

Medical -Engineering Pattern of Severe Iraqi Road Traffic Accidents

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Abstract A combined and thorough medical and engineering study of road traffic accidents in Iraq is presented in this paper. The medical investigation covered about 1500 road traffic accident patients transported by ambulance to various hospitals in Baghdad. In most cases, the medical survey team covered the diagnosis of the injury as soon as it was confirmed and death at the moment of arrival of the patient to the emergency department of the hospital. Multi-organ injury was predominating and the required injuries were performed successfully for single organ injury but the chance of successful operation decreased as the number of injured organs increased. To arrive at the major cause of death and/ or heavy injured road traffic accident patients, analysis of speed of vehicles on rural highways in Iraq was made. The traffic engineering study revealed that high speed of vehicles, exceeding the design speed of the highway with abnormality of spot speed distribution, was the major reason of such severe accidents. Death rate from road traffic accident in Iraq is 44.7 which makes Iraq the fourth country in the rate of road traffic accidents. Road traffic accidents are leading cause of both internal and external injuries and major cause of death. This paper reveals that liver, spleen and neck were the most reported organ injuries in road traffic accidents in Iraq. Pre hospital care, time between the crash and the admission to a trauma center and the availability of trauma center can affect significantly the outcome of the crash. Similarly, the use of seat belt, front and sideway airbags can decrease the rate of organs injuries due to road traffic accidents. A comparison of results of this study with those in other studies in different countries is presented and both agreements and disagreements are discussed.

Keywords: accident analysis, liver injury, public health, road traffic accident, spleen injury, traffic engineering

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1. Introduction

The function of a street or a road is to serve the motorist, the cyclist and the pedestrian in such a way that all can travel quickly, economically and safely to their destinations. However, Nicholson [15] pointed out that half a million people die each year as a result of road traffic accidents with about 15 million being injured each year. The Center for disease control and prevention report by Hoyert and Xu [6] showed that road traffic accidents in the U.S. caused 118,021 death in 2011. The World Health Organization [31] report shows that about 1.3 million die each year as a result of road traffic crashes.

Road traffic accidents are a major public health problem second to cancer. Traditionally, the severity of a public health problem is measured on a per person per year basis. Personal safety is commonly measured by the number of deaths and/or injuries measured per year per person, while traffic safety is commonly measured by the

number of deaths and/or injuries per vehicle kilometer of travel. WHO (World Health Organization) report [31] shows that without efforts to prevent accidents, it is predicted that 1.9 million person in the world die annually by 2020.

The WHO [31] report shows that road traffic crashes occur mainly in ages 15-29. The cost to the society of people killed in road traffic accidents is very large, as in almost all countries, there is a strong tendency for those killed in road traffic accidents to be relatively young between 17 and 25 years old and their loss of productivity at work is immense.

Jadaan [10] and Bener and Jadaan [2] pointed out that road traffic accidents have been a major leading cause of morbidity and mortality in developed and developing countries.

Unfortunately, from medical point of view, road traffic accidents research in Iraq has received but very little attention if any.

The aim of this paper is to arrive at some facts regarding single and multiple-organ injuries in road traffic

accidents in Iraq and to achieve the diagnosis and most important types of injuries and to find out the most critical factors affecting the mortality rate.

2. Time Period for Counting Road Fatalities

The internationally agreed time for counting fatalities due to road traffic accidents is 30 days of the accident as in the United Kingdom according to O'Flaherty [16]. However, France and Italy count deaths occurring within 6 days and 7 days of the accident respectively.

Some countries classify death as a road accident fatality only if the death occurs at the accident site while other countries use a 12 month period after the accident as, for example, in the USA leading to overestimating their fatality ratio. However, the most common period used is 30 day. It is worth mentioning that according to the United States department of commerce, the 2012 national data book shows that about 35 900 deaths happened in 2009 during a one year period of follow up, from which approximately 33 800 death happened in the first 30 days [28].

