A physical analysis of some emerged explanations about Chow Tsz-lok's death

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Abstract

On 4^{th} November 2019, Chow Tsz-lok fell from the third floor towards the second floor of Sheung Tak car park in Tseung Kwan O. Chow suffered multiple injuries, including a severe brain injury, which led to his death due to a cardiac arrest four days later. It was reported that Chow had a fractured right pelvis from likely a lateral compression, a torn internal iliac artery, a fractured skull base, bleeding in mainly the right half of the brain, and an intra-abdominal hemorrhage. He had no obvious injuries to his hands and feet, nor had he been shot with bullets or was he bruised from a beating. The toxicology results only showed drugs administered after his admission to the hospital [**1**].

In order for Chow to fall from the third floor, he had to cross a $1.2m$ wall first. Different explanations about the incident have been proposed. These explanations include: 1. Chow approached the wall and fell down accidentally, 2. Chow climbed over the wall on purpose and fell down in a horizontal position by accident and 3. Chow was rendered unconscious and thrown from the third floor by someone else (in other words, Chow was murdered). In this article, I am going to examine the possibility of explanations 1 and 2. Due to lack of evidence, I am not going to discuss about explanation 3.

Some data of the incident

According to Sr Chemist (Scene of Crime & Quality Management Sec) Dr. Cheng Yuk-ki, the height (h) of Chow is $1.75m$ [**2**]. Also, as stated by Dr. Kong Kam-fu, who is an Orthopaedic doctor, the distance (d) between the top of the $1.2m$ wall and the second floor is $4.3m$ [**3**]. As centre of mass of an upright male is located at approximately $0.56h$ [**4**], we can deduce that the height of Chow's centre of mass (h_{cm}) is around $0.98m$. The acceleration g due to Earth's gravitational field at Hong Kong is around $9.785ms^{-2}$ [**5**]. Data listed above is illustrated by Appendix, Figure 1.

Ruling out explanation 1

The centre of mass of Chow is at a height of $0.98m$, which is lower than the top of the $1.2m$ wall. Thus, it is impossible for Chow to fall down when he approached the wall. Explanation 1 can hold only if Chow's body structure is abnormal and has a much higher centre of mass than an ordinary male, but such occasion is very rare.

Analysis of explanation 2

According to explanation 2, Chow fell down in a horizontal position accidentally when he climbed over the wall, subsequently landed on the second floor with the right side of his body, leading to severe injuries of his right pelvis and right half of his head. Chow had no arm fractures, which suggested that he was unable to reflexively extend his arms for protection during the fall. Leung Tsz-hang, a medical doctor who treated Chow, pointed out the scenario that Chow lost his balance and could not react in time by using his hands unlikely [**6**]. In this section, I am attempting to determine whether Chow had sufficient time to react if he remained conscious.

a) Amount of time available for Chow to react

By elementary physics, we know $d = \frac{1}{2}gt^2$, hence $t = \sqrt{\frac{2d}{g}}$. After substitution, we calculate that falling time t of Chow is $0.937s$. As suggested by Dr. Kong Kam-fu, the perception reaction time of a normal person $t_r \in [0.5s, 0.7s]$ [**3**]. Therefore, maximum amount of time available for Chow is $max\{t - t_r\} = 0.437s$.

b) Estimation of time available for Chow to react if he falls forward onto the ground

According to Roger Tam, a fourth-year HKUST science student, Chow played basketball and netball [**7**]. This suggests Chow should had good reflexes. Moreover, a healthy teenager can extend his arms to protect himself if he falls forward onto the ground accidentally. By comparing the amount of time available for Chow to react to a sudden forward fall and the time obtained in (a), we can conclude about the probability that Chow failed to react if he was conscious.

For simplicity, we treat Chow's body as equivalent to two combined thin and uniform rods with a net centre of mass at $h_{cm} = 0.56h$. WLOG, we assume Chow's body then rotates clockwisely from an initial angle $\theta_0 = 10^o = \frac{\pi}{18}rad$. The lower rod and upper rod have mass m_1 and m_2 respectively, so we have $m_1 + m_2 = m$. This simplified model of Chow's body is illustrated by Appendix, Figure 2. Also, due to the uniformity of these two rods, their centre of mass is located at the midpoint of each rod, hence $\frac{0.28m_1+0.78m_2}{m} = 0.56$. After solving, we get $m_1 = 0.44m$, $m_2 = 0.56m$. This agrees nicely with [**8**], which shows body segments located above centre of mass, including head, neck, torso and upper arm, account for around 58% of body weight.

