

EVALUATION OF EXTERNAL INJURIES AS INDICATORS OF INTERNAL INJURIES IN VICTIMS OF BLUNT TRAUMA

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ABSTRACT

Background: Blunt trauma presents a challenge when external injuries are used to determine or predict the type and severity of internal injuries. **Objective:** to assess the relationship between internal injuries and external injuries in blunt trauma adult victims. **Methodology:** This retrospective study was conducted on adult victims of blunt trauma admitted to the Emergency hospital, Tanta University Hospitals from 1st January 2019 to 31st December 2019. Collected variables included sociodemographic data, circumstances of trauma, and sustained injuries. The Abbreviated Injury Scale (AIS) was calculated for external and internal injuries. **Results:** The study included 311 victims of blunt trauma. A significant association between external and internal injuries was detected in all body regions ($p < 0.05$), but the positive predictive value (PPV) of external injury was low (below 60%) except for the neck and extremities (75% and 62.4%, respectively). The negative predictive value was $\geq 90\%$ for all body regions except the head (80.6%). The correlations between AIS of external and internal injuries were positive, moderate, and significant in the neck ($r_s = 0.668$, $p < 0.001$), extremities ($r_s = 0.535$, $p < 0.001$), and head ($r_s = 0.334$, $p < 0.001$), but weak in the chest ($r_s = 0.147$, $p = 0.009$) and abdomen ($r_s = 0.123$, $p = 0.030$). **Conclusion:** external injuries are considered as poor indicators of the presence of internal injuries in most body regions. Physicians should not be tempted to rule in or out the presence of internal injury based on external examination. Forensic experts should determine the extent of internal injuries based either on complete autopsy or implement the techniques of the virtual autopsy to avoid misdiagnosing significant internal injuries.

Keywords: Abbreviated Injury Scale; injury; Falls; Road traffic accidents

INTRODUCTION

Trauma can be divided according to the causative instrument and mechanism of infliction into penetrating and blunt trauma. Penetrating trauma can be readily diagnosed due to the marked external signs present on the victims. On the other hand, blunt trauma may result in less marked injuries to some of the body regions, which may lead to missed or delayed diagnosis (Jansen et al., 2008).

Blunt trauma can present a challenge to emergency physicians who will find difficulty in extrapolating external injuries to determine or predict the type and severity of internal injuries. Even medicolegal experts face such a challenge when they are requested to examine living trauma victims or when only external postmortem examination is requested by authorities (Sah et al., 2017). This problem is particularly encountered in

cases of road traffic accidents (RTAs) where severe internal injuries are caused by transmitted force while external injuries are minimal (Carson and Cook, 2008).

Establishing a relationship between the severity of external and internal injuries can help physicians to early identify internal injuries, identify severe internal injuries, and start prompt treatment (Schmidt et al., 2020).

Medicolegal experts will also benefit if such a relationship can be established to write accurate medicolegal reports in situations where the external examination is only available or allowed (Sah et al., 2017). This may also be valuable in cases when only a report of external injuries is available while the dead body has been buried or passed with putrefactive changes and internal signs of trauma were altered. Moreover, the forensic pathologist sometimes faces cases in which complete autopsy carries an increased risk of transmission of infectious diseases such as the Human Immune Deficiency Virus or Ebola virus. In these situations, complete autopsies may impair the safety of the autopsy performers, and thus, the external examination may only be done, particularly if safety measures are not available (Gilliland, 2015).

The present study aimed to assess the relationship between internal injuries and external injuries in blunt trauma victims. Establishing such a relationship can help early identification of trauma victims who suffer from severe internal injuries and hasten prompt initiation of management.

SUBJECTS & METHODS

Study design and settings

This retrospective study was carried out following the approval of the Research Ethics Committee (REC) of the Faculty of Medicine, Tanta University (approval code: 34073). The hospital records of blunt trauma victims admitted to the Emergency hospital, Tanta University Hospital, during the period

from the 1st of January 2019 to the 31st of December 2019 were revised.

Ethical considerations

Confidentiality of the data was maintained by making code numbers for each victim and both the data collection sheet and the spreadsheet were kept anonymous.

Subjects

This study included 311 adult victims of blunt trauma who were admitted into the emergency department, Tanta University Emergency Hospital during the period from 1st of January 2019 to the 31st of December 2019.

