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# Multilayered Knowledge Base for Triage Task in Mass Casualty Situations

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**Abstract**

Use of portable ultrasound becomes common practice in mass casualty situations. The obtained information helps emergency crews to make decisions regarding on-site triage, helping in determination of adequate diagnostics in proper time for saving lives of patients.

In this article a design of multilayered knowledge base in domain of the abdominal region ultrasound examination for the case of mass casualty situations is described. Layers 1-2 correspond to casualty's severity state, and layer 3 – to pathologies when the free fluid is present in the abdominal cavity, that is not the consequence of an abdominal injury.

**Keywords:** Knowledge base re-engineering, on-site triage, mass casualty, medical ultrasound, hepato-pancreato-biliary region.

## 1 Introduction

The existence of people and society is increasingly being subjected to serious challenges caused by catastrophes, disasters or natural emergency situations (earthquakes, landslides, floods, etc.), technogeneous, biological, social and premeditated (terrorism) ones.

A *disaster* is a natural or man-made event that suddenly or significantly disrupts normal community function and causes concern for the safety, property and lives of the citizens. Thus, disaster is an event that exceeds the capabilities of the response.

Since 20th century due to technological progress the number of disasters considerably increased, as well as their magnitude. In disaster focus an enormous number of victims died before hospitalization, having injuries compatible with life, because healthcare services did not provide a full qualitative rapid aid.

A *mass casualty incident* is an event that exceeds the health care capabilities of the response, when health care needs additional large resources.

The problem of providing medical aid in the case of a large number of victims was understood in 1881. As a consequence of a fire at the Ring Theater in Vienna more than 400 persons with trauma and burns did not obtained medical aid up in the morning because of lack of overnight medical emergency service.

In case of mass casualty situations, the frequency of which is growing, the number of victims usually exceeds local medical resources. Terrorist attacks of great resonance – attacks on the World Trade Center in New York, bombings in Madrid and London – have resulted in large numbers of victims, comparable to those in military conflicts.

As a result of disasters about 2 million people die annually in the world, more than 200 million suffer trauma of diverse severity, consequently about 10 million people remain disabled. 75-85 % of fatalities occur within first 20 minutes. According to some studies, the number of deaths would be reduced by 30 % if victims are provided medical care timely in an hour after catastrophe [1].

These figures demonstrate the importance of providing in proper time medical assistance on the disaster site.

In the case of emergency situation or disaster, resulting in a significant number of victims in a short period of time many people simultaneously require urgent medical assistance and evacuation from the impact zone. Inevitably, for a period of time there is a strain that the necessity in medical assistance exceeds currently available medical capabilities and resources. Obviously, in such circumstances medical aiding to the full extent for all affected people is practically impossible, that highlights the importance of emergency diagnostics, triage and setting a schedule for evacuation.

## 2 Triage in the Disaster Scenarios

Emergency situation is characterized by the complexity of decisions to be made.

*Medical triage* in case of mass casualty accidents or disasters [2, 3] is a complex process of identification and differentiation of victims in homogeneous groups according to the severity and nature of injuries and the degree of emergency medical assistance. It determines sequence, mode and evacuation destination depending on available medical capabilities and resources, as well as specific circumstances imposed by the impact.

The basic aim of medical triage is ensuring the provision of medical assistance in optimum time and in maximum possible volume to the largest number (ideally – to all) of victims of the disaster. In extreme cases diagnostics requires from physician a strategy that reduces to sorting victims into several groups in order to ensure targeted aid, taking into account the severity of the case.

Priority 1 – *Absolute emergency.* Victims with serious and very serious injuries, illnesses, intoxication or contamination, compromising vital functions, which require immediate stabilization measures, as well as priority evacuation in assisted medical transport conditions.

Priority 2 – *Relative emergency.* Victims with serious or moderate injuries, illnesses, intoxication or contamination, with retained vital functions, but with the risk of developing life-threatening complications immediately ahead. They require urgent medical assistance, but not the immediate one.

Priority 3 – *Low urgency.* Victims with minor injuries, illnesses, intoxication or contamination, no life-threatening, which can be treated later, usually in outpatient conditions. They can be evacuated in non-specialized transport or independently.