3. Road Traffic Accidents with Death or Serious Injuries

According to WHO [32], the average annual death rate due to road traffic accidents in Iraq is 44.7 (standardized age death rate per 100,000 population) and is ranked as number 4 in the countries that has major death rates due to Road traffic accidents. This fact focuses the attention to the need of both medical and engineering research in Iraq regarding road traffic accidents. Note that the United Kingdom has a rate of 4.8 and ranked as 180, while United States is 13.9 and ranked 107.

Road traffic accidents are one of the main causes of death in USA [5]. More than 2.3 million adult driver needed to be treated in emergency room as a result of road traffic accident injuries in 2009 [6].

Sleet and Ballesteros [25] have shown in a histogram that road traffic accidents, for the period 2007-2009, are the main cause of death in US citizens who are visiting or in a foreign country.

4. Causes of Mortality and Disability

Accidental trauma is one of the leading causes of death worldwide for all the age groups. Sells and Blum [24] reported that, during the ages 14 to 25 of life, trauma is the leading cause of mortality and disability in the United States. Center of disease control and prevention report in USA [6] lists the Road traffic accidents as the fifth leading cause of death.

The most thing we think about in road traffic accident is morbidity due to injuries which is very common, however, Blaszczyński et al [3] pointed out that psychiatric morbidities such as depression, anxiety, driving phobias, anger, sleep disturbances and frequent headaches can seriously disable the person involved in the accident.

5. Factors Affecting Road Traffic Accidents Mortality

The most important factors affecting the mortality rate in road traffic accidents are the time elapsed between the injury and the operation required as well as the associated injuries.

Bowley and Boffard [4] showed that road traffic accidents are leading cause of both internal and external wounds most of these injury can't be treated by dressing alone.

The medical authors of this paper observed about 1500 patients from severe road traffic accidents, for the period 2000 to 2006, at different hospitals in Baghdad.

Their medical study revealed that about 17.4% of the patients observed suffered from single organ injury, while about 82.6% suffered from multi-organ injury. In multi-organ injuries, the surgeon faces the challenging problem of which organ should be dealt with and be preserved first taking into account the time, presence of shock and other associated injuries. However, arresting bleeding, reducing contamination and restoring the anatomical integrity should have their priority.

The medical study revealed also that the rate of mortality increased with increasing delay in arriving the patients to the hospital. This delay can be attributed to the delay in both contacting the ambulance and to the crowded roads leading to the hospital. This is in full agreement with the study by Coats and Davis [7] that showed that the time between the crash and the arrival of the hospital is critical and it usually takes at least 30-45 minutes to be in the emergency room after the crash.

In addition it was observed that the mortality rate increased also with each added organic injury.

WHO Road safety training manual [33] shows that Post crash outcome of injuries can be affected by the availability of pre hospital admission care and the availability of a good high level trauma center.

The study of this paper in Iraq revealed that the rate of mortality increased with increasing delay in arriving the patients to the hospital. This delay can be attributed to the delay in both contacting the ambulance and to the crowded roads leading to the hospital.

6. Speed and Road Traffic Accidents on Iraqi Rural Highways

The laws of mechanics express the fact that the speed of traffic is a vital factor in accident severity. This kinetic energy of a moving vehicle (with its occupants) increases as the square of the velocity. When an accident takes place between two moving vehicles, all this kinetic energy must be dissipated mainly in the form of damage to both the vehicles and their occupants. The analysis of a traffic conflict between two vehicles as an inelastic impact reveals that the dissipated energy is proportional to the square of the relative speed vector [12]. Accordingly, the severity of the conflict is significantly affected by the magnitude of the speed of each vehicle as well as by their angle of intersection. Oglesby and Hicks [17] reported that by the imposition of the 55 mph speed limit in 1974 in USA, there has been a dramatic decrease in both vehicle

speeds and road accidents. They reported that this action resulted into 4000 fewer deaths and 81000 fewer injuries annually.

Salter [22] pointed out that the knowledge of the spot speed spectra can be of great benefit in accident studies as it can give an indication of the accident potential on the highway.

