

## Physics Law Analysis to Support Successful Forensic Medical Investigation in Vertical Fall Cases

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**Abstract:** A reported case of death due to blunt trauma to the head due to falling from a height of approximately 10 meters from the top of a 3rd floor building. On the head of the victim looked skull fracture and brain tissue discharge. It is estimated that the victim fell with his head hitting the floor vertically because there were relatively no serious injuries on other body parts. In this case there is a trauma mechanism which is the law of physical mechanics. By using the law of forensic physics (Pascal's Law)  $P = F / A$ , a pressure of 10.007.1 pa is obtained, while the ability of the adult skull is only able to withstand pressures of less than 1000 pa, with such a large pressure, the skull will be destroyed. Damage to the body part of the victim who fell from a height depends on the height of the place, the speed of fall, and the position when falling. Using another forensic physics formula (Newton's Law), a velocity of 14.14 meters / second is obtained, and a falling time of 1.414 seconds, making it impossible for victims to make changes in body position as self-protection before death. A review of the laws of physical mechanics is needed as an analysis of forensic medicine in determining the mechanism of trauma and the medicolegal aspects of the wound.

**Key Words:** Head Blunt Injury; Physics Law; Forensic Investigation.

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### I. Introduction

In cases of death due to trauma, head trauma is the most common type of trauma found, which is 50% of all trauma cases. In the United States, the incidence of brain injury due to trauma is estimated at 180-220 cases from 100,000 population. Head injuries usually occur in young adults between 15-44 years, as many as 50% of cases are caused by traffic accidents and 10% due to blows, with an incidence of 15% due to suicide by falling from a height and 25% due to something else. Of all suicidal deaths by falling from a height which was successfully recorded, some of them have a history of mental disorders, alcohol dependence, romance problems and economic problems.<sup>1</sup> The investigation of how the mechanism of falling and death is an interesting issue because it involves medicolegal aspects that need to be analyzed. Below is reported a case of death due to blunt trauma to the head due to falling from a height of approximately 10 meters from the top of the building.

### II. Case report

Has been examined a deceased male body named Mr. E, 39 years old, brown skin color, body length 179 cm, straight black hair, hair length at the top 12 cm, side 6 cm and back 7 cm. From the results of external examination found a torn wound on the head accompanied by an occipital skull fracture of the skull with a length of 30 cm and a width of 9 cm with a brain decomposed. Also found abrasions on the right cheek with a length of 4 cm and a width of 2.5 cm. On the body of the victim was found extensive torn wounds on the head accompanied by the destruction of the skull caused by blunt trauma due to falling from a height without any signs of abuse before death.

### III. Discussion

#### 3.1. Medicolegal aspects

The assessment of injuries to the victim's body depends on the object that first struck the body, body position at the time of fall, and the height of the distance from where the victim jumped.<sup>2</sup> In the medicolegal aspect, injuries due to blunt force can take the form of one or a combination of bruises, abrasions, lacerations, broken bones or pressure sores. This depends on variations in the mechanism of trauma.<sup>2,3</sup> The following are variations in the mechanism of blunt trauma: (a) a blunt object that moves on a silent victim, (b) a victim who moves on a stationary blunt object, (c) a victim who moves on a moving blunt object. At first glance it looks the same in the findings of the wound but if it is considered further there are differences in the results of the three mechanisms.<sup>4</sup>

Organs or tissues in the body have several ways to withstand damage caused by objects or tools. This endurance causes various types of injuries namely abrasion, laceration, contusion / rupture, fracture, compression, and bleeding.<sup>5</sup> Hard blunt force on the head can affect certain parts of the head with their respective effects,<sup>6</sup> namely: (a) the skin can cause blisters, bruises, and tears, (b) on skull can cause cranium base fracture, and skull fracture, (c) in the lining of the brain can cause epidural hematoma, subdural hematoma and subarachnoid hematoma, (d) in the brain can cause cerebral contusion, cerebral laceration, cerebral edema and cerebral commotion. From the results of a forensic examination of the victim's body, several types of damage from trauma were found, namely:<sup>6,7</sup>

1. Open wound on the head
2. Skull fractures
3. Ruptures of brain membrane
4. Cerebral contusions
5. Intracranial hematoma
6. Discharge of brain tissue

