Relationship between External and Internal Injury in Fatal Road Traffic Accident

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Background: *Road traffic accidents are a major problem, causing death and injury in Thailand.*
Objective: *To study the relationship between external injury and internal injury which helps to diagnose severe cases caused by road traffic accidents and provides the information to reduce the chance of misdiagnosis.*
Material and Method: *The data of age, gender, external injury, the type of injury, internal injury, and the type of internal injury was gathered from 439 autopsy cases which affected regions of head, neck, chest, abdomen, and extremities. Chi-square and Binary Logistic Regression were used to analyses the relationship.*
Results: *The injury that had the greatest relationship with age was internal chest injury ($p = 0.002$), which was rarely found in children and was more common in the elderly. Males tended to have more head injuries than females ($p = 0.003$). The major cause of death from traffic accidents was head injury. Internal neck injuries depended on the position of the wounds nearby and the majority of injuries were caused by accelerate-decelerate mechanism. Multiple types of wounds or lacerated wounds could help to predict internal injury to head ($p<0.001$, $p = 0.001$), abdomen ($p = 0.001$, $p = 0.013$), and extremities ($p<0.001$, $p<0.001$). Abrasion wounds were the most common wound caused by traffic accident. Internal chest, neck or abdomen injuries had a relationship with internal injuries in the nearby anatomical regions ($p<0.05$). The external injury was found to relate to internal injury ($p<0.05$). However, the results should be interpreted with caution, because in some cases, in many regions, external injuries could not be found but internal injuries were present.*
Conclusion: *External injury was found to be related to internal injury. There was a relationship between gender and head injury whereby males had a significantly higher number of internal head injuries.*

Keywords: *Wounds, Traffic injury, Internal injury, External injury*

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The Royal Thai Police conducted an analysis that revealed 98,009 people had died in road traffic accidents from January 2006 to June 2015[1]. From January 2006 to September 2014, there were on average 100,000 injuries per year, 86,753 deaths were recorded, of which 66,853 were male and 19,900 were female. 80,447 had severe injuries, and 350,415 had minor injuries[2]. BR Sharma et al studied 163 traumas which had resulted in death and were cases where the patient had survived more than 24 hours, of these: 37 cases had either undiagnosed injuries or complications. From the autopsy report, 2 cases were found to have more than 500 ml of hemoperitoneum, and 4 cases of liver and spleen rupture which were misdiagnosed when the patient was hospitalized[3]. Duke GJ et al reported on 238 patients in ICU. It was found that 7 had been misdiagnosed of which 4 had died[4]. Three case report studies in the United States stated that in deaths which had occurred from traffic accidents with large vehicles it was discovered that there were severe internal injuries with little external injury. Carson HJ et al noted that collisions between passenger vehicles and very large vehicles generated massive internal injuries by transmission of force[5]. A completed autopsy is a valuable tool that can provide feedback to health care providers, thus preventing undiagnosed cases and improving medical care. This research aims to study the relationship between internal injury and external injury, and can be applied in the evaluation of injury from traffic accident cases with severe injury. This study can contribute ratios to quantify how strong the relationship is, and show the relationship between internal injury from the different areas.

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Material and Method

Completed autopsies of lethal vehicle collision

cases from the year 2006 to 2015 were selected for this retrospective study at the Department of Forensic Medicine, Faculty of Medicine, Srinakharinwirot University. The criteria used for inclusion in the study were; cases where the victim's death occurred at the site of the traffic accident and where death was caused by blunt force injury. The subjects would have had completed autopsy reports and photographs included. The criteria used for exclusion from the study were determined as the following: the deceased had suffered non-traumatic death (such as drowning in a submerged car), those cases where death had not occurred immediately following an accident and may, for example have spent a long period in hospital before dying of complications and those where death was caused by sharp force injury.

Information for the cases (n = 439) was gathered, relating to age, sex, external injuries (which were categorised as to whether wounds were found or not found), type of external injury (categorised as to whether no wound was found, abrasions, contusions, lacerations or multiple types of wound) and internal injury (categorised as; no injury found, bone fracture, internal organ injury or both types of injury).