Inclusion criteria:

Adult victims (male or female) with a history of blunt trauma to any of the body regions were included in the study.

Exclusion criteria:

Victims were excluded if they were less than 18 years old or admitted to another health care facility where the injuries were treated then referred to Tanta University Hospital. In addition, victims presenting later than 24 hours after trauma were excluded.

Methods of the study

The hospital records were thoroughly reviewed, and the following data were collected and recorded:

- a) sociodemographic data (age and gender)
- b) circumstances of trauma (manner and cause)
- c) external injuries in the skin
- d) internal injuries of bones or viscera as identified by radiographic imaging or by direct intraoperative observation.

The type of skin injury was categorized as no injury, abrasions, bruises, lacerations, or multiple types of wounds. Internal injuries were categorized as no injury, bone fracture, internal organ injury, or both bone and visceral injuries.

The body was divided into the following regions: head, neck, chest, abdomen and pelvis, and extremities. The relationship between the presence of external injury and

the presence of internal injury was assessed for each body region. The Abbreviated Injury Scale (AIS) scores (**Committee on Medical Aspects of Automotive Safety, 1971**) were calculated for the external injuries in the skin as well as for the internal injuries.

The calculation of AIS is based on the anatomical site as well as the severity of the injury. The AIS score of an injury range from 1 point (minor injury) to 6 (fatal injury) (**Committee on Medical Aspects of Automotive Safety, 1971**). If internal injuries were present in more than one structure, the score was calculated for each and the highest AIS score was chosen for internal injury. The AIS score of the skin was compared with those of internal injury.

Statistical analysis

Data were recorded in an Excel datasheet then imported into the Statistical Package for Social Sciences (IBM SPSS Statistics) for Windows, version 26 (IBM Corp., Armonk, N.Y., USA) to conduct statistical analysis. The AIS score was summarized as median, interquartile range (IQR), and range (minimum-maximum). Categorical variables were summarized as frequencies and associations between them were tested using either Pearson's Chi-square test for

independence or Fisher's exact test as indicated.

Binomial logistic regression analysis was performed to test the likelihood of internal injury in the presence of external injury, with the calculation of odds ratio (OR) along with their 95% confidence interval (CI), sensitivity, specificity as well as positive and negative predictive values (PPV and NPV). Statistical significance was considered at a p-value <0.05 to interpret the results of statistical tests.

RESULTS

The present study included 311 adult victims of blunt trauma, among whom 200 (64.3%) were injured due to falls and 111 (35.7%) were injured in RTAs. Table (1) summarizes the characteristics of studied victims. Approximately half the victims were in the age group 18 - <28 years old, while 19% were aged 38 - <48 years old; 16.4% belonged to the age group 28 - <38 years; 14.1% were 48 years old or above. Most victims were men (82.3%) and were injured in accidental circumstances (99%). The most frequent injured regions were the extremities (70.1%), followed by the head (44.4%), chest (23.8%), abdomen (18.3%), and the least injured region was the neck (1.9%).

Table (1): Characteristics of victims of blunt trauma (n = 311).

	n	%
Age (years)		
18 - <28	157	50.5%
28 - <38	51	16.4%
38 - <48	59	19.0%
48 or above	44	14.1%
Sex		
Male	256	82.3%
Female	55	17.7%
Manner		
Suicidal	3	1.0%
Accidental	308	99.0%
Cause of trauma		
Fall	200	64.3%
RTAs	111	35.7%
Victims of RTA		

Pedestrian	26	23.4%
Vehicle Driver	18	16.2%
Motorcyclist	30	27.0%
Passenger	37	33.3%
Head injury		
Absent	173	55.6%
Present	138	44.4%
Neck injury		
Absent	305	98.1%
Present	6	1.9%
Chest injury		
Absent	237	76.2%
Present	74	23.8%
Abdominal & pelvic injury		
Absent	254	81.7%
Present	57	18.3%
Injury to extremities		
Absent	93	29.9%
Present	218	70.1%

n: number; RTAs: road traffic accidents

Table (2) demonstrates the association between the presence of external and internal injuries in each body region. A significant association was detected in the head ($p=0.046$), neck ($p<0.001$), chest ($p = 0.010$), abdomen ($p = 0.031$), and extremities

($p<0.001$) where the lack of external injuries was associated with a lack of internal injuries in most cases, with rates of 79.4% in the head, 99.3% in the neck, 90.5% in the chest, 90.1% in the abdomen and 95.9% in the extremities.

