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Forensic investigation in a multiple trauma deceleration case due to road traffic accidents



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ABSTRACT

Background: Road traffic accidents (RTA) are the series of events from road events that are unexpected, and always cause damage to objects, injury and even death. Factors for the occurrence of RTA can be in the form of vehicle, road and human. In this case RTA occurred because of human negligence and road factors. The human factor in the form of the driver driving a vehicle at high speed with an estimated 160 Km/h at night, the other factor is the driver is sleepy or tired. Road factors contribute to the occurrence of accidents due to wide and declining road segments cause the driver unable to control vehicles at high speed, quiet roads and inadequate street lighting conditions. This accident resulted in a heavy damage to the vehicle and all passengers died. The explanation of the causes and patterns of death is important in forensic investigations of RTA victims.

Case description: A case of RTA with multiple deceleration injuries was reported. This traffic accident case involved a minibus car

speeding and crashing into a bulk cement tank truck that was stopped on the Banda Aceh-Meulaboh National Road, on 30 October 2016 around 04.15 a.m which caused all passengers of minibus died. The speeding minibus car suddenly stopped and hit the back of the tank truck, as a result the body moving at the speed of the vehicle suddenly slowed down (deceleration) causing multiple trauma. The effects on the bodies of the victims varied in the form of open head trauma, closed head trauma, chest trauma, abdomen and extremities. The mechanism and cause of death of the victims was massive bleeding in several organs, especially the head (traumatic brain injury) and chest (rib fracture).

Conclusion: Forensic investigations are very useful in determining the cause of death, mechanism of death, manner of death, magnitude of the impact, direction, speed, and nature of the traffic accident.

Keywords: Forensic investigations, traffic accidents, multiple trauma, deceleration.

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INTRODUCTION

Road traffic accidents (RTA) are the leading cause of death in the world. According to the data from Basic Health Research Ministry of Health Republic of Indonesia shows that in 2013 in Indonesia there were 99,951 victims of traffic accidents with 18.46% of them (18,448 victims) died. Head injuries (33.2%) is the first rank injuries suffered by victims which the cause of death due to road traffic accidents.¹ RTA is the eighth leading cause of death for young people aged 15 to 29 years and is responsible for more than 1.2 million deaths in the world, while the number of people injured as a result of RTA can reach 50 million which means 3.6% of all global deaths.² Recent studies have shown an increase in the number of road traffic accidents in many developing and developed countries. This has something to do with urbanization, industrialization, and transportation technology as well as an increase in the number of motorized vehicles from year to year.³

Several factors that influence the occurrence of traffic accidents can be divided into: a) Direct factors that contribute to individual accidents include: human factors in the form of road user behavior, as well as the ability and attitude of

drivers, road factors in the form of traffic engineering, road conditions and environmental influences, b) Indirect factors that contribute to the total population and accident rate in the country include demographics (population structure and distribution), and population and vehicle characteristics (number, type, usage and load).²

Injuries suffered by RTA victims can be divided into primary and secondary injuries. Primary injury is an injury caused by direct contact with a vehicle or object close to the victim such as a dashboard, steering wheel or chair. Primary injury to pedestrians can be seen on the back of the head or calf, which is if there is a fracture on the calf is called bumper fracture. Secondary injuries to pedestrians are generally the result of being thrown from a vehicle and due to a collision with the ground. Primary injury to the driver and passenger arises if the vehicle collides with a vehicle or a structure located on the side of the road that causes a part of the vehicle hit the victim's body, and secondary injury if the vehicle is reversed and if the victim is thrown from the vehicle.⁴

The most frequently injured body regions in a row are the head, thorax, abdomen and extremities.