The information was recorded so as to indicate the body region affected with anatomic zones divided as follows: head, neck, chest, abdomen and extremities. The data obtained was analyzed using SPSS version 23, to study the relationship between external injury and internal injury, using Chi-square and Binary logistic regression, and calculation of the predictive value of odds ratios.

The relationship between internal injuries in a specific region which may affect an internal injury to other regions could be extrapolated; also the relationship between internal injury in a specific region and the type of wound could be determined using Binary logistic regression and calculation of the predictive value of the odds ratios.

To study the relationship between age and internal injury in each region, and the relationship between sex and internal injury in each region, the Chi-square was used.

This study focused on analysis of external injuries to help predict internal injury in each region and $p<0.05$ were selected as significant. Permission and approval was obtained from the Human Research Protection Committee at Srinakharinwirot University, reference SWUEC/E-158/2559.

Results

Of the 439 cases from fatal traffic accidents, 367 were male and 72 were female. Gender related to internal head injury only. Males had significantly more internal head injuries than females ($p = 0.003$). Most deaths were in the reproductive age (in 23 cases the exact age was unable to be obtained), related to internal chest injury ($p = 0.002$).

Study of relationship between internal injury and external injury using Chi-square in each region showed that external injury had a relationship with internal injury. If an external injury was found in any region of the body, it could help to predict an internal injury in that region, as shown in Table 1.

On comparing the relationship between internal and external injury in each region using binary logistic regression, it was discovered that internal head injury could only be predicted by external head injury (p-value = 0.00, OR = 4.534) to determine whether internal neck injury was related with external head (OR = 2.895), neck (OR = 2.744) or extremities injury (OR = 1.964). The predictive value for internal neck injury from external head injury had approximation to external neck injury. Internal chest injury could only be approximately

Table 1. The relationship between external and internal injury in each region

Regions	External injury+ Internal injury+ (n)	External injury- Internal injury- (n)	External injury+ Internal injury- (n)	External injury- Internal injury+ (n)	Chi-square (Sig.)
Head	348	15	46	30	<0.001
Neck	36	246	24	133	<0.001
Chest	195	61	48	135	0.006
Abdomen	92	165	226	121	<0.001
Extremities	145	73	215	6	<0.001

- = mean no injury; + = mean with injury, n = number of cases

predicted 1.671 times from external chest injury. Internal abdominal injury could be predicted from external abdominal injury by the predictive value approximately 2.025 times. Internal extremities had relationship with external abdomen, neck or extremities injury. The prediction value from external extremities injury was 7.678 while neck injury had a predictive value in the opposite direction as shown in Table 2.

When examining the relationship between internal injury and the types of external wounds in each region, lacerated wounds (OR = 13.75), contusion wounds (OR = 5.667) and multiple types of wounds (OR = 4.135) in the head region, helped to predict internal head injury. However, abrasion to the head did not have a statistically significant relationship with an internal head injury. Internal neck injury had relationship with contusion wounds (OR = 3.699). Abrasion had relationship with internal chest injury (OR = 2.177). Wounds that related with internal abdomen injury were lacerated wounds and multiple types of wounds to the abdomen. The ratio of abdominal lacerated wounds was as high as 13.36 times. The types of external wounds which had significance to internal extremity injuries were abrasions, lacerated wounds, and multiple types of wound (Table 3).

Internal injury in each region did not relate to internal head injury. Internal chest injury should be monitored for internal neck injury (*p*-value = 0.002, OR = 2.292, 95% CI = 1.610 to 4.349). Internal neck injury or internal abdomen injury should be monitored for internal chest injury (*p*-value = 0.002, 0.000; OR = 2.267, 3.280; 95% CI = 1.610 to 4.349, 2.518 to 6.662 respectively). If internal extremities injury or chest injury is present, monitoring for internal abdomen injury is needed (*p*<0.001, <0.001; OR = 2.287, 3.319; 95% CI = 1.717 to 3.894, 2.518 to 6.662, respectively).