Table (2): External and internal injuries in body regions of studied victims (n = 311):

	Absent ext. injuries		Present ext. injuries		Test of significance	
	n	%	n	%	X ²	p
Head						
Absent int. injuries	173	79.4%	64	68.8%	3.994 ^a	0.046*
Present int. injuries	45	20.6%	29	31.2%		
Neck						
Absent int. injuries	305	99.3%	1	25.0%	FE	<0.001*
Present int. injuries	2	0.7%	3	75.0%		
Chest						
Absent int. injuries	237	90.5%	38	77.6%	6.719 ^a	0.010*
Present int. injuries	25	9.5%	11	22.4%		
Abdomen & pelvis						
Absent int. injuries	254	90.1%	22	75.9%	FE	0.031*
Present int. injuries	28	9.9%	7	24.1%		
Extremities						
Absent int. injuries	93	95.9%	75	35.0%	99.433 ^a	<0.001*
Present int. injuries	4	4.1%	139	65.0%		

n; number; ext: external; int: internal; a: Pearson's Chi square test for independence; FE: Fisher's exact test; *significant at $p<0.05$.

Table (3) depicts the types and AIS of external and internal injuries recorded in each body region. The most frequent wound type was skin bruises in all regions, while the most

detected internal injuries were fractures in the head, neck, chest, and extremities and visceral injury in the abdomen.

Table (3): Injuries and AIS in each body region in studied victims (n = 311).

	Head (n=138)		Neck (n=6)		Chest (n=74)		Abdomen & pelvis (n=57)		Extremities (n=218)	
External injuries										
No wound	45	32.6%	2	33.3%	25	33.8%	28	49.1%	4	1.8%
Abrasion	0	0.0%	1	16.7%	0	0.0%	0	0.0%	6	2.8%
Bruises	86	62.3%	3	50.0%	49	66.2%	26	45.6%	162	74.3%
Lacerations	1	0.7%	0	0.0%	0	0.0%	2	3.5%	30	13.8%
Multiple types	6	4.4%	0	0.0%	0	0.0%	1	1.8%	16	7.3%
Internal injuries										
No injury	97	70.3%	1	16.7%	38	51.4%	22	38.6%	75	34.4%
fracture	18	13.0%	5	83.3%	19	25.7%	10	17.5%	138	63.3%
Organ injury	15	10.9%	0	0.0%	12	16.2%	15	26.3%	1	0.5%
Bone/organ injury	8	5.8%	0	0.0%	5	6.8%	10	17.5%	4	1.8%
AIS of external injuries										
Median [IQR] (Range)	2 [0 – 2] (0 – 3)		2 [0 – 2] (0 – 2)		2 [0 – 2] (0 – 3)		0 [0 – 2] (0 – 2)		2 [2 – 2] (0 – 3)	
AIS of internal injuries										
Median [IQR] (Range)	0 [0 – 2] (0 – 6)		3 [3 – 3] (0 – 3)		0 [0 – 3] (0 – 4)		2 [0 – 3] (0 – 4)		2 [0 – 2] (0 – 5)	

n; number; AIS: abbreviated injury scale; IQR: interquartile range

Table (4) illustrates the results of binomial logistic regression analysis that was conducted to assess the presence of external injuries in each body region as a predictor of the presence of internal injury in the same region. The presence of external injuries was significantly associated with increased likelihood of finding internal injuries in the same body region by approximately 1.7 times in the head ($p = 0.047$), 457.5 times in the

neck ($p < 0.001$), 2.7 times in the chest ($p = 0.012$), 2.9 times in the abdomen ($p = 0.026$), and 43.1 times in the extremities ($p < 0.001$). The PPV of external injury was generally low (below 60%) except for the neck and extremities where it was 75% and 62.4%, respectively. The NPV was 90% or above for all body regions except the head where it was 80.6%.

