THE MEDICAL POINT OF VIEW INTO A SIMULATION PROJECT OF MANAGEMENT FOR SAFETY AND SECURITY IN DISASTERS AND EMERGENCIES OF INDUSTRIAL PLANTS (DIEM-SSP PROJECT).

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ABSTRACT
Industrial mass casualty incidents are an unfortunate reality in the 21st century, but there are few situational training exercises to prepare and to cope with emergencies management. The Authors realized a project to carry out development of the activities devoted to face the complexities arising from emergencies in industrial plants. The DIEM-SSP is a simulation project working on two interoperable simulators, based on the IEEE 1516 High Level Architecture (HLA), used as test-bed on specific case studies. The project is aimed to study innovative emergency procedures and proper routing of critical patients with severe traumas toward the most suitable first aid facilities. The project takes into account the emergency procedures considering the human factor and the possibility of mistakes. It is aimed to test and validate these methodologies through a test-bed based on distributed and interoperable simulation. The Authors report the medical contribution in this project.

Keywords: medical and surgical simulation, emergency management, triage, pre-hospital disaster.

1. INTRODUCTION

The emergency can be caused: by a fault of a system, by a human error or by natural factors (Meshkati 1995).
Hospitals play a critical role in providing communities with essential medical care during all types of disasters. Any accident that damages systems or people often requires a multi-functional response and recovery effort. Without an appropriate emergency planning, it is impossible to provide good care during a critical event.
In fact, during a disaster condition could occur patients with the same "critical" severity. Thus, it is essential to categorize and to prioritize patients with the aim to provide the best care to as many patients as possible with the available resources. Triage assesses the severity of patients to give an order of medical visit (Frascio, Mandolfino, Zomparelli and Petrillo 2017).
Aspects such as the definition of proper emergency procedures to be carried out in healthcare facilities, or directly in the emergency site, the assessment of their impact on the performance of such structures, the proper handling of injured people, the optimal healthcare facilities location and the human errors reduction must be duly taken into account.
Indeed a critical aspect in emergency management is related to the efficiency of first aid facilities. It is critical to have accurate symptoms assessment and quick decision-making to match critical patient needs. Real-time points-of-care, based on new approaches/methodologies, i.e. ultrasound, are the real added value for the assessment of critical patients both in pre-hospital and in in-hospital situations. Although recommendations in term of education and decision making have been proposed by a variety of specialties, to date they are still scattered and limited examples of standards for critical and intensive care professionals.
Efficient procedures are needed both on the emergency site and in hospitals; these procedures should be combined with a proper critical patients routing toward the most suitable first-aid facilities and with a reduction of human errors during the emergency management. Furthermore, new procedures or methodologies for emergency management must be carefully tested before being used: the need to assess their validity before their application in a real emergency situation depends on the need to have a clear picture of the procedures effectiveness.

2. SIMULATION

Simulation represents a good tool to check human and structures reaction to a stressing and challenging situation.
Simulation-based education is an important training strategy in emergency medicine postgraduate programs (Russell, Williamson, Bartko and Bradley 2005).
Simulation has been used successfully to train learners to provide acute care (Harris, Adler, Unti and McBride

2017).
Models for advanced and realistic patient simulation driven by intelligent agents is the solution in the educational programs for health students enabled by new technologies (Bruzzone, Frascio, Longo, Siri and Tremori 2012).
A simulation based evaluation methodology provides a fair framework to assess the effectiveness of models and we may obtain interesting insights and results from such an analysis.
It is worth saying that in such a context, any new emergency procedure or methodology needs to be extensively tested and validated before use. To this end, simulation has been widely recognized as the most suitable approach for investigating, analyzing and solving complex problems in real systems such as industrial plants and Critical Infrastructures (CIs).
The available literature clearly states that simulation can be effectively used for emergency management, even if much more can be done by using interoperable and distributed simulation, e.g. by using architecture for distributed simulation such as HLA.
In this case different interoperable simulation models, recreating the behaviour of different entities acting in the same scenario, could represent a useful simulation model.
It is expected a model able to recreate the evacuation process and the critical patients routing to first aid facilities and a simulation model recreating the emergency procedures.
According on previous positive experience of simulation in medicine, two interoperable simulators, based on the IEEE 1516 HLA, have been developed and used as test-bed on specific case studies, to get benefits from interoperable simulation, in federating multidisciplinary models for industrial plant emergency management.
Modern simulation, by using technology enables such as mobile solution, enhance its support to first responders, the dynamic reaction to crisis evolution as well as the improvement in training and management of safe routing and handling of injured people (Bruzzone, Frascio, Longo, Petrillo and Carotenuto 2014).

