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P6_2 The Pink Mist-ery

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Abstract
Was the explosion in season 2 of Grey's Anatomy an accurate representation if the scenario was to occur in reality? This paper reviews if the outcome and consequences of this explosion have been exaggerated through a mathematical analysis on two subjects affected, and comparing these to observations of the scene. It was found that the effects were greatly exaggerated due to the discrepancies in the energy for vaporisation, 3×10^9J, and energy of the explosion experienced by Subject 1, 1131×10^3J. Furthermore, Subject 2 would not suffer any more extensive injuries due to the increase in temperature of 0.043°C not being at a large enough magnitude to cause serious harm.

Introduction

The episode called "As We Know It" from Grey's Anatomy depicted the detonation of an explosive device within the hospital shortly after being removed from a patient. The explosion effects for two characters were chosen for further study; the person carrying the device (Subject 1) and a doctor standing at the epicentre of the detonation (Subject 2). In this scene, Subject 1 was completely vaporised and Subject 2 was only knocked back from the explosion.

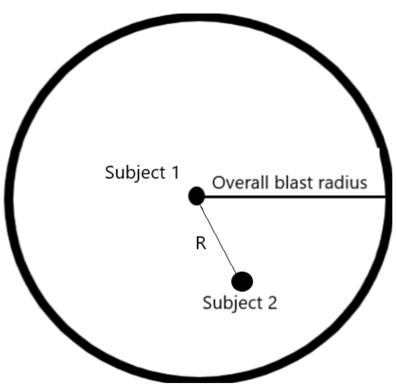

Figure 1: A general, not-to-scale schematic of the scenario, depicting the positions of both subjects (seen by black dots) in comparison to the maximum blast radius.

Throughout the analysis, it was assumed that the explosion was perfectly spherical and the energy released was uniformly distributed as it expanded. The time for the explosion to reach Subject 2 was estimated from the episode itself, which could lead to calculation errors. The debris caused by the blast has been assumed to have no effect on either subject.

Method and Results

To begin, the explosive was stated to come from a M981 bazooka and its composition was found to be a 50:50 split of Trinitrotoluene (TNT) and Pentaerythritol tetranitrate (PETN) at a mass of 225g combined [1]. The energy released per unit mass was found to be 1g of PETN produces 5810J of energy [2] and 1g of TNT generates 4000-4500J [3].

The total energy, E, of the stated explosive device is:

$$E = M_t E_t + M_p E_p \tag{1}$$

where M_t and E_t are the mass and energy of TNT respectively, M_p and E_p is the mass and energy of the PETN respectively.

Values of $M_t = 112.5$g, $E_t = 4250$J/g, $M_p = 112.5$g and $E_p = 5810$J/g were inputted and resulted in E to be approximately 1131×10^3J. (Note that the midway energy (4250J) was used for TNT).

Due to Subject 1's close proximity to the device, they were assumed to experience the entirety of this energy. Despite this, the energy calculated is lower than the magnitude required for complete vaporisation (3×10^9J [4]), therefore discounting the accuracy of the show's depiction of the explosion's consequences.

To determine if Subject 2 only experiences a knock-back from the force of the blast's shock waves, the distance at which the subject experienced the explosion was calculated [5]:

$$R = E^{1/5}\rho^{-1/5}t^{2/5} \tag{2}$$

where R is the distance from the epicentre to Subject 2 (represented by R in figure 1), ρ is the density of air (1.225kg/m^3 [5]) and t is the time period for the blast effects to hit Subject 2 (≈ 0.1s) [6]. A value of $R = 6.210$m was determined.

R can then be used to find the intensity, I, of the explosion at this distance using the inverse square law, with R being the radius of the sphere:

$$I = \frac{E}{4\pi R^2} \tag{3}$$

The results from equations (2) and (3) give an output intensity value of 2334J/m^2, which can be multiplied by the cross-sectional area of an average human body [7] to calculate the energy exerted on Subject 2:

$$E_h = 2334 \cdot 0.68 = 1587J \tag{4}$$

This was considered as the heat energy generated, which can be used to find the change in temperature experienced by Subject 2:

$$E_h = mc\Delta T \tag{5}$$

where m is the mass of Subject 2, c is the specific heat capacity of a human (~ 3.5 kJ kg $^{-1}$ °C^{-1})[8]$and\Delta T$ is the change in temperature.

This calculation can be treated in two ways; one in which heat is distributed uniformly across Subject 2 ($m = 75$kg), and the other being that just the exposed areas, i.e. skin, are affected ($m = 10.9$kg [9]). Both can be solved by rearranging equation (5) to determine ΔT, giving $\Delta T_{uniform} \approx 0.006$°C and $\Delta T_{exposed} \approx 0.043$°C.

Discussion and Conclusion

For either heat distribution, no major injuries are inflicted onto Subject 2. The rise in temperature inside the body is too small to cause any internal problems like hyperthermia and heat stroke for example.

To conclude, the scene does not give a true representation of the devastation this explosion would have caused on Subject 1, but does for Subject 2. Subject 1 would not be vaporised but Subject 2 would not sustain any other injuries other than the ones caused by the knock back.

Uncertainties in the results are recognised due to the assumptions used, such as the time stated for Subject 2 to experience the blast's effects, and sustained errors from assumptions made in the source papers used.

References

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