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Original Article

The Impact and Outcome of Elderly Drivers Involved in Road Traffic Accidents: Experience in Hsinchu Regional Hospital

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SUMMARY

Background: This study investigated the injury severity and mortality due to road traffic accidents in an elderly population in Hsinchu city.
Methods: Retrospective data from January 1, 2009 to December 31, 2018, of elderly patients sent to the emergency department due to road traffic accidents were analyzed. Statistical analyses of the injury severity, complications, hospital stay (ward and intensive care unit), and mode of transport (bicycle or motorcycle or car), were compared to evaluate the risk of injury in elderly groups.
Results: A total of 563 elderly drivers who were admitted to hospital were classified as young ($65 \leq age < 75$, N = 340), old ($75 \leq age < 85$, N = 187) and oldest ($age \geq 85$, N = 36) elderly. Most were transported to the emergency department between 8 a.m. to 4 p.m. by the Emergency Medical Service, tested negative for blood alcohol, and predominantly male and motorcyclists. The young elderly had significantly higher rates of injuries to the face, while all groups had more extremity and head injuries. There was no statistical difference in the Injury Severity Score (ISS), New Injury Severity Score (NISS), and Trauma Injury Severity Score (TRISS) between groups, but there were higher admission and mortality rates in the old elderly group.
Conclusion: Most road traffic accidents in the elderly groups involved male and motorcyclists, leading to hospitalization with extremities and head injuries. Age-related mortality was still higher in the old elderly, that the safety of old elderly drivers remains a problem in Hsinchu city.

1. Introduction

Road traffic accidents (RTAs) cause mortality and injuries in all age groups. One of the most important age groups in this regard is old people. A study showed that there was no significant difference in the mortality rate, emergency department (ED) stay time, and hospital stay time between elderly and young groups, with the lower Injury Severity Score (ISS) predicting a higher mortality in the elderly group. A review showed higher mortality rates in older adults admitted to trauma centers and higher odds of mortality in the very elderly adults (aged > 75 years). A cross sectional study revealed that the frequency of deaths in elderly people due to traffic accidents was decreased in suburban roads and increased in urban roads; mortality rate in old and old-old age groups were increased and in young-old group was decreased.[1–4]

Elderly drivers in Hsinchu city more depended on two-wheeled vehicles and cars for transport due to the poor mass transit system. However, the aging physical functions of the elderly, such as hearing and balance may affect their traffic safety. Therefore, this study was designed to explore the associated injury (type, severity, hospitalization) in RTA between different age groups and whether the risk of driving increases with age in elderly drivers.

2. Materials and methods

2.1. Ethics statement

The study was pre-approved by the Mackay Memorial Hospital Institutional Review Board (approval number 19MMHIS280e). No subject consent was required under IRB regulations.

2.2. Study design

2.2.1. Data

In this retrospective study, all data were collected from Hsinchu Mackay Memorial Hospital between January 1, 2009, and December 31, 2018, with middling first-aid capability. Cases involving hospitalization of the elderly due to RTA were classified into age groups: young ($65 \leq age < 75$), old ($75 \leq age < 85$) and oldest elderly ($age \geq 85$). A total of 2450 cases of elderly drivers involved in RTAs were identified, of which 563 patients were hospitalized and 340 (60.39%) were classified as young elderly, 187 (18.53%) were old elderly, and 36 (12.6%) were oldest elderly (Figure 1).

2.2.2. Study variables

Detailed patient data were collected including age, gender, ar-

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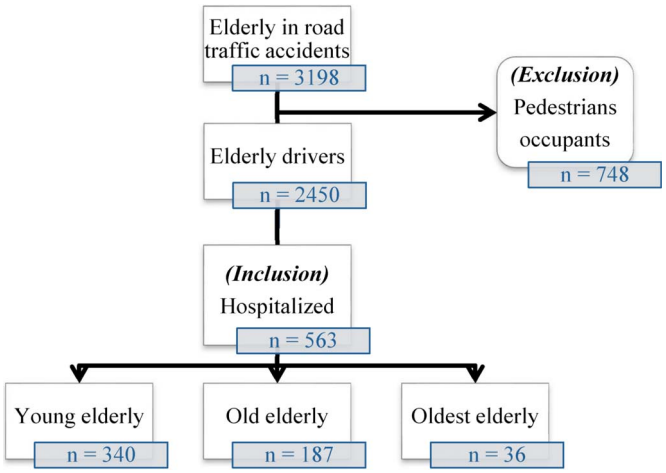