3. THE PROJECT

In this scenario it has been thought and realized the project DIEM-SSP, to carry out research and development activities, devoted to face the complexities that arise from emergencies management in industrial plants and CIs.
The goals of the DIEM-SSP project can be summarized:

1. Definition and study of innovative emergency procedures, that must be used within first aid facilities for critical patients, coming from the place where the emergency has occurred, suffering from severe traumas.
2. Proper routing of critical patients with severe traumas toward the most suitable first aid facilities, that must be detected through a study on the optimal infrastructures location and the design of the logistic network.
3. Reduction of the number of patients with severe traumas and the damages to critical infrastructures or industrial plants, through innovative emergency procedures, that take into account the human factor, namely its reliability and the possibility of mistakes.
4. Test and validation of these methodologies through a test-bed based on distributed and interoperable simulation.

4. THE MEDICAL POINT OF VIEW

The medical team job has to be focused on the study and analysis of the actual standard hospital pathway followed by severely injured patients, in order to identify critical issues and possible improvements.
Beginning from the selection of referent professionals involved in critical scenarios management (intensivists, surgeons, emergency doctors, anesthetists), the Authors have performed an assessment of the diagnostic resources habitually used by the emergency clinicians.
This activity was aimed at identifying and defining clinical performance indicators and outcomes to be used for evaluating the goodness of the procedures used.
The evaluation of the impact of the procedures used on the technical efficiency of the hospital has been evaluated by using the DIEM-SSP simulators.
To handle any emergencies that are created, it is necessary to develop a proper plan in order to respond to emergencies.

4.1. Advanced Medical Post

The term Advanced Medical Post (AMP) is referred to a medical station, sited in an area close to the disaster but in a safety zone, where the disaster casualties are cared and selected.
The organization of an advanced medical post can be improved on a strategic level to increase rescue quality, including enhanced survival of injured victims (Rauner, Schaffhauser-Linzatti and Niessner 2012).
The AMP provides different functions: to collect the victims, to concentrate the first aid resources, to perform the triage, to treat the injured people with life-saving maneuvers, to manage the ambulance transport of injured subjects in the most suitable hospitals.
The AMP could be of two levels (Gazzetta Ufficiale della Repubblica Italiana 2007):

- First level AMP, aimed to a limited disaster, able to treat about 30 yellow/red codes and expected for 12 hours of autonomous activity.
- Second level AMP, aimed to cope natural or catastrophic disaster, able to treat independently about 150 yellow/red codes and expected for 72 hours of autonomous activity.

The rescue pre-hospital procedures could be identified in three phases:

1. The triage of victims.
2. The first aid and stabilizing the injured people.
3. The medical activity into the AMP with re-evaluation of triage, first medical aid for critical subjects and the discharge of the victims to be transported to the nearby hospitals.

4.2. The Triage

Triage is one of the most important management and decision-making concepts in emergency wards and disasters (Pouraghaei 2017; Lindsey 2005; Turris 2012; Halpern 2012).

There are two sub-categories of triage, namely hospital and pre-hospital triage. (Cross 2013; Risavi 2001; Aylwin 2005; Dadashzadeh 2011; Göransson 2011).

Generally, when there is an overflow of patients in the emergency ward of hospitals or when there are numerous casualties and injured people at the accident scene, triage is the only way of developing the maximum facility for the maximum number of patients (Fry 2001; Sauer 2009; Lerner 2008; Andersson 2006; Twomey 2007)

One of the most important phases is the response phase, that addresses immediate threats presented by the disaster, including saving lives, also meeting humanitarian needs, and the start of resource distribution. In this phase a particular process involves the triage efforts that aims to assess and deal with the most pressing emergency issues. This period is often marked by some level of chaos, a period of time that cannot be defined a priori, since depend on the nature of the disaster and the extent of damage (Caunhye 2012).