In this case the victim suffered a fracture from the parietal bone to the occipital bone (figure 1). This is caused by the direction of the entry of trauma from the back of the head with great pressure. This fracture occurs because the pressure that exceeds the capacity of pressure that can be held by the skull. In this case there was a contusion at the location of the collision (coup contusion) and in the opposite direction from the entry of the trauma (counter coup contusion). The entry of a large pressure due to trauma to the skull bones will be forwarded into, resulting in a collision and brain friction on the protrusion and curve of the skull during a collision (figure 2). This causes nerve and axonal cell damage, with points of capillary bleeding and brain tissue edema.<sup>7,8</sup>



Figure 1. Skull fractures



Figure 2. Discharge of brain tissue

As a result of the mechanism of the coup and counter coup due to trauma, in this case there is a subdural hematoma. The impact that occurs from the direction of the trauma is accompanied by a shock to the brain that hits the skull, resulting in bleeding between the dura mater and the arachnoids. This hemorrhage originates from the rupture of the bridging vein that passes from the subarachnoid space or cerebral cortex to the subdural space, with an end in the vein sinus of duramater. Besides bleeding also occurs due to tears of cortical vessels, sub arachnoid, or arachnoid accompanied by tearing of the arachnoid layer.<sup>8</sup>

### 3.2. Physics Law Application

Damage to body parts in victims who fall from a height depends on the height of the place, the speed of fall, and the position on the jump.<sup>1</sup> By using the forensic physics formula (Newton's Law), it is obtained:<sup>9</sup>

$$\begin{aligned}
 v &= \sqrt{2gh} \\
 v &= \sqrt{2 \times 10 \times 10} \\
 v &= \sqrt{200} \\
 v &= 14.14 \text{ m / s} \\
 \\ 
 t &= \sqrt{(2h / g)} \\
 t &= \sqrt{(2 \times 10 / 10)} \\
 t &= \sqrt{2} \\
 t &= 1,414 \text{ s}
 \end{aligned}$$

Information:  
 v = speed (m / s)  
 g = earth's gravity (m / s<sup>2</sup>)  
 h = height of place (m)  
 t = time (s)

Then from the results above the velocity of the victim fell 14.14m / s and the time taken by the victim to reach the 1,414s floor. With such speed and time, it is not possible for victims to make changes in body position as self-protection before death. So the body part that first fell depends on the initial position of the victim jumped. In the case of casualties from a height is a trauma mechanism that is the victim moving on a stationary object. By using the forensic physics formula (Pascal's Law) a pressure which destroys the victim's body is obtained:<sup>9</sup>

$$\begin{aligned}
 P &= F/A \\
 P &= \frac{m \cdot g}{(\pi r^2)} \\
 P &= \frac{70 \times 10}{3,14 \times 0,15} \\
 P &= 10.007,1 \text{ Pa}
 \end{aligned}$$

Information:  
 P = Pressure (Pa)  
 F = Force, where the weight of the victim is obtained multiplied by the acceleration of gravity  
 A = Surface area of the object, in this case the body part of the first victim to fall

Thus, the pressure caused by the victim's body was 10,007.1 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 is only able to withstand pressures <1000 Pa. With such great pressure, the head bone will be destroyed.<sup>9</sup>

### 3.3. Cause, manner and mechanism of death

Forensic medical investigation can determine the cause, manner and mechanism of death. Cause of death of the case is blunt trauma on the head (traumatic brain injury). Based on the type of injury suffered by the victim, the victim suffered a broken skull and discharge of brain tissue. It seems that what happened to victim was a dynamic head trauma resulting in skull fracture, laceration of the brain (figure.1). At the time of the dynamic head position suddenly stopped as the result of acceleration-deceleration of the head.<sup>10,11</sup> According to the forensic physics, the greater the force resulting to the greater the impact on the victim. With a mass of body victim is 70 kg and a deceleration of earth's gravity 10 m / sec<sup>2</sup>, the magnitude of force when a head's victim hits a floor is:

$$\begin{aligned}
 F &= m \cdot a \\
 F &= \text{force, } m = \text{body victim mass, } a = \text{deceleration of earth's gravity, then:} \\
 F &= 70 \times 10 \\
 F &= 700 \text{ N}
 \end{aligned}$$

