# Motorcycle injuries and characteristics of frontal collision: Western Bangkok perspectives

## การบาดเจ็บของผู้ใช้รถจักรยานยนต์และรูปแบบที่พบเฉพาะในการชนทางด้านหน้า พิเคราะห์จากอุบัติเหตุที่เกิดขึ้นในฝั่งตะวันตกของกรุงเทพมหานคร

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## Abstract

**Objectives:** To explore the landscape of motorcycle accidents (MCAs), to correlate external and internal injuries and to characterize the prominent injuries in the most common colliding direction.

**Methodology:** Autopsy data of the MCA cases performed during January 2017 to October 2019 at Siriraj Hospital were analyzed focusing on demographic distribution, external and internal injuries, and specific signs to identify a driver in frontal collision.

**Results:** Almost seventy percent of the mortal traffic accidents is MCA while the majority of victims is male predominantly in young adults; about half are frontal collision. Overall, head injuries are found predominantly in external and internal of the body following by thoraco-abdominal and pelvic injuries, respectively. However, external injuries do not highly suggest internal organ injuries except for wounds found at the posterior head. The fuel-tank injury around perineum and thigh, previously described as the specific sign of the driver in frontal collision, is occasionally found in passengers while genital injuries might be better to help pointing out the motorcycle operator.

**Conclusion:** The study shows the landscape of MCAs that demographic data as well as distribution of injuries on the body may be useful to a clinical application and also to the policy authorities. In frontal collision, genital wounds are exclusively found in drivers in comparison with fuel-tank injuries.

**Keywords:** Motorcycle accident, frontal collision, injury

**บทคัดย่อ**

**วัตถุประสงค์:** เพื่อดูบริบทของการบาดเจ็บจากอุบัติเหตุรถจักรยานยนต์ ความสัมพันธ์ระหว่างบาดแผลกับการบาดเจ็บภายใน และรูปแบบการบาดเจ็บที่จำเพาะกับผู้ขับขี่รถจักรยานยนต์ในการชนทิศทางที่พบบ่อย

**วัสดุและวิธีการศึกษา:** รวบรวมข้อมูลรายงานการตรวจศพของภาควิชานิติเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล ระหว่างเดือนมกราคม พ.ศ.2560 ถึงเดือนตุลาคม พ.ศ.2562 เพื่อวิเคราะห์ข้อมูลทางประชากรศึกษา รูปแบบของการบาดเจ็บ และการบาดเจ็บในการชนทางด้านหน้าด้วยวิธีการทางสถิติพรรณา

**ผลการศึกษา:** ผู้เสียชีวิตจากอุบัติเหตุจราจรส่วนใหญ่กว่าร้อยละเจ็ดสิบเป็นอุบัติเหตุรถจักรยานยนต์ โดยผู้ประสบเหตุส่วนใหญ่เป็นเพศชาย และเกิดจากชนทางด้านหน้า การบาดเจ็บที่พบมากที่สุดที่ศีรษะ รองลงมาคือหน้าอก และท้อง และเชิงกราน ตามลำดับ อย่างไรก็ตาม การบาดเจ็บภายในร่างกายไม่สัมพันธ์กับบาดแผลบนร่างกาย ยกเว้นบาดแผลที่พบบริเวณทางด้านหลังศีรษะ นอกจากนี้ รูปแบบการบาดเจ็บรอบหัวเหน่าที่เรียกว่า fuel-tank injury ซึ่งเคยเชื่อว่าพบได้เฉพาะในผู้ขับขี่ในการชนทางด้านหน้านั้น พบว่ายังสามารถเกิดได้ในผู้โดยสารด้วย ดังนั้นรูปแบบการบาดเจ็บที่อวัยวะเพศจึงน่าจะใช้บ่งชี้ตัวผู้ขับขี่ได้ดีกว่า

**สรุป:** ข้อมูลจากการศึกษาครั้งนี้อาจใช้ประโยชน์ในทางคลินิกและในเชิงนโยบายจราจร และได้เสนอรูปแบบการบาดเจ็บที่น่าจะใช้บ่งชี้ตัวผู้ขับขี่ได้ดีกว่ารูปแบบเดิม