It is necessary to assess the conditions of the patients during the response phase and to reduce waiting time for medical services and transport (Hamm 1997). A timely and quickly identification of patients with urgent, life-threatening conditions is needed (Buckle 1999). Accurate triage is the “key” to an efficient operation and to determine severity of illness or injury for each patient who enters the emergency department (Christ 2010).

The term triage comes from the French verb trier, meaning to separate, sift or select.

A system for classification of patients was first used by Baron Dominique Jean Larry, a chief surgeon in Napoleon’s army (Burris 2004). Originally, the concepts of triage were primarily focused on mass casualty situations. Many of the original concepts of triage remain valid today in mass casualty and warfare situations. Triage is a dynamic and complex decision making process (Bullard 2008).

In general, patients should have a triage assessment within 10 minutes of arrival in the emergency department in order to ensure their proper medical management. But, it is not always possible to achieve this purpose. Some weaknesses characterize every triage models. It is worthy to underline that exist several methods of triage for evaluating the condition of a patient and treat him/her accordingly. The triage methods most commonly used are: Australasian triage scale, the Canadian Triage and Acuity Scale, Manchester Triage System and Emergency Severity Index. Each protocol may be very different from another in terms of methods of care, treatments and strategies (Lerner 2008). Furthermore, the medical staff has to analyze several factors to decide in which hospital the patient should properly be conducted (Andersson 2006). The effective triage is based on the knowledge, skills and attitudes of the triage staff. However, despite this knowledge it is evident that the use of one triage algorithm is limited (Twomei 2007; Australasian College for Emergency Medicine 2000; Considine 2004).

The critical trauma patient has only 60 minutes, the “golden hour”, from the time of injury to reach definitive surgical care or the odds of a successful recovery diminish dramatically.

4.2.1. The Triage of DIEM-SSP project

We proposed the START SYSTEM: S (simple) T (triage) A (and) R (rapid) T (treatment).

It is one of the triage systems widely accepted and used to manage disasters, first applied in the US in the 1983.

START was developed by the Newport Beach Fire and Marine Department and Hoag Hospital in Newport Beach, California in 1983.

Initially it used the ability to obey commands, respiratory rate, and capillary refill to assign triage category.

Modifications to START in 1996 substituted radial pulse for capillary refill, with a report of improved accuracy, especially in cold temperature.

The Benson revision START-SAVE (Secondary Assessment of Victim Endpoint), also incorporates additional factors that determine "survivability" over time, as the event progresses and assumes limited response resources (Benson 1996).

There has been limited rigorous scientific review of various forms of mass casualty incident triage used around the world (Garner 2001; Jenkins 2008; Cone 2005)

New methods of triage using new algorithms have been proposed, but not tested in the field.

At present START remains the most commonly used mass casualty triage algorithm in the US.

In other words, START was done at the scene of unexpected incidents in a preliminary fashion and involves passing alongside some casualties who died; hence attempts are merely directed towards people who have a higher chance of survival (Armstrong 2008).

We preferred the START system even if, as other quick triage protocols, it has some limitations including negligence of the injury mechanism, limited assessment, and failure to monitor patients with a mild or moderate injury, whose transfer is delayed (Neal 2010; Kahn 2009; Healey 2003).

The criteria used to triage patient in a mass casualty incident, as in the DIEM-SSP project is expected, differ to traditional In-Hospital Triage (IHT).

The traditional IHT is based on severity, usually completed by nurses, the sickest patient are seen first, many resources may be dedicated to save one critical patient and detailed hystory can be collected and assessment completed.
But when the number of casualties overcome resources the triage is heavily determined by available resources, it can be done by any member of emergency team.
Critical patients may not receive treatment.
Disaster triage implies that the most seriously injured may be relegated to the end of the line and left untreated, even at risk of death, if their care would absorb so much time and attention that the work of rescue would be compromised. This is one of the few places where a "utilitarian rule" governs medicine: the greater good of the greater number rather than the particular good of the patient at hand. This rule is justified only because of the clear necessity of general public welfare in a crisis (Jonsen 1998).
The START-SAVE triage was developed to direct limited resources to the subgroup of patients expected to benefit most from their use. The SAVE assesses survivability of patients with various injuries and, on the basis of trauma statistics, uses this information to describe the relationship between expected benefits and resources consumed. Pre-existing disease and age are factored into the triage decisions. As an example: an elderly patient with burns to 70% of body surface area is unsalvageable under austere field conditions and would require the use of significant medical resources- both personnel and equipment and would be triaged to an "expectant area." Conversely, a young adult with a Glasgow Coma Scale score of 12, who requires only airway maintenance, would use few resources and would have a reasonable chance for survival with the interventions available in the field, and would be triaged to a "treatment" area. The START MDR-SAVE methodology is the first systematic attempt to use triage as a tool to maximize patient benefit in the immediate aftermath of a catastrophic disaster (Benson 1996).