From the results of identification in 70 cases that caused death, the cause of death was caused by: pure thoracic trauma (30% of individuals), pure head trauma (23% of individuals) or a combination of two regions (18% of individuals). Cerebral injury can be caused by a head that moves freely and without protection. Movement that is free from the head causes a greater likelihood of having contact with various surfaces of objects in the vehicle such as, glass, dashboard, seats, steering wheel, chassis, and other parts.⁵

CASE REPORT

A reported traffic accident case involving a minibus passenger car with a bulk cement tank truck that occurred in the Banda Aceh-Meulaboh National Road, Km 15.5, Gampong Mon Ikeun, Lhoknga District, Aceh Besar, on 30 October 2016 around 04.15 local time. In this accident there were seven victims died and one person was seriously injured, for six people died were carried out forensic examinations, while the other one was immediately taken by the family. The process of identification and external examination of the dead bodies was carried out at the Forensic Medicine Installation of the Zainoel Abidin General Hospital in Banda Aceh.

According to information from the head of the Aceh Besar police department, the chronology of the RTA is estimated to have started when a minibus drove fastly from Meulaboh towards Banda Aceh. Once arrived at the scene, the minibus drove to the right lane, where there was a bulk cement tank truck parked and a deadly accident was inevitable. The minibus crashed into the back of the truck, causing the front of the minibus fall apart. From monitoring on location and photographs circulating on social media, the speed of the minibus when the incident reached 160 km/hour.

In this case, the victims were taken to the hospital delivered by police officers with a letter request for post mortem examination and submitted to a

forensic medical expert to be made visum et repertum. The results of the post mortem examination from all victims are as follows:

- a. Victim 1: Driver, a man, the initials is MK, 22 years old, body height of 175 centimetres. From the results of physical examination found: Open wounds on the head, eyebrows, right chest, right abdomen, front right thighs, back right thighs, right heels, back left thighs and left scrub. Extensive blisters on the left forehead, face, right arm, left arm, right abdomen, and left calf. Bruises on the abdomen around the center, right abdomen, inner left calf. Broken ribs in the right chest.
- b. Victim 2: Passenger, a man, the MK is MK, 61 years old, body height of 154 centimeters. From the results of physical examination found: Open wounds on the right face, left face, right forehead and right on the axis of the body, nose, lower lip, upper jaw, left wrist back and back of the left leg. Open fracture of the frontal bone, visible brain tissue out. Both eyeballs pushed back. Part of the crushed face is pushed back.
- c. Victim 3: Passenger, a man, the initials are RA, 33 years old, body height of 178 centimetres. From the results of physical examination found: Open wounds on the chin, left wrist, and right calf, Many abrasions on the face, forehead, neck, chest, abdomen, right thigh, right calf, and right instep. A bruise on the lower right arm. Broken ribs on the right chest.
- d. Victim 4: Passenger, a man with the initials RI, 18 years old, body height of 160 centimetres. From the results of physical examination found: Active bleeding from the nose and mouth. Bruises on both lips. The surface of the right chest is higher than the left chest. Broken ribs 3,4,5 middle of the left chest.
- e. Victim 5: Passenger, a man, the initial is EM, 43-year-old, body height of 166 centimetres. From the results of physical examination found: Open wound on the right face, lower lip and neck. Bruises on the left chest, and right thigh.
- f. Victim 6: Passenger, a man. The initial is MA, 40-year-old, body height of 165 centimetres. From the results of physical examination found: Open wound on the left forehead, left ear, left elbow, left wrist, inside, left wrist outside, right lower leg and right ankle. Bruises on the left eye, left lower lip, left neck, left chest and right thigh.



Figure 1 Crash injury in the victim no.2 and after reconstruction

Table 1 Fatal injury and cause of death of the victims

Victims	Position	Fatal Injury	Mechanism and cause of death
1.	Driver	Open wounds on the head, broken ribs in the right chest, the intestine spits twenty-three centimetres in the right abdomen	Massive bleeding due to blunt force on the head, chest and abdomen
2.	Passenger	Open fracture of the frontalis bone, visible brain tissue out, both eyeballs pushed back, part of the crushed face is pushed back	Massive bleeding due to blunt force on the head
3.	Passenger	Open wounds on the chin, many abrasions on the face, broken ribs on the right chest	Massive bleeding due to blunt force on the head, and broken ribs on the right chest
4.	Passenger	Active bleeding from the nose and mouth, broken ribs 3,4,5 middle of the left chest	Massive bleeding due to blunt force on the head, and broken ribs on the left chest
5.	Passenger	Open wound on the right face, lower lip and neck	Mass bleeding due to blunt force on the head.
6.	Passenger	Open wound on the left forehead, bruises on the left eye	Mass bleeding due to blunt force on the head.