For this reason, spot speed surveys on various Iraqi rural highways were carried out under the supervision of the senior author [20]. Table (1) summarizes the main speed distribution results and the corresponding mathematical statistical measures. It is quite obvious from this table that the maximum speed on all highways exceeded the design speed of the highway of 100 km/h. This is especially true for Baghdad-Tikrit highway where the maximum speed recorded was 180 km/h.

It is quite obvious from Table 1 that each of the studied spot speed spectrum extends over a relatively wide speed range indicating that relatively low speeds as well as high speeds are exercised on all rural highways studied. Such high speed differences can contribute significantly to road traffic accidents as reported by Oglesby and Hicks [17]. Similarly, Sweedler [27] reported that when the speed variance is high, the probability of a crash increases.

Salter [22] reported that the distribution of speeds of cars on a highway with free-moving traffic is substantially normal. However, the use of Chi-square Goodness-of-fit test shows that all the spot speed spectra studied are abnormal for a level of significance of $\alpha = 5\%$. Note that the abnormality of each distribution is associated with skewness as shown in Table 1. Razouki [20] introduced a modified normal distribution (Cramer, 1960) for the studied speed distributions making use of the skewness and thus he achieved an improved normal distribution as tested using the Chi-square Goodness-of-fit test. This phenomenon of abnormality appears to be strongly associated with highways having high accident potential [8].

Table 1. Spot Speed Results For Different Iraqi Rural Highways After Razouki [20]

Highway	Basrah-Amara-Baghdad	Baghdad-Samarra	Tikrit-Baghdad
Type of highway at survey station	2-lane single carriageway	2-lane dual carriageway	2-lane dual carriageway
maximum observed speed (km/h)	130	144	182
minimum observed speed (km/h)	30	32	35
speed range (km/h)	100	112	147
average spot (km/h)	70.7	85.6	100.8
standard deviation (km/h)	20.2	17.1	34.75
Skewness	0.784	0.643	0.228

7. Medcial Treatment of Victims of Road Traffic Accidents

Treatment of victims in road traffic accidents starts from pre-hospital care. Pre hospital care is not as easy as it looks like, even the well trained doctors in hospital trauma managements will not be expected to perform well at the

road side unless they went through an extensive road side based medical training [7].

A study by Khorasani-Zavareh et. al. [11] showed that many factors can work as barriers in the way of facilitating the urgent management of the victim in a road traffic accident, such as: Cultural backgrounds, limited knowledge of laypeople, secondary accidents, traffic jams and delays in the arrival of the emergency team.

Triage is the first step in the management plan in which the victims priority and need to urgent care is assessed. In the emergency room, the initial assessment will start by triaging the patients in groups according to priorities and the need for critical care. Starting with the most critical patients, a sequence of assessing the airways first, then after securing adequate airways, breathing assessment will follow, and then circulation and exclusion of shock state must be done followed by head to toe examination to exclude any missed injuries or burns. Laprotomy and thoracotomy are needed in some cases. Follow up and rehabilitation therapy might be necessary [19].

8. Most Important Types of Injuries in Road Taffic Accidents

Although collision between the victim and the external environment might be the most cause of injuries related to motor vehicle accidents, but still these injuries can be due to acceleration or deceleration effect on the internal organs like liver and spleen [30].

Rapid Deceleration accidents are a major cause of injuries to the distal aorta, renal pedicles, diffused axonal injury at the grey white matter junction in the brain as well as spinal injuries. The use of seat belts can reduce the risk of serious injury by 45% for front seat passengers [21].

Whiplash injuries are a type of vertebral column injuries that happen due to sudden movements. If the motor vehicle got hit from the back leading to sudden acceleration, a sudden extension or flexion movements can occur and usually lead to spinal whiplash injuries [14]. A range from neck trauma to instant death due to spinal cord injury can happen [13].

Internal organs damage due to blunt trauma is common if the abdomen is affected. Tearing of the liver is very common especially in the upper surface leading to intra peritoneal bleeding. Minor accidents can cause tears to an already exciting pathology in the liver like hepatic adenomas. Both conditions can cause serious fatal bleeding if left untreated immediately [26]. Other abdominal organs damage is spleen and small intestine [29].