Table (4): Predicting internal injury from external injury in studied victims (n = 311)

Injuries	p	OR	95% CI of OR	Sens (%)	Spec (%)	PPV (%)	NPV (%)
Ext. head for Int. head	0.047*	1.7	1.0 to 3.0	31.2	79.4	32.3	80.6
Ext. neck for Int. neck	<0.001*	457.5	32.1 to 6515.6	75.0	99.3	75.0	99.4
Ext. chest for Int. chest	0.012*	2.7	1.3 to 6.0	22.4	90.5	23.5	91.1
Ext. abd. for Int. abd.	0.026*	2.9	1.1 to 7.4	24.1	90.1	28.1	90.4
Ext. extremities for Int. extremities	<0.001*	43.1	15.2 to 121.9	65.0	95.9	62.4	96.0

Ext: external; Int: internal; OR: odds ratio; CI: confidence interval; NPV: negative predictive value; PPV: positive predictive value; Sens: sensitivity; Spec: specificity; * significant at $p < 0.05$.

Table (5) shows the correlation between AIS of external and internal injuries in each body region. The correlations were positive, moderate, and significant in case of injuries in the neck ($r_s=0.668$, $p<0.001$), extremities

($r_s=0.535$, $p<0.001$), and head ($r_s=0.334$, $p<0.001$). Correlations were positive, weak, and significant in the chest ($r_s=0.147$, $p = 0.009$) and abdomen ($r_s=0.123$, $p = 0.030$).

Table (5): Spearman's rank-order correlation between AIS of external and internal injuries (n = 311).

		AIS of external injury	
		r_s	p
AIS of internal injury	Head	0.334	<0.001*
	Neck	0.668	<0.001*
	Chest	0.147	0.009*
	Abdomen	0.123	0.030*
	Extremities	0.535	<0.001*

AIS: abbreviated injury scale; r_s : correlation coefficient; * significant at $p<0.05$.

DISCUSSION

Internal injuries caused by blunt trauma can be readily missed as external signs of blunt trauma may be absent or minimal (Jansen et al., 2008). The discrepancy between the mild external wounds and the severer internal injuries has been reported in Japan in approximately 50% of the autopsies in victims of RTAs (Planning and Development Committee of The Medico-Legal Society of Japan, 1997). Consequently, blunt trauma presents a challenge for both physicians and forensic examiners who attempt to infer from external injuries the type and severity of internal injuries.

The present study aimed to assess the relationship between internal injury and external injury. The study was conducted on 311 adult victims of blunt trauma. Half the victims were within the age group 18 -<28 years. The higher prevalence of this age group among victims of blunt trauma could be attributed to their higher activity, consisting mainly of university students and workers/employees who are traveling on the roads almost daily, and thus are more prone to be involved in RTAs. Moreover, young manual workers within this age group may suffer falls from height while working in the

building industry. The same explanations also interpret the higher predominance of male victims in the present study, taking into account the cultural and demographic standards of our community where a considerable proportion of women are housewives, and their outdoor activities are much limited than men. Such a predominance of male gender in victims of blunt trauma was reported by previous studies, both in Egypt and other countries (Shahin et al., 2016; Bussayamanont et al., 2017; Sah et al., 2017; El-Sarnagawy et al., 2018).

A significant association was detected between the presence of external and internal injuries in the head, neck, chest, abdomen and pelvis as well as the extremities. The presence of external injuries significantly increased the probability of finding internal injuries in all body regions, but notably in the neck (OR=457.5) and extremities (OR=43.1). Although one-third of the studied victims were injured in RTAs, cervical injuries as whiplash injury were not encountered.

In agreement with these results, Bussayamanont et al. (2017) studied 439 autopsies from RTAs and found a significant association between external and internal injuries in all body regions. They conducted a regression analysis which revealed that the

presence of external injury significantly increased the likelihood of the presence of internal injury in the head, neck, chest, abdomen, and extremities by approximately 4.5, 2.7, 1.7, 2, and 7.7 times, respectively.