DISCUSSION

Definition of RTA

According to Indonesian Law No.22 of 2009, in chapter I regarding general provisions, article 1 paragraph 24, a RTA is an unexpected and unintentional road event involving a vehicle with or without another road user that results in human casualties and/or property loss. Chapter VII Article 47 states that the scope of types and functions of vehicles in this law include: motorized and non-motorized vehicles. Motorized vehicles include passenger cars, bus cars, freight cars, and special vehicles. Non-motorized vehicles include vehicles that are driven by other people’s energy and vehicles that are driven by animal power. In addition, Article 229 states that an RTA is classified as: a minor accident is an accident that results in damage to vehicles and / or goods; a medium accident is an accident that causes minor injuries and damage to vehicles and/or goods; or serious accident is an accident that results in death or serious injury. Traffic accidents as referred to may be caused by negligence of road users, vehicle infringement, and road and/or environmental infringement.⁶

Risk factors of RTA

Understanding of risk factors is very important in identifying the exact cause of an accident. The causes of traffic accidents can be related to human factors, road factors, environmental factors and vehicle factors. The human factor is triggered directly by human behaviour while around the road. Risk factors from drivers who are connected to the direct causes of accidents such as fatigue, improper overtaking, neglect, inexperience, and illness experienced.⁷

In this case the driver seems tired and sleepy, so he cannot control his car at high speed and crashes into a truck that is stopping as a result the car stops

suddenly. Exposure to deceleration forces lasting longer than 0.2 seconds can cause fluid transfer or tissue deformation. This causes a decrease in blood pressure, an increase in pulse rate, weakness, and pale skin. Injuries that occur in slowing can range from shock, concussion, blisters, sprains, skin tears, and rupture of internal organs to fractures, breathing and blood circulation, bleeding, and organ damage.⁸

Deceleration injuries

A slowdown injury is caused by the force applied when a fast-moving object stops or decelerated suddenly. Deceleration injuries can occur in high-speed vehicles which then stop or slow down suddenly or when the passenger of the vehicle is thrown out when the vehicle is moving very fast. Most experiments to assess slowdown injuries have been carried out on air transportation, because the acceleration factor is usually far greater than land transportation.⁹ In this case, if the estimated mass of minibus vehicles without passengers was 1085 kg, and the average mass of passengers was 60 kg, the mass of vehicles with 6 passengers became 1445 kg with the speed of the car when it hit a truck 160 km/h or equivalent to $160 \times 1000 \text{ m} / 60 \times 60 \text{ sec} = 44.44 \text{ m/sec}$, then the deceleration is denoted by “a”.

$$a = \frac{V_t - V_o}{t}$$

a = deceleration, V_t = final speed 160 km / h = 44.44 m / sec, V_o = initial speed 20 km / h = 5.56 m / s, t = time needed to reach the final speed (12 seconds), then the minibus that hit the truck experienced a slowdown of:

$$a = \frac{44,44 - 5,56}{12}$$

$$a = 3,24 \text{ m/sec}^2$$

Forensic investigation and Forensic physics analysis

Usually the forensic medicine investigation can determine the manner of death, cause of death and mechanism of death. Cause of death is the disease or trauma that directly caused the victim's death, for examples include a heart attack, a head injury, a gunshot wound to the head, or a drug overdose.¹⁰ In this case the cause of death of all victims was a head injury (traumatic brain injury). Based on the type of injury suffered by the victim, only victim 2 (passenger) suffered a broken skull and facial bones. It seems that what happened to victim 2 was a stationary head trauma resulting in facial skeletal fracture, calvary fracture, laceration of the brain, skull basilar fracture and the other fracture (Figure 1). At the time of the accident the dynamic head position is the result of acceleration-deceleration of the head. In contrast to static head trauma that lasts a long time, dynamic head trauma usually occurs due to force that hits the head in a fast time. The victims suffered a primary brain injury that occurred as a result of a direct impact on his head when he hit the dashboard. Head injuries are classified into primary injuries and secondary injuries. Primary injury is damage caused by mechanical impact and stress of deceleration in the head bones and brain tissue, resulting in head fractures (head bone or cranium base) and intracranial lesions. Dynamic head trauma usually occurs in cases of direct impact to the head that is free to move or with a collision or action on the body that causes the head to move.¹¹ According to the forensic physics, the greater the force resulting to the greater the impact on the victim. With a mass of 1445 kg and a deceleration of 3.24 m / sec², the magnitude of force when a minibus car hits a truck is:

$$F = m \cdot a$$

F = force, m = vehicle mass, a = deceleration, then:

$$F = 1445 \times 3.24$$

$$F = 4681.8 \text{ N}$$

Mechanism of death is the specific physiological derangement that actually led to the cessation of life. For example, a head injury victim could die from a deadly change in brain function or from severe damage to the brain, leading to coma. Here the cause of death is a head injury, but the mechanism is a massive bleeding or hypovolemic shock, respectively.¹⁰ Picture of damage to the skull a little more can also provide clues about the impact of violence that occurs on brain organs, the amount of power used, the direction of violence and others. Damage due to blunt force produces signs of impact in the

form of bruises, broken bones to bone fragments. It can also be determined the amount of power delivered to produce such violence, seen from the number of bone fragments formed and changes in the shape of the bone's elasticity. In blunt force, signs of impact, fractures or clipped marks can indicate including the shape of the object that hits the bone at the time of the collision and the type of injury that is often called marginal haemorrhage.^{5,12} The strength of the collision in this case is symbolised by the impulse "I", then with a force of 4681.8 N:

$$I = F \Delta t$$

I = Impulse, F = force, t = time of collision, for example 6 seconds, then:

$$I = 4681.8 \times 6$$

$$I = 28090.8 \text{ N} \cdot \text{sec}$$

from the calculation above, the magnitude of the impact force of a minibus car with the body of a truck is 28090.8 N.sec

Manner of death is how the cause of death came about. The five manners of death are natural, accidental, suicidal, homicidal, and undetermined. A head injury (the cause of death), may have been accidental, suicidal, or homicidal, for example. Only deaths from disease are natural.¹⁰ In this case the manner of death is road traffic accident. The pattern of injury due to traffic accidents has a difference with the pattern of injuries due to other violence. Information about this injury pattern can be used as a reference in the medical management of traffic accident cases. The dynamics of physical forces involved in an injury due to mechanical forces in traffic accidents become the basic concept in explaining and estimating the lesions associated with trauma and the underlying mechanisms.¹³ The form of injury is also affected by the pressure when the minibus crashes into the back of the truck, in this case it is estimated that the pressure represented by "P" is as follows:

$$P = F / A$$

P = pressure, F = force, A = car surface area estimated at car length 4.120 m, width 1.630 m and height = 1.695 m, then:

$$A = 2 (\text{length} \times \text{width}) + 2 (\text{length} \times \text{height}) + 2 \text{width} \times \text{height}$$

$$A = 2 (4.120 \times 1.630) + 2 (4.120 \times 1.695) + 2 (1.630 \times 1.695)$$

$$A = 2 (6.7156) + 2 (6.9834) + 2 (2.76285)$$

$$A = 2 (16.46185) = 32.9237 \text{ m}^2$$

$$P = F / A$$

$$P = 4681.8 / 32.9237$$

$$P = 142.20 \text{ Pa}$$

In accordance with Newton's Law 3, the pressure exerted on a stationary object, then the pressure will continue to turn in the direction with the same amount in the opposite direction (action = reaction). Adult skull head only able to withstand pressures <1000 Pa. With such great pressure, the head bone will be destroyed.¹⁴

At the time of the traffic accident, the minibus car crashed into the back of the truck and possibly turned right because only the passenger no.2 beside the driver's body was destroyed with a broken head while the other passenger had his head intact. It is estimated that the car has a rotation of 90 degrees. With the force when the minibus crashed into a truck 4681.8 N, the rotating force (torque) of a minibus can be calculated as "T".