The most common injured organ in abdominal trauma is liver, while most common cause of significant bleeding in the abdomen is the spleen [19].

Pedestrians mostly get lower limbs injuries followed by body, head and upper limbs injuries. A coexistence of skull, pelvic and extremity fractures together is an indication of bad prognosis [23].

A study in Australia by Bambach et. al. [1] showed that in strained passengers 35% of the injuries were in the spines, 23% in the thorax, 20% were head injuries, upper extremities were 13%, lower extremities were 5%, face injuries were 3%, and abdomen injuries were 1%.

While a study by Okeniyi et. al. [18]. showed that from 263 children that were involved in an accident, 87.1% from them had limb injuries, 43.3% had head injuries, 10.6% had maxillofacial injuries, 3.4% had chest injuries, 1.1% had abdominal injuries, 0.8% had pelvic injuries, 0.4% had spines injuries.

9. Collection of Data Concerning Road Traffic Accident Patients In Iraq

For the purpose of this research paper, the collection of data was made in two stages. In the first stage , medical data was collected followed by engineering data in the second stage.

As mentioned previously, about 1500 patients were admitted to the hospitals at which the medical research group was working in Baghdad during the period 2000-2006. Ethical clearance of this study was granted through the hospitals and the universities they belong to. After stabilization of the victims, patients who were able to communicate were provided by informed consent and a permission to include their data in the study was taken. To differentiate between dead patients from only injured but still alive road traffic accident patients, both the pulse and blood pressure measurements were made together with visual observation of respiratory rate. The diagnosis for the injured patients was then made with the help of the attending specialist, if needed.

In each case of road traffic accident, questions were directed to the involved patients with full consciousness only. The questions were concerned with type of crash (collision on head or back , overturning,...), climatic conditions, conditions of the car and the quality of the driver and approximate time of the accident and whether during the day-time or night time.

Inadequate and/or not reliable data was rejected for the purpose of this paper. Visiting the site by the senior author was made wherever possible to see the type of the road as well as its alignment at the location of the crash and whether the appropriate traffic signs are installed or not. In addition, the collected data included number of lanes, lane and shoulder widths, road surface and shoulder types and median width for the case of divided highways.

Regarding the occupant characteristic of the patients brought to the hospital after the crash, observation by the medical authors concerning safety belt usage, age and sex of the involved patients, was made. In addition, for the purpose of arriving at the actual reason for the crash from traffic engineering point of view, a short speed survey (of about 15 minutes duration), was carried out on the related highway location using the manual method.

10. Results of Survey in Baghdad-Iraq

The driver's behavior is characterized through desire of increased speed of passenger cars and disobedience to traffic signals although all rural highways in Iraq are characterized by high percentage of truck traffic resulting into high speed variance and abnormality of spot speed spectra supporting the traffic data presented in Table 1. However, it is worth mentioning at this stage that all rural

highways involved in this work are in flat topography encouraging high speed.

To show the results of the comprehensive medical survey on road traffic accident patients carried out in Baghdad-Iraq for the period 2000-2006, Table 2 presents the diagnosis of the injured patients from which it is obvious that, in general, spleen, liver and neck were the most commonly injured organs followed by vertebral column, limbs, chest and head injuries. Intestine was the least common injuries.

Table 2. Frequency Of Individual Organs Damage In Road Traffic Accidents In Iraq During The Period 2000-2006

Organ Injured	Absolute Frequency	Relative Frequency (%)
Liver	433	17.6
Spleen	407	16.54
Neck	382	15.52
Vertebral column	369	15
Lower limb	244	9.91
Chest	217	8.82
Head	198	8.04
Upper limb	124	5.04
Intestine	87	3.53
Σ	2460	100%

This fact is shown also graphically in Figure 1. The Pie chart of Figure 2 shows the percentage of individual organs damage in road traffic accidents in Baghdad- Iraq indicating that liver and spleen followed by neck and vertebral column are the most common injuries.