In case of mass casualty situations examination should be made on the site, in reduced time in order to determine the right strategy for saving. This specific character requires an approach, different from the traditional clinical examination. Structure of trauma and injuries varies essentially depending on the disaster's nature.

Ultrasound diagnostics at the disaster site is aimed at determining the level of urgency to save lives and to prevent any complications for people at risk.

Portable ultrasound has clear advantages over other imaging equipment (particularly, computed tomography) to be applied in remote places. Since ultrasound is painless and safe technique that captures images in real-time (showing the structure and movement of the body's internal organs and blood vessels) and portable light-weight ultrasound scanners can be used easily at the accident site, this method has been accepted as an important initial screening tool in disaster medicine.

For instance, to confirm liver injury ultrasound-competent physician has to answer the following four questions:

1. Is liver contour discontinued?

2. Are modifications in the liver structure (mostly circumscribed) observed?

3. Are collection(s) in the liver surrounding areas detected?

4. Does the patient have severe pains with acute onset (post-traumatic)?

If the answer is YES for all questions, then the obtained conclusion is "Post-traumatic lesions of liver with perihepatic hematoma", which corresponds to "Priority 1 – Absolute emergency".

FAST (Focused Assessment with Sonography for Trauma) examination, a well-known rapid bedside ultrasound examination used in emergency medicine, was grown widespread in the early 1990s.

"The FAST examination is based on the assumption that the majority of clinically significant abdominal injuries result in hemoperitoneum. The standard FAST protocol is directed to detection of fluid in the pericardial and peritoneal spaces. With regard to the CAVEAT protocol is limited to intraperitoneal hemorrhage" [4]. CAVEAT is the concept of a comprehensive sonographic examination in the evaluation of chest, abdomen, vena cava, and extremities in acute triage.

As discovery of free fluid in the abdomen can lead to appropriate and timely diagnostics, FAST can be used to guide clinical decision-making, e.g. as a quick method for triaging patients.

Rozycki et al. [5] have found that ultrasound was the most sensitive and specific in patients with penetrating chest wounds or in hypotensive blunt abdominal trauma patients (sensitivity and specificity nearly 100 %).

In [6] ultrasound was performed by relief teams after the 1988 Armenian earthquake as a primary screening procedure in 400 of 750 injured multiple casualty incident (MCI) patients admitted to a large hospital within 72 h of the event. The average time spent on evaluation of a single patient was approximately 4 min. Traumatic injuries of the abdomen were detected in 12.8 % of the patients.

In [7] sonography was used after an MCI in Guatemala in which the dead far outnumbered the injured. In that setting, ultrasound was useful for excluding internal trauma.

Ultrasound has been utilized in military deployments in Kosovo, Afghanistan and Iraq [8]. The British Air Assault Surgical Groups deployed to Kuwait during 2003 included the use of a hand-held ultrasound scanner by the forward medical units FAST examinations performed by trained emergency physicians using portable equipment at a large military combat hospital in Iraq. It had very high sensitivity as confirmed by subsequent operative reports and computed tomography imaging. In that particular experience ultrasound was performed in patients who sustained blunt, blast and penetrating trauma [8].

Statistics shows that in cases of natural disasters, catastrophes and accidents about 70 % of affected persons need specific healthcare approach limited in time.

So, it is important to offer recommendations on the evacuation priority and creation groups for evacuation from the disaster focus, according to destination (specialized centers or general profile medical institutions) based both on triage results and limited possibilities for transportation in case of a large number of victims.

The main limitation of the FAST examination is that the operator must be knowledgeable in its clinical use and be aware that *it does not* *exclude all injuries* [9].

The limitations of FAST (as a task-focused approach) are caused by the narrow view in emergency situation formalization. In fact, the plausible reason of patient critical state can lie outside the emergency. For instance, the potential false-positive diagnosis of free traumatic fluid in the peritoneum may be due to fluid present in patients for physiologic reasons, including ovarian cyst rupture, as well as pathologic reasons, such as patients with ascites or inflammatory processes in the abdomen or pelvis [9].