**คำสำคัญ:** อุบัติเหตุรถจักรยานยนต์, ชนทางด้านหน้า, บาดเจ็บ, ผู้ขับขี่

**Introduction**

Traffic injury becomes an important problem as it causes an impact on economic and public health system. In 2018, the problem resulted in ~210,000 injured individuals, 9,000 disables and 21,000 deaths that brought Thailand to the 9th globally highest number of traffic accidents[1]. Economic growth and population expansion leads to an increase number of vehicles; the updated number of licensed vehicles in Thailand until the end of November 2019 are ~40.6 million of which ~52.5% are motorcycles[2]. Within these numbers, vehicles in Bangkok are approximately 10.6 million comprising of ~30.6% motorcycles[2]. However licensed motorcycle drivers in Bangkok are only ~1.5 million, twice lower than that of the vehicles[2]. This is possible that the number may not include immigrant drivers from outside the capital city, so the real number of actively-using vehicles in Bangkok might outnumber the statistics. A crowd of vehicles results in a risk of accidents and is eventually one of major problems of the country. Approximate 1,500 deaths-by-traffic a year in Bangkok has been shown in the three-recent-year statistics (2016-18) whereby ~92.5% are caused by motorcycle accidents (MCAs)[1]. Interestingly, the hottest spot is located on the west bank of Bangkok, half size of the city, where medico-legal services are covered by Siriraj Hospital accounting for ~30% of the incidents[1].

Evans and Frick (1990) proposed the mathematical conjecture explaining a relative risk in traffic injuries that the risk tends to increase risk to the occupant of a lighter vehicle[3]. Therefore, an MCA should result in a higher morbidity or mortality than other types of vehicle when crashing

with the same force. It is supported by several previous studies showing that MCAs result in the most severe injuries and likely affect the drivers rather than the passengers[4-7]. However, those studies were underwent in the countries where road traffic deaths are lower than Thailand as well as no systematic research has been conducted in this country.

Besides those, one of the most important forensic issues is to identify who is the motorcycle driver because they fully involve in a legal prosecution. Shiono et al. (1990) observed two fatal frontal-collision MCA drivers with perineal-wound characteristic later coined the term "fuel-tank injury" which had been believed to be specific to identify the driver[8]. However, more observations have also revealed this characteristic is able to be found on the pillion passenger[9,10]. To address this issue, a broader survey is aimed in this study to clarify if the perineal injuries are useful to identify the MCA driver and if so, which characteristic is more specific and in what direction of impact this can be found.

**Material and Methods**

This study was conducted by retrospectively reviewing the autopsy data including case histories, autopsy reports and autopsy photographs of all traffic-accident cases which were performed in the Department of Forensic Medicine, Siriraj Hospital during January 2017 to October 2019.

Exclusion criteria are the cases of an unclear detail of accident, or occurring in a multiple-crash or run-over incident, or having a complex mechanism e.g. fall from height and drowning, or having the cause of death irrelevant to traffic accident.

The data was recorded focusing on demographic data including gender and age; a direction of collision; an activity of the victim i.e. being a driver, a passenger or a pedestrian; external and internal injuries of the following body regions – head, chest, abdomen and pelvis.

Analysis of descriptive statistics, chi-squared and Fisher-exact test, sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively) were carried out by SPSS v.20 and Microsoft Excel 2013 software.