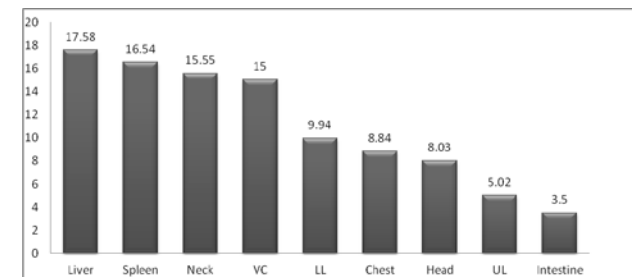


Figure 1. Percentage of individual organs damage in road traffic accidents in Iraq for the period 2000-2006

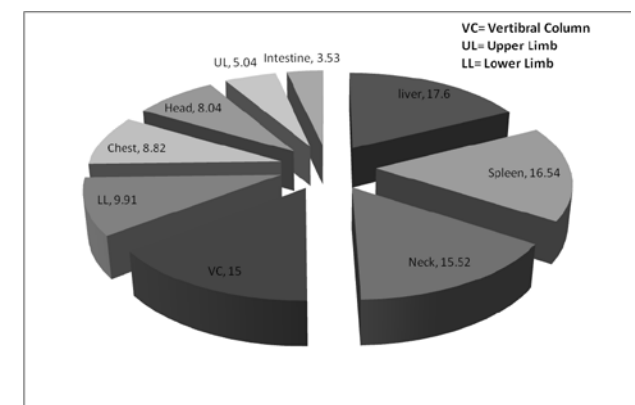


Figure 2. Pie chart for percentage of individual organs damage in road traffic accidents in Iraq for the period 2000-2006.

In addition, Figure 3 shows the percentage of single, double (dual), triple and four and more organ injuries involved in the road traffic accidents studied in Baghdad-Iraq. It is quite obvious from this Pie Chart that about 50% of patients suffered from three organ injuries, while four and more organ injuries were low about 8% only. This indicates the severity of road traffic accidents on Iraq

rural highways. The frequency of single and multiple organs damages in road traffic accident in Iraq during the period 2000-2006 is shown in Table 3.

Table 3. Frequency Of Single And Multiple Organs Damages In Road Traffic Accidents In Iraq During The Period 2000-2006.

No. of organs injured	Absolute frequency	Relative frequency (%)
Single organ	261	17.4
Dual organs	378	25.2
Triple Organs	734	48.93
4 organs and more	127	8.47
Σ	1500	100%

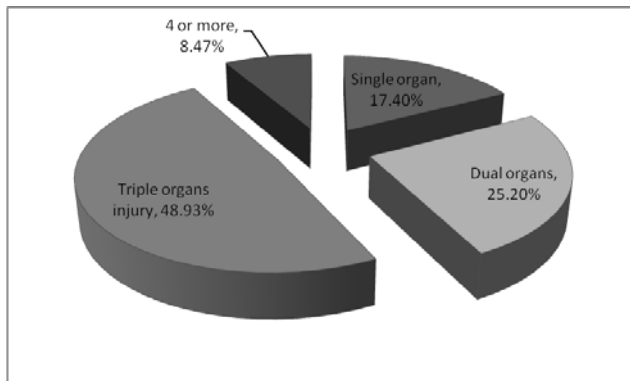


Figure 3. Relative Frequency of single and multiple organs damages in road traffic accident in Iraq during the period 2000-2006.

11. Discussion and Comparison

Results of road traffic accidents in Iraq showed that the most frequent organ injured in the motor vehicle accidents for passengers or pedestrians were the liver followed by the spleen. This is in disagreement with Bambach et. al. [1] due to the fact that the study by Bambach et. al. [1] showed that abdominal injuries were the least to happen. This can be attributed to the fact that Bambach study was restricted to a population of all strained passengers, while in the present Iraqi study there was no restriction on the type of passengers. However, it is important to note that most Iraqi passengers did not wear a seatbelt, thus losing the protective effect of seatbelt on the abdominal organs during the crash.

It is important to note at this stage that the results of the present study are in agreement with a study by Rivara et. al [21] that showed that the use of seat belts can reduce the risk of serious injury by 45% for front seat passengers.