However, a considerable proportion of victims in the current study, as well as previous studies (Carson and Cook, 2008; Steinwall et al., 2012), showed extensive internal injuries while external injuries were lacking or minimal. The interpretation of sensitivity, specificity, PPV, and NPV of external injuries in the current study demonstrated that the dependence on the presence of skin wounds only to diagnose the presence of internal injuries will result in missing a considerable proportion of internal injuries as indicated by the low sensitivity of external injuries in all regions. Moreover, diagnosing internal injury in one body region based on the presence of external injury will yield a high percentage of false-positive diagnoses (i.e., anticipating internal injury while it is not present), as indicated by low PPV. The absence of external injuries infers a higher probability of the absence of internal injury as shown by the high specificity and NPV. According to the results of this study - if external injuries were used to predict the presence of internal injuries - missed diagnoses will be highest in the chest and abdomen, followed by the head and least in the extremities and neck (as inferred from sensitivity).

This discrepancy was also reported by **Carson and Cook (2008)** who demonstrated few external injuries in three victims of RTAs while the internal injuries were extensive as observed on autopsy. This was also reported in a case report of a pedestrian by **Nishitani et al. (2009)**. They explained the discrepancy between external and internal injuries that vehicles provided some protection to the victims, while the collision resulted in transmission of force that induced shear forces inside the victims' bodies causing the massive internal injuries.

The rates of missed internal injuries as well as the body regions with the highest rates widely varied among the studies, presumably due to differences in the cause of trauma (RTA only or other causes of blunt trauma) and the severity of injuries. Studies that were conducted on deceased victims are expected to demonstrate different results from those conducted on surviving victims as the severity of trauma in the former group is higher.

Yartsev and Langlois (2008) studied retrospectively the postmortem files of 291 RTA victims in Australia. They found that most injuries of the chest, abdomen, and pelvic regions were not predictive of abdominal organ injury, with PPVs below 66%. Only extensive head and neck injuries had good PPV to predict internal injuries.

Steinwall et al. (2012) studied hospital files and autopsy reports of 132 trauma victims who died after admission to a trauma unit. They showed a rate of missed internal injuries of 10.6%, where these injuries were detected at autopsy. In partial agreement with our results, missed internal injuries were more frequent in the chest, followed by the head. **Keisham et al. (2015)** assessed retrospectively 362 victims of RTAs. They reported that 23.2% of victims sustained severe internal injuries with minor external injuries. The rate of missed internal injuries was much higher than reported by other studies in the chest and abdomen (91.2% and 91.7%, respectively), while it was 16.7% in the head and neck.

On the other hand, **Moharamzad et al. (2008)** reported on 251 victims of RTAs and stated that the highest rates of missed internal injuries were in the head (72.2%), followed by the neck (13.8%). **Munteanu et al. (2014)** revised the autopsy reports of 339 victims of RTAs and found that 167 (49%) had head injuries, out of whom 78 (46.7%) showed no external injuries.

The present study also assessed the relationship between the AIS of external and

internal injuries in each body region. The correlations were positive, moderate, and significant in case of neck ($r_s=0.668$, $p<0.001$), extremities ($r_s=0.535$, $p<0.001$), and head injuries ($r_s=0.334$, $p<0.001$). Correlations were negligible in chest ($r_s=0.173$) and abdomen ($r_s=0.159$).

Yartsev and Langlois (2008) reported almost no correlation between the severity of external injury (categorized as abrasions, bruises, and lacerations) and that of internal injury. When they assessed the correlations within a subgroup of victims with severe lacerations, they found significant, though weak ($r_s<0.3$) correlations in head injuries. They concluded that the severity of bruises or abrasions correlates poorly with the severity of internal injuries. The strongest correlations existed in the case of distorted cranium.

Sah et al. (2017) investigated 496 autopsy cases with blunt head trauma at a tertiary hospital. They reported a positive moderate to strong correlation between the AIS score of scalp injuries with that of internal head injury.

Clinical and forensic implications can be drawn from the results of the current study. In the case of physicians who may rely on the presence of external injuries to order investigations, write primary reports, or design management, care should be taken as the rate of missed internal injuries will be high in most body regions. However, the determination of the impact of missed serious injuries on victims' management and outcome should be assessed within each specialty.