Figure 1. Flow diagram of the study.

rival time, method of transportation, collision manner, vital signs at ED triage. Other information collected included the immediate Glasgow Coma Scale (GCS) assessment at ED triage, Abbreviated Injury Scale (AIS) for each body region, the Injury Severity Score (ISS), New Injury Severity Score (NISS), Trauma Injury Severity Score (TRISS), days of hospital and intensive care unit (ICU), mortality, associated complications. The ISS data was stratified to compare differences in injury severity using clinical cutoffs: ≥ 16 for severe and ≥ 25 for critical injuries. The injury severity measured by various scoring systems (GCS, AIS, ISS, NISS, and TRISS) was the primary outcome, with associated complications, hospital and ICU stay and mortality as secondary outcomes.

2.3. Statistical analysis

The data were analyzed using SPSS 23.0 statistical software (IBM, Armonk, NY). Significance between three groups was calculated by one-way ANOVA for continuous variables and the Chi-square test for discrete variables. The results are presented as the mean ± standard deviation and considered statistically significant if the p-value < 0.05. Multinomial logistic regression analyses were used to identify the significant predictor variables of the ISS. When the 95 % confidence intervals of its odds ratios (OR) does not include 1, it means that it is statistically significant (p < 0.05).

3. Results

In Figure 1, 2450 elderly patients involved in RTAs were identified. The data for 563 patients admitted were analyzed in this study, 340 young elderly, 187 old elderly, 36 oldest elderly (Table 1). The most common form of transport was the motorcycle, with most RTAs in all groups involving men. Most patients were transported to ED between 8 a.m. to 4 p.m. by the Emergency Medical Services due to a motorcycle injury. There were no significant differences in GCS between the three groups, the common distribution of GCS scores was 13–15 (Table 2). The analysis of the AIS revealed significantly

Table 1
Demographics of hospitalized elderly due to trauma.

Variable	65 ≤ age < 75 (n = 340)	75 ≤ age < 85 (n = 187)	Age ≥ 85 (n = 36)	p value
	n (%) / mean (SD)	n (%) / mean (SD)	n (%) / mean (SD)	
Gender				< 0.00
Male	174 (51.18%)	150 (80.21%)	34 (94.44%)	
Female	166 (48.82%)	37 (19.79%)	2 (5.56%)	
Time				0.32
08:00–16:00	199 (58.53%)	126 (67.38%)	22 (61.11%)	
16:00–00:00	110 (32.35%)	46 (24.6%)	12 (33.33%)	
00:00–08:00	31 (9.12%)	15 (8.02%)	2 (5.56%)	
Transportation				0.06
EMS	195 (57.52%)	119 (64.32%)	29 (80.56%)	
Private	88 (25.96%)	39 (21.08%)	3 (8.33%)	
Transfer	56 (16.52%)	27 (14.59%)	4 (11.11%)	
Mechanism				0.69
Bicycle	16 (4.71%)	12 (6.42%)	3 (8.33%)	
Motorcycle	308 (90.59%)	168 (89.84%)	31 (86.11%)	
Car	16 (4.71%)	7 (3.74%)	2 (5.56%)	

Table 2
Injury severity and mortality of traumatic hospitalized elderly.