$$T = rF \sin \alpha$$

T = rotating force, F = force, r = throwing distance (for example 5 meters), $\sin \alpha$ = turning angle (for example 90°), then:

$$T = 5 \times 4681.8 \times \sin 90^\circ$$

$$T = 23409 \text{ Nm}$$

So we can predict the mechanism of trauma, cause of death, mechanism of death and manner of death. The cause of death of the victims is multiple blunt trauma. Multiple trauma is a medical term that describes the condition of a person who has suffered several traumatic injuries, such as severe head injuries, neck injuries, chest injuries, abdominal injuries and extremities injury. Multiple trauma is when there are 2 or more physical injuries to a particular region or organ, one of which can cause the death. In this case the fatal injury that could have caused the death of the victims can be seen in [table 1](#).

In the literature mentioned that the cause of death as a result of coma, asphyxia and syncope. These three causes of death are certainly on a pathophysiological level or it can be said that the mechanism of death is not a cause of death. But in the case of reporting in visum et repertum the three causes of death must be explained in terms of postmortem findings. When making conclusions in visum et repertum, the doctor must provide an objective report found on the body. What happened to the body that was made as a cause of death that can be seen on the inside and outside examination (autopsy) on the body.¹⁵

Massive bleeding

Trauma can cause a person to lose blood massively. Massive bleeding results in compensation for physiological changes such as tachycardia,

vasoconstriction, and activation of cytokines and hormones, as well as clotting cascades to maintain ongoing blood volume loss. Because of this massive haemorrhage, hypoperfusion (hypovolemic shock) occurs resulting in metabolic acidosis and hypothermia. The clotting factors and platelet function will drop at 35°C. Resuscitation of patients with crystalloids or colloids results in hemodilution and is associated with the dilution of clotting factors, further exacerbating more bleeding and finally coagulopathy. All of these factors produce a triad of death, namely: acidosis, hypothermia and ongoing coagulopathy.¹⁶ Physiological changes in bleeding shock include: 1) decreased cardiac output, 2) cell damage due to hypoxia with metabolic effects, 3) activation of coagulation and fibrinolytic cascades, 4) activation of inflammatory mediators which causes cellular damage, 5) endothelial cell damage activates intravascular coagulation and causes consumptive coagulation.¹⁷

In this case what was seen in the victim was multiple trauma which resulted in bleeding in several organs, especially in the head. Actually, to say a person died of bleeding must be determined by how much blood comes out of the body. In the literature mentioned the amount of blood loss of more than 50% can cause death. Normal blood volume in humans ranges from 7% of body weight or 70 cc per kg of body weight, for example humans have a weight of 70 kg then the amount of blood is 4900 cc or 4.9 litres. Then a person can die if he loses blood around 2.5 litres.¹⁸

In shortly, it can be said that there is a relationship between the mechanism of trauma, manner of death, cause of death and mechanism of death. In this case, all victims died as a result of a traffic accident (manner of death) which caused multiple trauma, especially on the head, chest, abdomen and extremities (cause of death) resulting in heavy bleeding in several organs (mechanism of death) that cannot be covered by medical treatment.

CONCLUSION

Forensic investigations are very useful in determining the mechanism of trauma, cause of death, mechanism of death, manner of death, In road traffic accident medical report, the doctors can explain their findings in the form of visum et repertum. The benefits of a forensic investigation on RTA are actually more on prevention so that no more accidents occur in the future by studying the impact caused and the factors causing the accident.

By using Forensic physics can determined how much force, pressure and strength of the collisions

that occur in the RTA that can cause fatal damage to the victim's body and death. As a doctors we can provide more precise forensic analysis to support the investigation of a case by the police. The role of physical science and other sciences strongly supports the objectivity and validity of the results of forensic examinations.

CONFLICT OF INTEREST

The authors declare there is no conflicts of interest.

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AUTHOR CONTRIBUTION

TS as a forensic medicine specialist and ethics-medicolegal consultant, he is responsible for the forensic medicine investigation in this case, basic concept and final editing in the manuscript preparation. K as an anesthesiologist and candidate of neurosurgery anesthesiology consultant, she is responsible for English improvement and making basic concept of management of traumatic brain injury and mass bleeding.

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