The present Iraqi study also shows that neck injuries were also common in about 15.52% while Bambach et. al[1] study showed that there is about 0% of neck injuries. The reason of this difference is due to the lack of use of safety distance rules enforcement in Iraq during the time of collection of data. This increases the rate of rear end accidents in addition to the sudden stops due to unexpected road barriers with lack of warning sign ahead or serious driver disobedience to traffic signs.

However, the present study showed that Vertebral Column injuries were common which is in full agreement with Bambach et. al. [1]

Head (8.04%) and chest (8.82%) injuries in this study were lower than those reported by Bambach et.al [1] namely (20% & 23%) respectively. The reason may be

due to the use of front and side air bags in the cars used in Iraq during the time of the study and the difference between the natures of the accidents.

In the present Iraqi study, limbs injuries were (5.04%) in upper limbs and (9.91%) in lower limbs while head injuries were (8.04%). On the other hand a study by Okeniyi et. al. [1] showed that limb injuries were 87% and head injuries were 43%. The difference is due to the age difference, as Okeniyi et. al. study was performed on children only. The anatomical difference and weight distribution pattern between children and adults make limbs and head more prone to be injured in road traffic accident in children rather than any other part.

Figure 4 shows graphically a detailed comparison between the present Iraqi study and the above discussed study presented by Bambach et.al. [1]

The spot speed surveys carried out at or near the accident locations indicated that the speed of some vehicles exceeded the upper speed limit as well as even the design speed of the highway. This is in complete agreement with Table 1 after Razouki [20]. At some accident locations, it was observed that significant difference in elevation existed between pavement and shoulder surfaces encouraging overturning and in some cases bleeding of flexible pavements was quite obvious that increased the braking distance and hence the frequency of accidents.

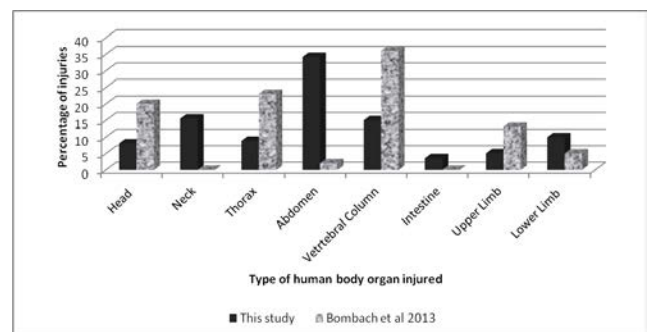


Figure 4. Comparison of the Present Study with Bambach et.al (2013) study in Australia

12. Conclusions and Recommendations

The conclusions of this work can be summarized as follows:

1. Liver, spleen and neck injures were the most common injuries in road traffic accidents on Iraqi rural highways in flat topography.
2. About 17.4% of the road traffic accident patients observed suffered from single-organ injury, while about 82.6% suffered from multi-organ injury.
3. The mortality rate increased with increasing delay in arriving the road traffic accident patients to the hospitals as well as with increased added organic injury.
4. Regarding neck injuries as well as the most frequent organ injured in road traffic accidents, there is disagreement between the present study and Bambach et.al. [1]. study in Australia. The Australian study was restricted to strained population only, while no restriction took place in the Iraqi study.

5. There is some disagreements of this Iraqi study with other studies in the world, due to age differences of population involved in various studies in different countries.
6. Enforcing seatbelt laws help to decrease the rate of internal organ injuries due to road traffic accidents. Similarly, safety distance rules help to decrease rear end crashes which decrease the rate of neck injuries. Front and sideway airbags help to decrease head and chest injuries during a crash.
It is recommended for further studies to determine the statistical significance of each factor.
7. It is strongly recommended to control vehicular speeds on Iraqi rural highways to prevent any possibility of violating the speed limits on any highway.
8. All age groups were involved in the crash for passengers in passenger cars and buses or couches. However, almost all occupants did not use the safety belt except those in the front seat close to the driver. This is especially true for occupants of buses.

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