Variable	65 ≤ age < 75 (n = 340)	75 ≤ age < 85 (n = 187)	Age ≥ 85 (n = 36)	p value
	n (%) / mean (SD)	n (%) / mean (SD)	n (%) / mean (SD)	
GCS				0.05
< 8	8 (2.35%)	12 (6.42%)	3 (8.33%)	
9–12	5 (1.47%)	4 (2.14%)	1 (2.78%)	
13–15	327 (96.18%)	171 (91.44%)	32 (88.89%)	
AIS				
Head/neck	125 (36.76%)	62 (33.16%)	13 (36.11%)	0.70
Face	74 (21.76%)	24 (12.83%)	5 (13.89%)	0.03
Chest	111 (32.65%)	64 (34.22%)	9 (25%)	0.55
Abdomen	16 (4.71%)	12 (6.42%)	2 (5.56%)	0.67
Extremities	264 (77.65%)	140 (74.87%)	28 (77.78%)	0.76
ISS				0.08
< 16	267 (78.53%)	127 (67.91%)	26 (72.22%)	
16–24	56 (16.47%)	50 (26.74%)	8 (22.22%)	
≥ 25	17 (5%)	10 (5.35%)	2 (5.56%)	
NISS	10.42 (7.09)	11.74 (7.07)	11.22 (7.03)	0.11
TRISS	0.94 (0.11)	0.92 (0.16)	0.92 (0.17)	0.22
Hospitalization (day)	5.9 (6.61)	6.97 (8.92)	5.94 (4.79)	0.27
ICU (day)	0.61 (4.27)	1.18 (7.37)	0.89 (4.25)	0.52

higher injury rates to the extremities in all groups, with the young elderly experiencing more facial injuries. Most patients had an ISS less than 16, and with no significant difference between the three groups regarding NISS, TRISS, and days of hospitalization or in ICU.

The injury types are shown in Table 3, with all elderly drivers having a higher rate of extremity fracture, and the old and oldest elderly had more femoral fracture than the young elderly. There was no significant difference in the injuries to the head, face, chest, and abdomen injury between elderly groups, but there was a higher percentage of subdural hemorrhage (SDH), and subarachnoid hemorrhage (SAH) in head injury; rib fracture with hemothorax in the chest injury, as well as tibia/fibula/femoral fractures in the extremity injuries.

The old elderly group had a higher hospital rate and ICU rate, with the mortality rate increasing with age and the oldest groups having the highest ICU mortality rate (Table 4). Motorcycle related RTA was the leading cause of admission to ward and ICU in elderly. After stratifying admission stay, elderly patients spend 3–7 days on a ward, and < 3 days in ICU, with the highest mortality occurring in the first three days, especially for the old elderly group.

Regarding factors that influenced ISS, the old elderly and patient with a head or chest injury had a higher rate in $16 \leq ISS < 24$ (OR = 2.680, 18.521, 4.373) when compared to ISS < 16; patients with head or chest or abdomen injury tended to be more serious with ISS ≥ 25 (OR = 122.618, 12.523, 6.331) when compared to $16 \leq ISS < 24$ (Table 5).

Table 3
Associated injuries of traumatic hospitalized elderly.