Discussion

From the fatal traffic accident cases shown in Table 1, wounds were found to help to predict possible

Table 2. Relationship between internal injury and external injury in each region

Region	*p*-value	OR	95% CI for odds ratio
Internal head injury and external head injury	<0.001	4.534	2.187 to 9.397
Internal neck injury and external head injury	0.01	2.895	1.283 to 6.536
Internal neck injury and external neck injury	0.001	2.744	1.550 to 4.857
Internal neck injury and external extremities injury	0.022	1.964	1.100 to 3.504
Internal chest injury and external chest injury	0.025	1.671	1.065 to 2.623
Internal abdominal injury and external abdominal injury	0.001	2.025	1.344 to 3.050
Internal extremities injury and external neck injury	0.026	0.474	0.246 to 0.913
Internal extremities injury and external abdominal injury	0.013	1.733	1.124 to 2.671
Internal extremities injury and external extremities injury	<0.001	7.678	3.221 to 18.303

OR = odds ratio; CI = confidential interval

Table 3. Relationship between the types of wound and internal injury in each region

Internal injury and types of wound	*p*-value	OR	95% CI for odds ratio
Internal head injury and lacerated wound	0.001	13.750	2.537 to 34.987
Internal head injury and contusion wound	0.01	5.667	1.603 to 22.792
Internal head injury and multiple types of wound	<0.001	4.135	2.159 to 9.386
Internal neck injury and contusion wound	0.019	3.699	1.973 to 8.021
Internal chest injury and abrasion wound	0.006	2.177	1.237 to 3.726
Internal abdominal injury lacerated wound	0.013	13.636	1.726 to 108.205
Internal abdominal injury multiple types of wound	0.001	5.455	2.277 to 20.509
Internal extremities and abrasion wound	0.032	2.920	1.043 to 7.491
Internal extremities and lacerated wound	<0.001	17.176	5.994 to 47.885
Internal extremities and multiple types of wound	<0.001	12.807	5.192 to 30.122

OR = odds ratio; CI = confidential interval

internal injury. Locating the region of the injury was important to predict internal injury. However, even when no external injury was found, internal injury may still have been present. The number of cases that did not have external injury but had internal injury for each region of the body were as follows: head 30, neck 133, chest 135, abdomen 16, extremities 6. Without careful examination, these might not have been detected.

At the IALCH trauma unit, 14 out of 132 (10.6%) internal injuries were missed and found only at autopsy. The thorax had the highest number of missed injuries followed by the head[6].

According to the report of Moharamzad Y et al, in 251 deaths caused by traffic accident, the head was the region most commonly misdiagnosed (72.2%), followed by the neck (13.8%)[7].

From Supriya Keisham et al study, 362 of road traffic accident cases, 84 had fatal internal injuries without significant external injury. In that study, 12 out of 72 cases were head and neck injuries, 31 out of 34 cases were chest injuries, and 22 out of 24 cases were abdominal injuries[8].

In a comparative study of external and internal injuries by Yartsev A et al, it was reported that of 291 cases, there was no significant prediction of internal lethal injury. Wounds were graded by the severity and location to predict injuries of internal organs that could lead to death. The most useful wounds that helped to predict possible internal injury were; lacerated wounds in many areas, abrasion wounds together with lacerated wounds or deformity, the best predictions were related to the head region[9].

In our study, internal head injuries accounted for (86.1%) and extremities (34.4%). Extremities with no obvious wounds but with broken bones were only 6 cases. Compared with Seid M et al study, the most common injury of 230 non-fatal traffic accident cases were head injury (50.4%), and extremities (47.0%)[10]. Injuries of internal extremities could be easily detected by the deformity due to the severity of the injuries in fatal traffic accident cases. The relationship between extremities and the other regions remained unclear because of inadequate information about the types of traffic accident.