We can proceed to estimate Chow's body's moment of inertia I. By parallel axis theorem,

$$\begin{aligned} I &= \frac{1}{3}(0.44m)(0.56h)^2 + \frac{1}{12}(0.56m)(0.44h)^2 + (0.56m)(0.78h)^2 \\ &= \frac{742}{1875}mh^2 \end{aligned}$$

Torque acting on the combined rod, $\tau = 0.56hmg\sin\theta$, where θ is the angle rotated by the rod. By $\tau = I\ddot{\theta}$,

$$\begin{aligned} 0.56hmg\sin\theta &= \frac{742}{1875}mh^2\ddot{\theta} \\ \ddot{\theta} &= \frac{75g}{53h}\sin\theta \end{aligned}$$

This nonlinear differential equation is tedious to solve. For convenience, we use small angle approximation: $\sin\theta \approx \theta$, and obtain $\ddot{\theta} \approx \frac{75g}{53h}\theta$. By solving, we get $\theta(t) = \frac{\pi}{36}\exp\left(\sqrt{\frac{75g}{53h}}t\right)$. When the rod hits the ground, $\theta = \frac{\pi}{2}$. Substituting $\theta(t) = \frac{\pi}{2}$ gives $t \approx 1.03s$. Therefore, the estimated amount of time available for Chow to react to a sudden forward fall is

$max\{1.03 - t_r\} = 0.53s$.

The result obtained in (a), $0.437s$, is merely around 18% less than $0.53s$, showing that it is likely for Chow to have adequate time to react by extending his arms if he fell down consciously, which should led to arm fractures; nonetheless, Chow had no obvious injuries in his arms. This hinted that Chow might be unconscious during the fall, making explanation 2 unlikely.

Conclusion: not so constructive

So far we have ruled out explanation 1, and arrived at the conclusion that explanation 2 is unconvincing; what left behind is explanation 3. However, as I have mentioned in the beginning, I am not going to discuss about explanation 3 due to lack of evidence, thus I should end my analysis here.

Appendix

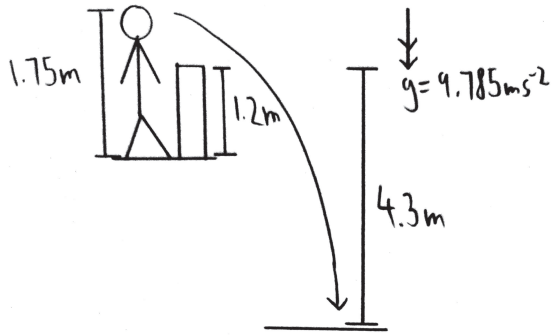

Figure 1: Some data of the incident

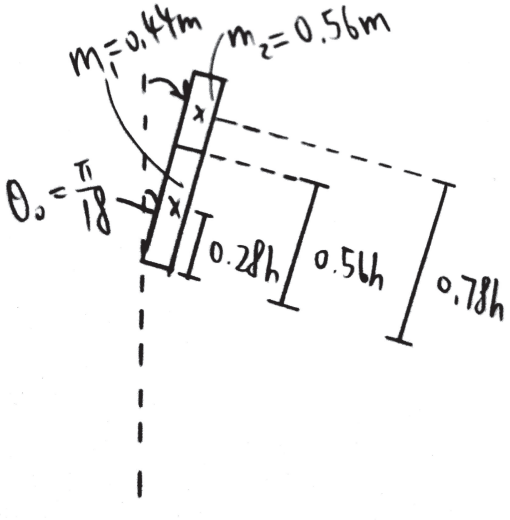

Figure 2: A simplified model of Chow's body during a sudden forward fall

Reference

[**1**] Apple Daily HK, 2019.11.12: [Death of Chow] Injuries exposed! Right iliac fractures, no obvious injuries to hands or feet. Traumatologist: Chow may have lost consciousness before falling

[**2**] Stand News, 2019.12.28: [Inquest about the cause of death of Chow] Government Chemist: if a person has the same height as Chow, he would spot the emptiness behind the wall at a distance of $0.8m$

[**3**] Hong Kong Citizen News, 2020.12.30: [Inquest about the cause of death of Chow] Orthopaedic doctor inferred that Chow fell down by accident

[**4**] https://hypertextbook.com/facts/2006/centerofmass.shtml

[**5**] T.M. Yarwood and F. Castle, Physical and Mathematical Tables, revised edition, Macmillan and Co LTD, London and Basingstoke, Printed in Great Britain by The University Press, Glasgow, 1970, pp 22 & 23.

[**6**] The Standard, 2020.12.4: New footage on student's death

[**7**] The New York Times, 2019.11.07: Anger in Hong Kong after student dies from fall following clash with police

[**8**] RAMACHANDRAN, HARI & Vasudevan, Devanandh & Brahma, Aditya & Pugazhenthi, S.. (2016). Estimation of mass moment of inertia of human body, when bending forward, for the design of a self-transfer robotic facility. Journal of Engineering Science and Technology. 11. 166-176.