In medicolegal investigations on deceased subjects, the external examination and partial autopsy will result in missing internal injuries. This problem was addressed by previous studies particularly in the case of hospital autopsies as there is a trend in several countries to reduce the rate of complete hospital autopsies to reduce expenditure (**Gilliland, 2015**). Moreover, forensic experts face this challenge in some circumstances in

which authorities grant only external examination of the dead body or partial autopsies as in France (**Lorin de la Grandmaison et al., 2008**) and some Arab countries (**Mohammed and Kharoshah, 2014; Al-Waheeb et al., 2015**). Several studies have shown that the cause of death would not be precisely determined based on mere external examination (**Yartsev and Langlois, 2008; Subedi et al., 2013; Subedi et al., 2014**), particularly in case of trauma involving acceleration and deceleration as RTAs (**Carson and Cook, 2008; Gilliland, 2015**) and falls. A promising approach to investigate the interior of the body in communities that object to body dissection is virtual autopsy (virtopsy) (**Bolliger and Thali, 2015**).

CONCLUSIONS

External injuries are poor indicators of the presence of internal injuries in most body regions. The present study possessed several points of strength, by including various types of injuries in different body regions that are caused by blunt trauma. However, some limitations are present due to the retrospective nature of the study, thus documentation of injuries depended on the hospital files. Moreover, as autopsy reports were not available for the deceased victims, we were unable to assess more internal injuries that could be missed by radiography and detected only on dissection.

RECOMMENDATIONS

1- Physicians should depend on radiologic imaging to identify internal injuries and not be tempted to rule in or out the presence of internal injury based on external examination.

2- Forensic experts should also determine the extent of internal injuries based either on complete autopsy or implement the techniques of the virtual autopsy to avoid missing significant internal injuries.

3- The conduction of a prospective study which includes the autopsy reports of victims who were referred for medicolegal investigation is recommended.

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تقييم الإصابات الخارجية كمؤشرات للإصابات الداخلية في ضحايا الإصابات الرضية

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الخلفية: تمثل الإصابات الرضية تحديًا عندما تستخدم الإصابات الخارجية في تحديد أو توقع نوع وشدة الإصابات الداخلية. **الهدف:** تقييم العلاقة بين الإصابات الداخلية والإصابات الخارجية في ضحايا الإصابات الرضية من البالغين. **طريقة البحث:** أجريت هذه الدراسة الاسترجاعية على البالغين الذين أصيبوا بإصابات رضية وتم إدخالهم إلى مستشفى الطوارئ بمستشفيات جامعة طنطا من ١ يناير ٢٠١٩ إلى ٣١ ديسمبر ٢٠١٩. تضمنت المتغيرات التي تم جمعها البيانات الاجتماعية الديموغرافية وظروف الإصابة والإصابات التي حدثت. تم حساب مقياس الإصابات المختصر (AIS) للإصابات الخارجية والداخلية.

النتائج: شملت الدراسة ٣١١ ضحية للإصابات الرضية. وقد اكتشف ارتباط ذو أهمية إحصائية بين الإصابات الخارجية والداخلية في جميع مناطق الجسم ($p < 0.05$)، لكن القيمة التنبؤية الإيجابية للإصابة الخارجية كانت منخفضة (أقل من ٦٠٪) باستثناء الرقبة والأطراف (٧٥٪ و ٦٢,٤٪ على التوالي). كانت القيمة التنبؤية السلبية ٩٠٪ أو أعلى لجميع مناطق الجسم باستثناء الرأس (٨٠,٦٪). وقد كانت العلاقة بين AIS للإصابات الخارجية والداخلية إيجابية ومتوسطة وذات دلالة إحصائية في الرقبة ($p < 0.001$, $r_s = 0.668$)، والأطراف ($p < 0.001$, $r_s = 0.535$)، والرأس ($p < 0.001$, $r_s = 0.334$)، ولكنها كانت ضعيفة في الصدر ($p = 0.009$, $r_s = 0.147$) والبطن ($p = 0.030$, $r_s = 0.123$).

الاستنتاجات: تعد الإصابات الخارجية مؤشرات ضعيفة لوجود إصابات داخلية في معظم مناطق الجسم. لا ينبغي للأطباء أن يحكموا على وجود إصابة داخلية أو استبعادها بناءً على الفحص الخارجي. يجب على خبراء الطب الشرعي تحديد مدى الإصابات الداخلية بناءً على التشريح الكامل للجثة أو تنفيذ تقنيات التشريح الافتراضي لتجنب التشخيص الخطأ للإصابات الداخلية الهامة.

الكلمات المفتاحية:

مقياس الإصابة المختصر - إصابة خارجية - السقطات - إصابة داخلية - حوادث المرور