External head injuries and the type of wounds helped to predict internal head injuries, especially lacerated wounds, which were indicative of the severity. Males had a significantly higher number of cases of internal head injury when compared to females (p = 0.003). Petre Liviu Munteanu et al reported that of 339 deaths from traffic accidents, 49% had head injuries and skull fractures. Males were found to have significantly more head injuries than females (Pearson Chi2 = 4.519, p = 0.034). Although external injury was found related to skull fractures (p = 0.024), 78 cases without external injuries had shown skull fractures[11].

In the neck region, internal neck injury could be predicted from external neck injury (p = 0.001), head (p = 0.01), extremities (p = 0.022), abrasions (p = 0.05), contusion wounds (p = 0.019), and internal chest injury (p = 0.002). External neck injuries were found in only 60 out of 439 cases while internal neck injuries were found in 169 cases due to the neck being smaller than other external regions. In addition, Tameem A et al reported acceleration-deceleration as a main mechanism for neck injuries[12]. Whiplash trauma often occurred with no significant tissue damage (Uhrenholt L et al, 2011)[13]. Predictions of internal neck injuries were used for wounds from nearby regions such as head, neck or internal chest injury.

No external chest injuries were found in 196 cases, and where external chest injuries were found 128 were abrasion wounds, 6 lacerated wounds, 61 contusion wounds and 48 multiple types of wounds. From Reddy NB et al research, the injuries of intrathoracic organs can occur without any injury to the chest wall. External wounds were found more than intrathoracic injury. The most commonly injured organ in traffic accidents were the lungs, followed by the heart[14]. B. Suresh Kumar Shetty et al explained that chest injuries may have been caused by movement of organs which impacted the chest wall or caused laceration to lung and heart, or were caused by direct injury to the chest such as rib fractures, rupture to lung or heart[15]. Age related to chest injuries (p-value = 0.002), in children under 10 years old, 3 in 10 children had internal chest injuries (OR = 5.056), but in adults 60 to 70 years old, 39 in 47 had internal chest injuries (OR = 12.833), of those aged over 70 years old, 17 in 21 had internal chest injury (OR = 9.917). Singh D et al study reported on deaths by traffic accidents for the under 18 age group. 81.4% died from head and neck injuries while 9.8% died of chest injuries[16].

Internal abdominal injury could be predicted from the external abdominal wounds, (p = 0.001, OR = 2.025), lacerated wounds (p = 0.013, OR = 13.636) and multiple types of the wounds (p = 0.001, OR = 5.455) related to internal abdominal injuries. Kumawat JL et al reported the most common internal abdominal organ injury occurred to the liver, followed by the spleen, kidneys and digestive tract[17]. There was more chance of abdominal internal injury due to there being no bone

to protect the organ except for the right liver lobe[14].

The most common types of wounds were abrasion wounds. Lacerated wounds were found less in the neck (7 cases) and chest regions (6 cases). In Farooqui JM et al study, the most common type of wounds in 98 fatal road traffic accident cases were abrasion wounds in every region. Only 1 out of 55 in the chest region had lacerated wounds[18].

The limitation of this study was that neither the severity of wounds nor the specific types of traffic accidents could be classified and this may have had an affect on the interpretation. For further post mortem studies, the severity of the wounds should be graded and the cause of the injury such as pedestrian, driver, passenger, motorbike or bicycle should be specified.

Conclusion

External injury was found to be related to internal injury. There was a relationship between gender and head injury whereby males had a significantly higher number of internal head injuries. External head injuries and the type of wounds helped to predict internal head injuries. Age was related to chest injuries. Internal neck injuries could be predicted from wounds to nearby regions such as head, neck or internal chest injury. Internal abdominal injury could be predicted from the external abdominal wounds. Internal chest, neck or abdomen injuries had a relationship with internal injuries in the nearby anatomical regions. The study should not be used to interpret minor injuries from traffic accidents. The absence of external injuries should not lead to the conclusion that internal injuries are absent.