Manner of death is how the cause of death came about. A head injury (the cause of death), may have been suicidal, accidental or homicidal, for example.<sup>10</sup> In this case the manner of death is maybe suicide. There

are some things that have not been revealed from the death of the victim including, what is the background of the incident experienced by the victim?. According to the victim's family information, before the incident at about 06.00a.mat local time, the victim had talked to his wife that the victim wanted to leave the house because someone was calling. What causes the victim to fall from height?, as for the possible causes of victims falling from a height is a mental disorder (hallucinations), heart disease, under the influence of drugs and alcohol, slipping, shocked, hit by the wind or pushed by someone. The cause of the victim could not be ascertained because of the absence of eyewitnesses.

If it is a case of suicide by jumping from a height, which body part first fell?. Based on the case that was recorded by the police investigator, usually suicides fell from a height of 10 meters, the first part to fall was the lower limb. But in this case, the first part to fall is the head with no signs of fracture in the extremities. This happens according to how the first position when jumping. Is there a disease experienced by the victim that causes falls from a height, such as psychiatric illness or heart disease?. In this case, the victim's previous illness was unknown. This will be revealed when an internal examination (autopsy) is performed. In this case an investigator was not asked for an autopsy. Is the victim under the influence of drugs? In this case it is unknown whether the victim is under the influence of drugs. This will be revealed if laboratory tests are carried out.

#### **IV. Conclusion**

In the above case it can be concluded: The cause of death of the victim is bleeding from the head due to blunt trauma caused by falling from a height. At an altitude of 10 m, the falling speed of 14.14 m/s takes 1.4 second to get to the bottom, not allowing the victim to change the position of the fall in self-protection efforts. Thus, the first part of the fall is determined by the initial position of the victim jumping from a height. With a magnitude of force 700 N and pressure of 10.007.1 Pa, trauma damage was obtained in the form of cerebral contusions, fracture convexity of the skull and subdural hematoma which caused the death of the victim. The cause of the victim falling from a height is not known with certainty, the possibility is a case of suicide, because no signs of violence were found before the victim fell. By using the physics law, the doctors can provide strongly supports to the police investigator.

#### **References**

- [1]. Windi. Forensic traumatology. 2006. Cited from: <http://www.freewebs.com/traumatologie2/traumatologi.htm>.
- [2]. Oemichen, M, R. N. Auer, H.G. Koenig. Injuries of the brain's coverings', forensic neuropathology and associated neurology, Springer, Germany. 2006: 112-147.
- [3]. Dahlan S, Trisnadi S. Forensic medicine. Sultan Agung University School of Medicine. Semarang. 2019.
- [4]. Cetin G. Suicides by Jumping from Bosphorusbridge in Istanbul. Forensic SciInt. 2001:157-162.
- [5]. Shkrum MJ, Ramsay DA. Craniocerebral trauma and vertebrospinal trauma. Forensic pathology of trauma. Humana Press, New Jersey. 2007:19-73.
- [6]. Dolinak M, David E, Matshes W, Lew EO. Forensic neuropathology. Forensic pathology principles and practise, Elsevier Academic Press, USA. 2005: 423-52.
- [7]. Suryadi T, Kulsum. Forensic investigation in a multiple trauma deceleration case due to road traffic accidents. Bali Med J 2020; 9(1): 172-177.
- [8]. Jafardi I. Head injury, Publisher PT Buana Ilmu Populer, Jakarta Barat, 2004: 7-27, 67-76.
- [9]. Foster B. Pascal and Newton's law in free fall style. Jakarta: Publisher Erlangga. 2005.
- [10]. Lyle DP. The cause, mechanism and manner of death. 2020. Cited from <https://www.dummies.com/education/science/forensics/the-cause-mechanism-and-manner-of-death>.
- [11]. Syah BIA, Suarjaya IPP, Rahardjo S, Saleh SC. Anesthesia management in severe head injury patients from acute epidural hematoma with pregnancy. Indonesian Neuroanesthesia Journal. 2017; 6 (3): 169-177.

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