4.2.2. START Adult Triage Algorithm

Here is reported a synthesis of the START adult algorithm (Benson 1996). Four distinct clinical triage categories for mass casualty patients, with each category assigned a distinct name and colour.
The 4 Triage Categories are:

- Minor: Green Triage Tag Colour, which comprehends: victim with relatively minor injuries, status unlikely to deteriorate over days, patient may be able to assist in own care: also known as "walking wounded".
- Delayed: Yellow Triage Tag Colour, which comprehends: victim's transport can be delayed, includes serious and potentially life-threatening injuries, but status not expected to deteriorate significantly over several hours.
- Immediate: Red Triage Tag Colour, which comprehends: victim can be helped by immediate intervention and transport, requires medical attention within minutes for survival (up to 60 minutes), includes compromise to patient's airway, breathing, and circulation (the ABC's of initial resuscitation).
- Expectant: Black Triage Tag Colour, which comprehends: victim unlikely to survive given severity of injuries, level of available care, or both, palliative care and pain relief should be provided.

How this information would be used in a mass casualty event:

- Emergency first clinical responders would follow the clinical algorithm to evaluate each patient and assign a triage category and color based on various clinical parameters.
- The information would be noted on the triage tag attached to the mass casualty victim.
- Rescuers following after the triage officer would view the color and text of the triage tag and take appropriate action.

Clinical parameters used to evaluate patients include:

- Ability to walk.
- Presence or absence of spontaneous breathing.
- Respiratory rate greater or less than 30 per minute.
- Perfusion assessment using either the palpable radial pulse or visible capillary refill rate.
- Mental status as assessed by ability to obey commands.

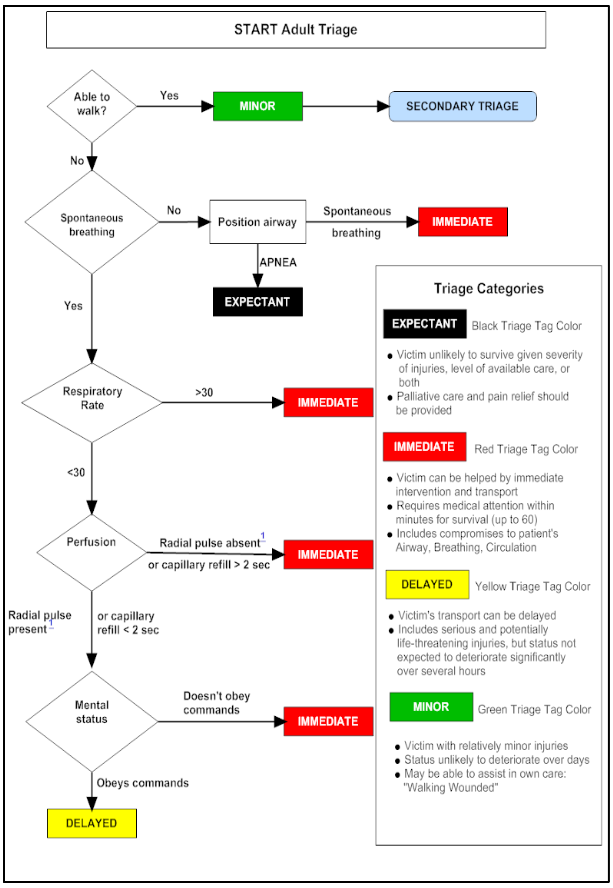

Figure 1: the START Triage Algorythm

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