What is already known on this topic?

Review literatures show that external injuries had neither relationship nor non-relationship to internal injuries from traffic accidents. The methods and statistics used were different from this study.

What this study adds?

This study adds the ratios to predict internal injuries from external injuries, age, sex, types of wounds, and other regions of internal injuries.

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Potential conflicts of interest

None.

References

1. Wichaidit MP. Statistics and information throughout the year [Internet]. Road Safety Thailand. 2012 [cited 2017 Feb 21]. Available from: http://roadsafetythailand.com/main/index.php/data-statistics-th/statnormal.
2. Road Safety Control-Transport Statistics Sub-Division, Planning Division. Statistics [Internet]. 2017 [cited 2017 Feb 21]. Available from: http://apps.dlt.go.th/statistics_web/statistics.html.
3. Sharma BR, Gupta M, Harish D, Singh VP. Missed diagnoses in trauma patients vis-a-vis significance of autopsy. Injury 2005; 36: 976-83.
4. Duke GJ, Morley PT, Cooper DJ, McDermott FT, Cordner SM, Tremayne AB. Management of severe trauma in intensive care units and surgical wards. Med J Aust 1999; 170: 416-9.
5. Carson HJ, Cook BA. Massive internal injury in the absence of significant external injury after collisions of passenger vehicles with much larger vehicles. J Forensic Leg Med 2008; 15: 219-22.
6. Steinwall D, Befrits F, Naidoo SR, Hardcastle T, Eriksson A, Muckart DJ. Deaths at a Level 1 Trauma Unit: a clinical finding and post-mortem correlation study. Injury 2012; 43: 91-5.
7. Moharamzad Y, Taghipour H, Hodjati FN, Hodjati FA, Hashemzadeh M, Mirjalili M, et al. Mortality pattern according to autopsy findings among traffic accident victims in Yazd, Iran. Chin J Traumatol 2008; 11: 329-34.
8. Keisham S, Singh AB, Kamei R, Memchoubi P. A Study of fatal internal injuries without significant external injuries in road traffic accidents in imphal from 2009-2014.J Indian Acad Forensic Med 2015; 37: 16-8.
9. Yartsev A, Langlois NE. A comparison of external and internal injuries within an autopsy series. Med Sci Law 2008; 48: 51-6.
10. Seid M, Azazh A, Enquselassie F, Yisma E. Injury characteristics and outcome of road traffic accident among victims at Adult Emergency Department of TikurAnbessa specialized hospital, Addis Ababa, Ethiopia: a prospective hospital based study. BMC Emerg Med 2015; 15: 10.
11. Munteanu PL, Ro'u M, Panaitescu V, Punga A. Patterns of head injuries in lethal road traffic accidents in Buzau County. Rom J Leg Med 2014; 22: 9-12.

12. Tameem A, Kapur S, Mutagi H. Whiplash injury. ContinEducAnaesthCrit Care Pain 2014; 14: 167-70.
13. Uhrenholt L, Freeman MD, Jurik AG, Jensen LL, Gregersen M, Boel LW, et al. Esophageal injury in fatal rear-impact collisions. Forensic Sci Int 2011; 206: e52-7.
14. Reddy NB, Hanumantha, Madithati P, Reddy NN, Reddy CS. An epidemiological study on pattern of thoraco-abdominal injuries sustained in fatal road traffic accidents of Bangalore: Autopsy-based study. J Emerg Trauma Shock 2014; 7: 116-20.
15. Shetty BSK, Kanchan T, Menezes RG, Bakkannavar SM, Nayak VC, Yoganarasimha K. Victim profile and pattern of thoraco-abdominal injuries sustained in fatal road traffic accidents. J Indian Acad Forensic Med 2012; 34: 16-9.
16. Singh D, Singh SP, Kumaran M, Goel S. Epidemiology of road traffic accident deaths in children in Chandigarh zone of North West India. Egypt J Forensic Sci 2016; 6: 255-60.
17. Kumawat JL, Mathur PN, Mathur K, Mehta FS. A retrospective study of blunt trauma abdomen. JEMDS 2015; 4: 10263-9.
18. Farooqui JM, Chavan KD, Bangal RS, Syed MM, Thacker PJ, Alam S, et al. Pattern of injury in fatal road traffic accidents in a rural area of western Maharashtra, India. Australas Med J 2013; 6: 476-82.