In this paper we describe the algorithm that would allow physician rescue team in reduced time to appreciate diagnosis, severity, the life-threatening in order to make appropriate decisions about how to help, treat and evacuate from the disaster site.

In distinction from FAST, in our approach we consider emergency situation as a particular case of ultrasound examination domain formalization and take into account the injury severity.

## 3 Approach Based on SonaRes Knowledge Base

Abdomen region is the important one, as the most difficult cases to diagnose with extremely dangerous consequences are lesions of the abdominal cavity organs (liver, spleen, kidneys, large vessels of the abdomen, gallbladder and pancreas).

The paper authors over several years elaborated SonaRes technological platform, designed for development of medical informatics applications to support diagnostic process based on ultrasound examination method [10-11].

SonaRes technological platform consists of two main parts – SonaRes methodology and SonaRes technology. SonaRes methodology consists of knowledge acquisition strategy, knowledge representation and storage form, inference mechanism. SonaRes technology offers knowledge base editor and tools that allows creation of information systems of different destination.

The main part of SonaRes technological platform represents SonaRes knowledge base, which includes the following formalized expert knowledge:

- 335 facts and 54 decision rules for gallbladder,
- 231 facts and 52 decision rules for pancreas,
- 167 facts and 31 decision rules for liver,
- 257 facts and 15 decision rules for bile ducts.

Based on facts, the decisions rules describe organs pathologies and anomalies.

Our approach presumes to re-engineer SonaRes knowledge base for on-site triage task in mass casualty situations, performing the following steps:

1. to add to the knowledge base information (facts and decision rules) that describes blood vessels;
2. to identify conclusions (decision rules) that describe fluid presence, obtaining *knowledge base – critical level 1*;
3. to localize the obtained conclusions into 4 areas of the FAST examination;
4. to identify information (facts and decision rules) that allows to make severity assessment (fluid volume and patient state severity), obtaining *knowledge base – emergency level 2*;
5. to identify conclusions (pathologies and anomalies) that describe presence of free fluid in the abdominal cavity, which is not the consequence of an abdominal injury, obtaining *knowledge base – non-injury level 3*;
6. to validate completeness of all 3 levels of the knowledge base for emergency situation;
7. to reorder the set of facts according to their information value in order to minimize the number of inference steps;

8. to classify conclusions from levels 1-2 in priority groups (absolute emergency, relative emergency, low urgency).

In this way we re-engineer SonaRes knowledge base structure from multimodule organ oriented to multilayered triage task oriented and overcome limitations of the FAST examination, taking into account physiologic and pathologic reasons.

## 4 Conclusion and Future Work

The current consensus supports ultrasound screening of mass casualties for evaluating trauma patients. In particular, FAST examination is used to identify presence of intraperitoneal or pericardial free fluid, presumed to be consequences of bleeding. It is important to note, however, that the FAST examination is a screening test, and false-negative conclusions do occur.

We propose a methodology of re-engineering of SonaRes knowledge base for on-site triage task in mass casualty situations.

As a result we obtain a multilayered knowledge base designed for emergency (mass casualty) situations, when injuries need immediate surgical intervention:

- *critical level 1* – corresponds to fluid presence
- *emergency level 2* – corresponds to severity assessment
- *non-injury level 3* – corresponds to presence of free fluid due to physiologic and pathologic reasons.

Our approach allows to differentiate process of on-site triage depending on time available for decision-making.

In cases when there is a need and the conditions allow (for instance, during transportation) to repeat examination, our approach, in distinction from FAST, provides more competent assistance, evaluating state severity assessment.

The following work could be done in the future:

- a scoring system to be added in priority groups (absolute emergency, relative emergency, low urgency), as it is usual for physicians;

- based on the re-engineered knowledge base, an algorithm to be created and validated on virtual scenarios.

In addition, there is a well suited provision of emergency physicians and rescue teams with a decision support system to assist emergency examination, helping in establishing the correct diagnostics in opportune terms. For example, it is possible to use SonaRes technological platform [10] that already exists and was tested in creation of a system that uses portable scanners and is aimed for diagnostics under field conditions, accessible through easy of use under mass casualty conditions, lack of time and qualified medical personnel.

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