**Results**

A total number of 1,266 cases autopsied at Siriraj Hospital during January 2017 to October 2019 were obtained whose causes of event primarily involved in a traffic accident. Of total, 851 cases (67.29%) died in the MCAs. However, 243 of those cases (28.55%) were excluded according to the criteria, so the final number included in the study is 608 cases (48.02% of total traffic-accident involvement) as described in **Table 1.**

**Table 1  Deaths involving in the MCAs during January 2017 to October 2019**

|  |  | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|---|
| **Inclusion** |  | 226 | 191 | 191 | **608** |
| **Exclusion** | Inadequate history | 16 | 66 | 5 | 87 |
|  | Multiple impact / run-over | 50 | 40 | 38 | 128 |
|  | Complex mechanism | 7 | 6 | 5 | 18 |
|  | Minor or no injury | 2 | 5 | 3 | 10 |
| **Total** |  | 301 | 308 | 242 | **851** |

Among the included MCA cases, 530 cases are males (87.71%) and 78 cases are females (12.83%) and the data of each year is statistically uniform as shown in **Table 2.**

**Table 2  Sex distribution in the fatal MCAs during January 2017 to October 2019**

|  | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|
| **Male** | 195 (86.28%) | 171 (89.53%) | 164 (85.86%) | **530 (87.17%)** |
| **Female** | 31 (13.72%) | 20 (10.47%) | 27 (14.14%) | **78 (12.83%)** |

*Chi-squared p-value = 0.50

Distribution curve of the age ranges is skewed right with the highest mode falling in the range of 21-30 YO as shown in Fig. 1. The data shows a uniform pattern in every selected year without statically difference as shown in **Table 3.**
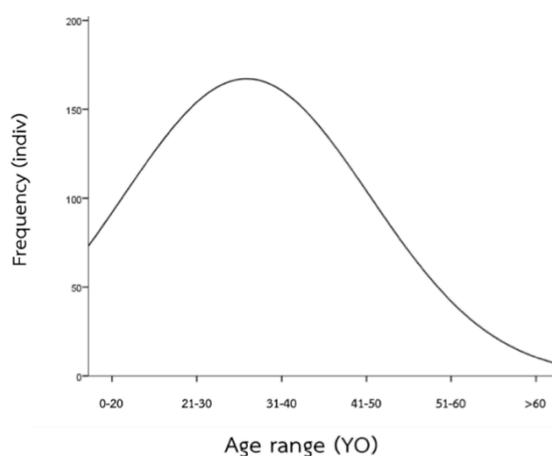


**Fig. 1 Distribution curve of total fatal MCAs** showing the largest area under curve at the age range of 21-30 YO

**Table 3   Distribution of age range in the fatal MCAs during January 2017 to October 2019**

| Age range (YO) | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|
| 0-20 | 65 (28.76%) | 55 (28.80%) | 38 (19.90%) | 158 (25.99%) |
| 21-30 | 72 (31.86%) | 60 (31.41%) | 67 (35.08%) | 199 (32.73%) |
| 31-40 | 35 (15.49%) | 30 (15.71%) | 34 (17.80%) | 99 (16.28%) |
| 41-50 | 26 (11.50%) | 21 (10.99%) | 24 (12.57%) | 71 (11.68%) |
| 51-60 | 19 (8.41%) | 14 (7.33%) | 17 (8.90%) | 50 (8.22%) |
| >60 | 9 (3.98%) | 11 (5.76%) | 11 (5.76%) | 31 (5.10%) |

*Chi-squared p-value = 0.80

The vast majority of the deceased which are drivers are also uniform between the years and present the total number of drivers as 548 (90.13%) against that of the passengers (60, 9.87%) as shown in **Table 4.**

**Table 4   Types of the fatal MCA occupants during January 2017 to October 2019**

| | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|
| Driver | 202 (89.38%) | 176 (92.15%) | 170 (89.01%) | 548 (90.13%) |
| Passenger | 24 (10.62%) | 15 (7.85%) | 21 (10.99%) | 60 (9.87%) |

*Chi-squared p-value = 0.53

Analysis of the directions, the number of frontal collisions are a bit ahead those of the other directions in aggregation showing of approximately 53.45 against 46.55% in total. The patterns of impact direction were statistical difference in the year 2018 in comparison with the others as shown in **Table 5.**

**Table 5   Direction of the MCA collision during January 2017 to October 2019**

| | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|
| Frontal | 119 (52.65%) | 117 (61.26%) | 89 (46.60%) | 325 (53.45%) |
| Other | 107 (47.35%) | 74 (38.74%) | 102 (53.40%) | 283 (46.55%) |