Variable	65 ≤ age < 75 (n = 340)	75 ≤ age < 85 (n = 187)	Age ≥ 85 (n = 36)	p value
	n (%)	n (%)	n (%)	
Head/neck				
Concussion	11 (3.24%)	2 (1.07%)	1 (2.78%)	0.23
SCI	14 (4.12%)	5 (2.67%)	0 (0%)	0.34
C-spine fx	4 (1.18%)	2 (1.07%)	0 (0%)	0.99
Skull fx	9 (2.65%)	5 (2.67%)	3 (8.33%)	0.15
SAH	41 (12.06%)	24 (12.83%)	7 (19.44%)	0.45
ICH	19 (5.59%)	9 (4.81%)	1 (2.78%)	0.74
SDH	35 (10.29%)	29 (15.51%)	5 (13.89%)	0.20
Face				
Ortibal fx	5 (1.47%)	2 (1.07%)	1 (2.78%)	0.57
Nasal fx	2 (0.59%)	1 (0.53%)	0 (0%)	
Zygoma fx	10 (2.94%)	6 (3.21%)	1 (2.78%)	0.982
Maxillary fx	10 (2.94%)	3 (1.6%)	2 (5.56%)	0.260
Mandible fx	3 (0.88%)	0 (0%)	0 (0%)	0.636
Chest				
Rib fx	91 (26.76%)	49 (26.2%)	9 (25%)	0.969
Hemothorax	18 (5.29%)	18 (9.63%)	4 (11.11%)	0.113
Pneumothorax	5 (1.47%)	4 (2.14%)	0 (0%)	0.850
Hemopneumothorax	3 (0.88%)	1 (0.53%)	0 (0%)	0.999
Abdomen				
Hepatic injury	2 (0.59%)	1 (0.53%)	0 (0%)	0.999
Spleen injury	3 (0.88%)	1 (0.53%)	0 (0%)	0.999
Renal injury	2 (0.59%)	3 (1.6%)	0 (0%)	0.535
Intestine injury	1 (0.29%)	2 (1.07%)	0 (0%)	0.416
L-spine fx	5 (1.47%)	4 (2.14%)	1 (2.78%)	0.480
Extremities				
Clavical fx	36 (10.59%)	18 (9.63%)	2 (5.56%)	0.621
Scapula fx	3 (0.88%)	3 (1.6%)	0 (0%)	0.779
Humeral fx	21 (6.18%)	13 (6.95%)	0 (0%)	0.273
Radial fx	31 (9.12%)	11 (5.88%)	1 (2.78%)	0.215
Ulnar fx	20 (5.88%)	7 (3.74%)	1 (2.78%)	0.458
Metacarpal fx	6 (1.76%)	4 (2.14%)	0 (0%)	0.871
Pelvic fx	11 (3.24%)	6 (3.21%)	0 (0%)	0.549
Femur fx	45 (13.24%)	38 (20.32%)	8 (22.22%)	0.064
Tibial fx	44 (12.94%)	19 (10.16%)	5 (13.89%)	0.607
Fibula fx	41 (12.06%)	17 (9.09%)	4 (11.11%)	0.581
Calcaneous fx	3 (0.88%)	5 (2.67%)	1 (2.78%)	0.196
Metatarsal fx	8 (2.35%)	1 (0.53%)	1 (2.78%)	0.210

4. Discussion

4.1. Age-related severity and mortality

RTA are a significant cause of mortality in the elderly population, not only owing to age factors, but also relating to decreasing physical functions, and the insufficient ability for systemic compensation. A study showed the most significant injury regions were the head and neck, extremities, and thorax. A review article, reported that for motor vehicle collisions in older adults between 60 and 74 years, the majority were male and involved minor trauma. The overall mortality rate was 14%, 15% in North America and 17% in trauma centers, with old elderly adults (aged > 75 years) and pedestrians having higher rates of mortality.[5–8] In our study, the stratified groups of elderly patients involved in RTAs were predominantly male and motorcyclists. Mostly they were sent to ED by EMS, with GCS of 13–15 on arriving ED. The ISS ranged from 16 points to 25 points. The admission, mortality rates of the ward and ICU were higher in the old and oldest groups. Most admitted patients stayed in hospital for 3–7 days, while mortality was highest within the first three days from central or circulation failure; for prolonged admission (> 28 days), the most cause of mortality was respiratory failure. In this study, there were more in-hospital-cardiac-arrest (IHCA) and out-of-hospital-cardiac-arrest (OHCA) patients in the old elderly groups. Taken together, these results suggest that age has an important impact on elderly drivers involved in RTA.

4.2. Injury characteristics

RTAs involving two-wheeled vehicles (including motorcycles and bicycles) are a serious problem in Taiwan due to their severity. Indeed, motorcycle related RTA contributed to the most traffic deaths in Taiwan. However, helmets were made mandatory for motorcyclists in 1997, leading to a significant decrease in fatalities and head injuries. The current study showed that elderly and female motorcyclists and bicyclists resulted in greater hospitalization. Head and extremity injuries accounted for most injuries to pedestrians and cyclists whereas chest injuries were more common in car accidents.[9–12] In this study, the hospitalization and mortality rate were significantly higher in motorcycle accidents than bicycle and car. Motorcycles are not as safe and suitable for the elderly as bicycles or cars as they are faster and offer less protection, which caused the most face, chest, abdominal and extremity injury.