การศึกษาความสัมพันธ์ระหว่างบาดแผลภายนอกและการบาดเจ็บภายในผู้เสียชีวิตจากอุบัติเหตุจราจร

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ภูมิหลัง: *อุบัติเหตุจราจรเป็นปัญหาสำคัญที่ก่อให้เกิดการบาดเจ็บและเสียชีวิตในประเทศไทย*

วัตถุประสงค์: *เพื่อศึกษาความสัมพันธ์ระหว่างการบาดเจ็บภายนอกและการบาดเจ็บภายในเพื่อช่วยในการวินิจฉัยการบาดเจ็บภายในที่อาจจะเกิดขึ้นในกรณีอุบัติเหตุจราจรที่มีความรุนแรงและลดอัตราการวินิจฉัยไม่ครบถ้วน*

วัสดุและวิธีการ: *เก็บข้อมูลเกี่ยวกับ อายุ เพศ การบาดเจ็บภายนอก การบาดเจ็บภายในจากการผ่าศพ 439 ราย โดยพิจารณาตามกายวิภาคส่วนศีรษะลำคอทรวงอกท้องและแขนขาวิเคราะห์โดยใช้สถิติ Chi-square และ binary logistic regression*

ผลการศึกษา: *การบาดเจ็บภายในที่สัมพันธ์กับอายุคือการบาดเจ็บที่ตำแหน่งทรวงอกซึ่งพบในผู้สูงอายุมากกว่าเด็ก (p = 0.002) การบาดเจ็บภายในที่สัมพันธ์กับเพศคือการบาดเจ็บบริเวณศีรษะ ซึ่งพบในผู้ชายมากกว่าผู้หญิงอย่างมีนัยสำคัญทางสถิติ (p = 0.003) สาเหตุการตายหลักจากอุบัติเหตุจราจรคือการบาดเจ็บบริเวณศีรษะ การบาดเจ็บบริเวณลำคอขึ้นอยู่กับตำแหน่งการบาดเจ็บภายนอกบริเวณลำคอและศีรษะเนื่องจากกลไกการบาดเจ็บตำแหน่งนี้ส่วนใหญ่เกิดจากกลไกการเร่งและการชะลอตัวการพบบาดแผลฉีกขาดและบาดแผลหลายชนิดช่วยในการทำนายการบาดเจ็บภายในศีรษะ (p<0.001, p = 0.001) ช่องท้อง (p = 0.001, p = 0.013) และแขนขาได้ (p<0.001, p<0.001) บาดแผลถลอกเป็นบาดแผลที่พบได้บ่อยที่สุดจากอุบัติเหตุจราจรการบาดเจ็บภายในทรวงอก ลำคอ ช่องท้องมีความสัมพันธ์กับการบาดเจ็บภายในตำแหน่งที่ใกล้เคียงกันตามกายวิภาค (p<0.05) การบาดเจ็บภายนอกมีความสัมพันธ์กับการบาดเจ็บภายใน (p<0.05) อย่างไรก็ตามการแปลผลควรใช้ความระมัดระวังเนื่องจากมีหลายกรณีที่ไม่พบการบาดเจ็บภายนอกในขณะที่พบการบาดเจ็บภายใน*

สรุป: *การบาดเจ็บภายนอกมีความสัมพันธ์กับการบาดเจ็บภายในมีความสัมพันธ์ระหว่างเพศและการบาดเจ็บบริเวณศีรษะซึ่งพบในผู้ชายมากกว่าผู้หญิงอย่างมีนัยสำคัญทางสถิติ*