*Chi-squared p-value, overall = 0.02; pairwise: 2017 v 2018 = 0.08, 2017 v 2019 = 0.23, 2018 v 2019 < 0.01

To explore if external wounds could identify internal injuries, Table 6 presents a number of injuries in the MCA deceased bodies distributed on each body region in correlation with different directions of impact. Head injuries either on the external or internal site of the body obviously lead those on the other sites while the pelvic traumas are of the least number. Correlation between the external and internal injuries of each case in terms of clinical statistics, i.e. sensitivity, specificity, PPV and NPV, are analyzed and shown in **Table 7.**

**Table 6  Number of external and internal injury in relation with directions of impact**

| | | | Direction of impact | | |
|---|---|---|---|---|---|
| | | | **All** (608 cases) | **Frontal** (325 cases) | **Others** (283 cases) |
| **External injury** | Head | Anterior | 448 (73.68%) | 297 (76.62%) | 199 (70.32%) |
| | | Posterior | 274 (45.07%) | 123 (37.85%) | 151 (53.36%) |
| | | Both | 185 (30.43%) | 91 (28.00%) | 94 (33.22%) |
| | Chest | | 214 (35.20%) | 144 (44.31%) | 70 (24.73%) |
| | Abdomen | | 144 (23.68%) | 96 (29.54%) | 48 (16.96%) |
| | Pelvis | | 101 (16.61%) | 72 (22.15%) | 29 (10.25%) |
| **Internal injury** | Head | | 539 (88.65%) | 285 (87.69%) | 254 (89.75%) |
| | Chest | | 404 (66.45%) | 237 (72.92%) | 167 (59.01%) |
| | Abdomen | | 297 (48.85%) | 193 (59.38%) | 104 (36.75%) |
| | Pelvis | | 46 (7.57%) | 26 (8.00%) | 20 (7.07%) |

All = any direction of impact, Frontal = frontal collision, Others = the other non-frontal collisions

**Table 7  Relation between external and internal injuries in each part of the body**

| | | | Sensitivity (%) | | | Specificity (%) | | | PPV (%) | | | NPV (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All | Frontal | Others | All | Frontal | Others | All | Frontal | Others | All | Frontal | Others |
| **External injuries** | Head | Anterior | 75.88 | 80.00 | 71.26 | 43.48 | 47.50 | 37.93 | 91.29 | 91.57 | 90.95 | 18.75 | 25.00 | 13.10 |
| | | Posterior | 48.42 | 41.05 | 56.69 | 81.16 | 85.00 | 75.86 | 95.26 | 95.12 | 95.36 | 16.77 | 16.83 | 16.67 |
| | | Both | 79.64 | 75.86 | 83.81 | 74.29 | 84.21 | 62.50 | 95.14 | 96.70 | 93.62 | 36.62 | 36.36 | 37.04 |
| | Chest | | 45.84 | 52.79 | 35.98 | 84.83 | 77.17 | 90.76 | 85.05 | 85.42 | 84.29 | 45.43 | 39.23 | 50.70 |
| | Abdomen | | 35.69 | 39.90 | 27.88 | 87.78 | 85.61 | 89.39 | 73.61 | 80.21 | 60.42 | 58.84 | 49.34 | 68.09 |
| | Pelvis | | 54.84 | 58.97 | 45.83 | 87.73 | 82.87 | 93.05 | 33.66 | 31.94 | 37.93 | 94.48 | 93.68 | 94.88 |

All = any direction of impact, Frontal = frontal collision, Others = the other non-frontal collisions