4.3. Head injuries

Studies have shown that head injuries are the leading cause of hospitalization and deaths among bicyclists and motorcyclists. The overall incidence of head injury was 29.9 % in the young population increasing to 38.6% in the elderly. Furthermore, intracranial injuries differed significantly between the various age groups. Although the incidence of epidural hematomas was similar in all age groups, the incidence of subdural hematoma and SAH increased with age. The bicyclists had significantly more extremity injuries, while motorcyclists had more head, neck, face, and thoracic injury. A review article reported that car and motorcycle accidents were more frequent in countries with a higher mortality, while bicycle-related accidents

Table 4
Mortality of hospitalized elderly.

Variable	65 ≤ age < 75 (n = 1594)	75 ≤ age < 85 (n = 705)	Age ≥ 85 (n = 151)	p value
	n (%) / mean (SD)	n (%) / mean (SD)	n (%) / mean (SD)	
Admission cases	340 (21.33%)	187 (26.52%)	36 (23.84%)	0.02
Bicycle	16 (1.0%)	12 (1.70%)	3 (1.99%)	
Motorcycle	308 (19.32%)	168 (23.83%)	31 (20.53%)	
Car	16 (1.0%)	7 (0.99%)	2 (1.32%)	
Admission date				0.07
< 3 d	72 (4.52%)	47 (6.67%)	8 (5.30%)	
3–7 d	173 (10.85%)	71 (10.07%)	12 (1.70%)	
8–14 d	73 (4.52%)	51 (7.23%)	14 (1.99%)	
15–30 d	18 (1.13%)	13 (1.84%)	2 (1.32%)	
> 30 d	4 (11.76%)	5 (0.71%)	0 (0%)	
Mortality cases	8 (0.25%)	9 (1.28%)	2 (1.32%)	0.15
< 3 d	6 (0.38%)	8 (1.13%)	1 (0.66%)	
3–7 d	1 (0.06%)	0 (0%)	0 (0%)	
8–14 d	0 (0%)	0 (0%)	0 (0%)	
15–30 d	1 (0.06%)	0 (0%)	1 (0.66%)	
> 30 d	0 (0%)	1 (0.14%)	0 (0%)	
Cardiac arrest cases				0.24
OHCA	2 (0.13%)	6 (0.85%)	1 (0.66%)	
IHCA	6 (0.38%)	3 (0.43%)	1 (0.66%)	
ICU cases	31 (1.94%)	19 (2.69%)	3 (1.98%)	0.53
Bicycle	0 (0%)	1 (0.14%)	2 (1.32%)	
Motorcycle	28 (1.76%)	16 (2.27%)	1 (0.66%)	
Car	3 (0.19%)	2 (0.28%)	0 (0%)	
ICU mortality case	5 (0.31%)	3 (0.43%)	2 (1.32%)	0.37
< 3 d	3 (0.19%)	2 (0.28%)	1 (0.66%)	
3–7 d	1 (0.38%)	0 (0%)	0 (0%)	
8–14 d	0 (0%)	0 (0%)	0 (0%)	
15–30 d	1 (0.06%)	0 (0%)	1 (0.66%)	
> 30 d	0 (0%)	1 (0.14%)	0 (0%)	
ICU days				0.70
< 3 d	16 (1.0%)	8 (1.13%)	1 (0.66%)	
3–7 d	7 (0.44%))	3 (0.43%)	1 (0.66%)	
8–14 d	5 (0.31%)	4 (0.57%)	0 (0%)	
15–30 d	2 (0.13%)	2 (0.28%)	1 (0.66%)	
> 30 d	1 (0.06%)	2 (0.28%)	0 (0%)	

Table 5
The variables affecting the severity of ISS.

