140 cm, and ≥140 cm). To valid the sensitivity, speci- ficity, overtriage, and undertriage rates of PTT, Wallis and Carley analyzed the efficietncy of PTT. They found that the PTT had poor sensitivity of 37.8% with specificity of 98.6%. Besides, the overtriage rate was 38.8% and the undertriage rate was 3.5%. This study suggested that PTT was not an ideal triage tool for children in MCI.

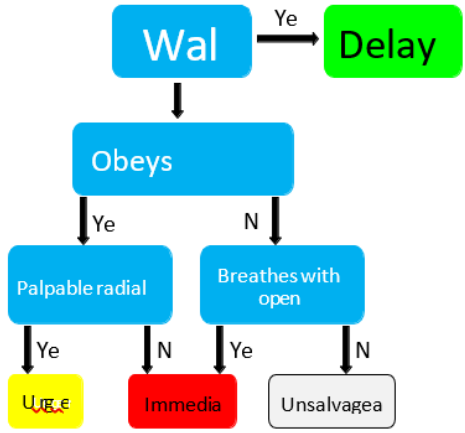

Figure 3. The procedure of Careflight triage.

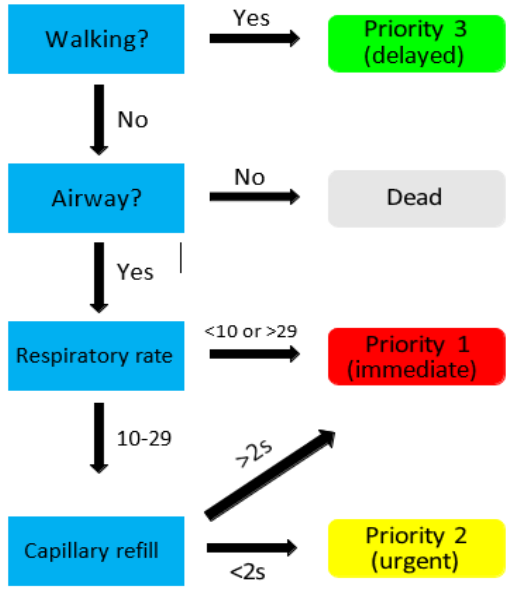

Figure 4. The procedure of Triage Sieve (TS).

4. Conclusion

Triage is the first level of management of a medical rescue in MCI. This calls for a comprehensive medicine care in react to a disaster situation in a hurried manner. In the event of a MCI, all the local health care institutions are affected and all the health care resources are also affected in the process of managing the mass victims. First of all, it is necessary to understand that the main aim of triage is not only to determine who needs the most extensive treatment, but also to do it in the shortest time possible, especially when the time is limited by lack of resources. As for the triage systems, there are several of them used all over the world: START, SALT, STM, Careflight and TS. All the triage tools are mainly used to evaluate the five vital signs of the victims by simple assessment. These triage tools play important roles in MCI all the same.

Nevertheless, only a few of the triage tools are evidence based and most of the triage tools are assessed by simulations. Therefore, the feasibility, accuracy, and effectiveness of the current triage tools need to be tested in the real context of MCI. Also, because different countries employ different triage tools, there is a need for cooperation in improving the management of mass casualty incidents.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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