Focusing on the injuries specifying a motorcycle driver, the results below in Fig. 2 show a number of cases who have fuel-tank and genital injuries in Venn diagrams. Genital injuries here are included any wound presented on the external genitalia of both sexes.
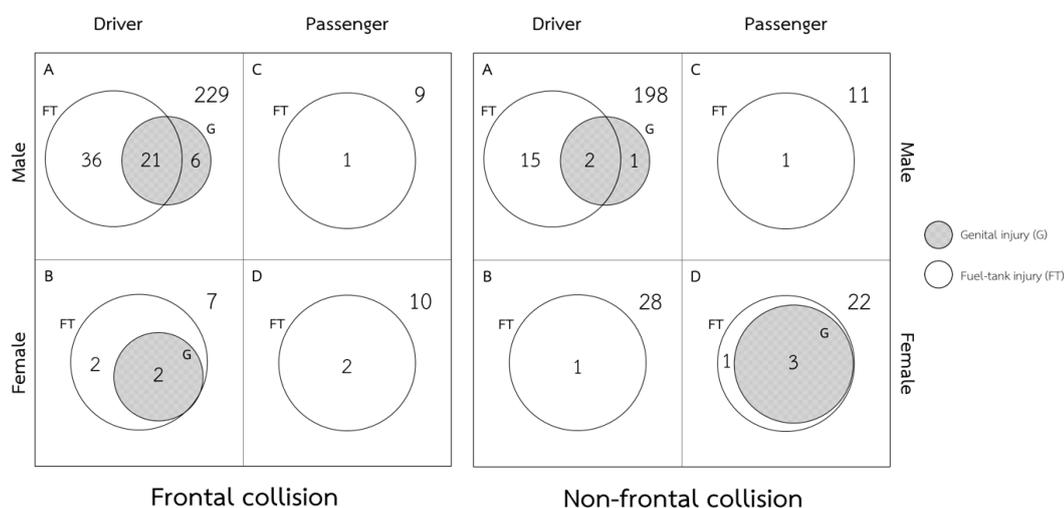
**Fig. 2 Venn diagram showing number of MCA victims suffered from fuel-tank and genital injuries.** Four blocks on the left represent the number of drivers (**A** and **B**) and passengers (**C** and **D**) in frontal-collision events separated by sex (**A** and **C** = male, **B** and **D** = female) and four blocks on the right are those of non-frontal collisions arranged in the same pattern. Numerals show the number of victims with fuel-tank **(FT)** and genital **(G)** injuries.

The fuel-tank injuries observed in this study is as typical as described by Shiono et al. (1990)[8] and they can be seen similarly in almost the cases who carry and in either drivers or passengers as well as in any direction of impact as shown in **Fig.3.**



**Fig.3   Fuel-tank injury.** Picture **A** is taken from one male driver and Picture **B** belongs to one female passenger.

Among the above number of passengers having fuel-tank injuries, it is to remark that the driver who died together with the male passenger in a frontal collision (block **C**) did not have a fuel-tank injury, in contrast, the other one died with the female passenger (block **D**) did contain the injury. Furthermore, some passengers with fuel-tank injuries contained superficial abrasions on their inner side of thighs as shown in **Fig.4.** However three female passengers in a non-frontal collision (block **D**) had severe genital injuries ranging from a large laceration to a blunt penetrating wound as shown in **Fig.5.**



**Fig.5 Varied patterns of genital injuries in female passengers of non-frontal collisions.** Picture **A** is a penetrating wound at groin; Picture **B** is a laceration on labia majora; and Picture **C** is a large avulsed laceration covering the whole area of genital organ with penetration into pelvic cavity.

In males, genital injuries are observed in the drivers involving in any direction of impact. Additionally, they may be seen alongside fuel-tank injuries as presented in **Fig.6.**
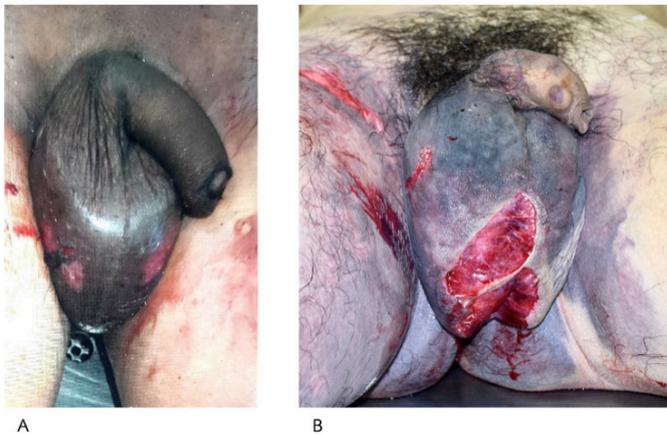