Variable	16 ≤ ISS < 24 vs. ISS < 16		ISS ≥ 25 vs. ISS < 16	
	OR	p value	OR	p value
Age (75 ≤ age < 85 vs. 65 ≤ age < 75)	2.68	< 0.00	2.26	0.10
Age (Age ≥ 85 vs. 65 ≤ age < 75)	1.86	0.24	2.00	0.44
AIS				
Head/neck (Yes vs. No)	18.52	< 0.00	122.61	< 0.00
Face (Yes vs. No)	0.85	0.62	0.85	0.75
Chest (Yes vs. No)	4.37	< 0.00	12.52	< 0.00
Abdomen (Yes vs. No)	1.34	0.58	6.33	0.00
Extrimites (Yes vs. No)	0.59	0.05	0.89	0.81

were more common in countries with a lower mortality rate. In the elderly, the most damaged parts of the body are the head and neck (32.1%) lower limbs (29.4%) and upper limbs (19.7%).[13,14] In this study, the elderly patients tended to have a head injury (36.76% vs. 33.16% vs. 36.11%) secondary to extremity injury (77.65% vs. 74.87% vs. 77.78%), with SAH and SDH being the main head injury despite the wearing of helmets being mandatory.

4.4. Chest and abdominal injury

Seat belt reduce the morbidity and mortality in the car accidents but increase chest injuries in the elderly. Chest injuries are common in motor vehicle accident victims, abdominal and spinal cord injuries are more common in car victims and pelvic injuries are more frequent in elderly pedestrians.[10] Chest injury is the second cause of mortality in elderly drivers involved in an RTA[15] In this study, chest injury was the third most injury in the three elderly groups, with multiple rib fractures being the most common injury. When stratified to injury type, the old and oldest elderly tend to have hemothorax leading to more serious hypovolemic shock, whereas abdominal injurys were less common. Vertebral compression fracture was more common in old elderly, and mild increasing spleen/renal/intestine injury in young elderly. Both chest and abdominal injuries caused more serious damage and hypovolemic shock in elderly patients, thereby increasing the mortality rate and admission/ICU stay.

4.5. Morbidity and mortality related to the ISS

Elderly people have pre-existing chronic medical problems and lack of physical reserves, but some studies consider injuries to the elderly as similar to other adult trauma. Elderly people are less likely to be injured than younger people but more likely to have fatal outcomes. ISS is probably the most widely correlated to geriatric trauma outcomes, with trauma patients with an ISS > 20 most likely to die, especially if they are > 75 years old.[16] In our study, we found a lower mortality rate of the elderly patients 0.25% vs. 1.38% vs. 1.25%, that lesser medical disease, lower driving speed and less alcohol consumption could be the causes of lower mortality rate than literature. There were no statistical significance of NISS, TRISS between three groups. However, the old elderly group and patient with head and chest injury had higher trend of ISS score with $16 \leq$ ISS < 24 (OR = 2.68, 18.52, 4.37), was in concern with higher mortality rate in ward and ICU of the old elderly. Thus, we suggest that ISS is still the appropriate evaluation tool for the prediction of old elderly RTA outcome.

5. Limitations

The study used retrospective design, hence there was a lack of comprehensive data about injury mechanisms and circumstances, driving speed, helmet-wearing, alcohol consumption (blood level), the accident location (highway or road). Injured patients who were declared dead at the scene of the accident or who were discharged from the ED to other hospital were not included in the study, which may have induced a survival bias.

6. Conclusion

Motorcycles are the most common mode of transport for the elderly in the Hsinchu city, causing hospitalization. Injuries to the extremities were the leading cause of morbidity in elderly RTA, and despite helmet wearing being mandatory, head injury was still the second common cause of morbidity in elderly, resulting in SAH/SDH and mortality during the first three days, chest injuries as the third common cause induced serious damage in elderly patients. Age-related mortality was higher in the old and oldest groups, the safety of old elderly drivers remains a problem a Hsinchu city. Thus, we though it is urgent to establish a policy like health examination, annual driving test, and proper road design to help the elderly drive more safely.

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