**Fig.6 Male genital injuries.** The wounds in Picture **A** is limited exclusively on scrotal sac without a fuel-tank injury while Picture **B** shows multiple wounds found on penis and scrotum and with fuel-tank injuries on thigh and groin.

**Discussion**

Despite preventability, the topmost unnatural deaths in Thailand is caused by traffic accidents[14]. Similar to another developing countries, motorcycles are the most popular mode of transportation[4] showing by a number of registered vehicles that a number of motorcycles is about half of the others except in Bangkok where they are comparable[2]. The higher uses, the higher accidents, not surprising, MCAs lead the other mode of traffic injuries and deaths[1]. As well, over half of the traffic deaths in this study support this fact.

Males share the highest number of death rate concordant with the sex rate of driving-license holders. This is also concordant with the death rate of which the driver ratio is higher. Both ratios are comparable to those found in developing countries[5,11] possibly reflecting the behavior of vehicle uses. However, there might be another contributing factor e.g. riding experience, types of motorcycle, road types, struck objects or vehicles, collision types, helmet uses, time of travelling, light condition, law enforcement and etc.[4,7,11,13].

The modal age-range is in a teenage to adult age (>15 to 35 YO) similar to many studies[4,11,13]. The pattern in each year of study shows no significant difference as similar as the sex distribution and the occupant ratio that is probably conformable to a population behavior.

The three-year data reveals the major direction of MCA impact which is frontal. This direction is consistent with what found in Iran[13] but opposed to that in Malaysia[11]. The prevalence of crash directions might not best explain a fatality risk but probably associated with a cause of accident.

In a clinical context, it is interesting to interrogate if external wounds are able to clue internal injuries which require an emergency intervention and reflect a severity of event. Head injuries, prevalent the most among others, reveal that wounds on the posterior side are most associated with internal injuries, with the highest PPV, followed by wounds on the chest, abdomen and pelvis, respectively.

However, the results also indicate that no external wounds in any body region does not rule out an internal injury.

As mentioned in the previous studies[8], fuel-tank injuries seem to be an outstanding sign to identify whether the dead body is a motorcycle driver however the number of observed injuries are too low. Moreover, some studies have reported that the fuel-tank injuries are not as specific as previously believed[9,12], additionally, another sign which is the injury on scrotal region has been suggested[9,12]. Here, it is found that a fuel-tank injury can occur in whatever the occupant is, either a driver or a passenger, and in any circumstance, a frontal or non-frontal collision. By focusing only genital injuries, these kinds of wound can be observed in both sexes, however, none is found on the passengers of frontal collisions. Thus, it is not incorrect to say that, to date, wounds on the external genitalia are very useful and probably specific to identify who is the driver in a frontal-collision MCA, especially in a male driver.

## Conclusion

Though this study was conducted by using the data in a part of Bangkok, a large urban region, the results could be applied to another part of the country because the population here migrating from various regions might somewhat reflect a similar behavior. Other contributing factors should be taken into account for any in-depth study of traffic fatalities as different places might have different environments. However, by looking at external wounds in a severe MCA patient or either a deceased body, the analytic results in this study may more or less help identify a probability of internal injury. To determine which one of the MCA victims in a frontal collision is a driver, it is suggested that searching for a genital injury in associated with other information including a thorough scene investigation might be very useful and be careful to judge by using a fuel-tank injury alone.

## Acknowledgement

## Ethical statement

This project was granted the ethical approval by the Institutional Review Board (IRB) of the Faculty of Medicine Siriraj Hospital number Si 280/2020

## Conflicts of interest

None

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