Journal of Interdisciplinary Science Topics

Could the Black Knight have survived to bite King Arthur's legs off?

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16/04/2018

Abstract
The paper examines the feasibility of the Black Knight surviving to the end of the duel with King Arthur in Monty Python and the Holy Grail. By looking into the blood loss accrued when each limb is chopped off the level of haemorrhaging is found throughout the scene. Given the blood loss he would have sustained it is unclear as to whether the Black Knight would have been able to survive until the end of the scene. However, he would have certainly lost consciousness and died seconds after the fade to black.

Introduction
In Monty Python's 1975 film, *Monty Python and the Holy Grail* King Arthur, and his knights of the round table are followed as they quest for the Holy Grail [1]. Early in the movie King Arthur encounters the Black Knight, who is guarding a bridge across a stream. After the knight refuses passage across the bridge they lock swords in battle, wherein King Arthur summarily removes each of the Black Knight's arms and legs.

Throughout all of this the Black Knight still maintains a belief of his assured victory and, proclaiming "I'll bite your legs off", just before the screen fades to black as the scene changes. This paper looks at the possibility of the knight surviving for the entire scene due to implications caused by the removal of a limb.

Theory
During the fight with King Arthur it can be observed that when the Black Knight loses a limb he spends a few seconds looking at the missing limb before seemingly realising it is missing. As the knight shows no pain response, and seems to be unphased by the loss of the limb it is therefore assumed that he has a disease similar to Congenital insensitivity to pain with anhidrosis (CIPA) [2]. This would explain why he seems to feel no pain and therefore has no pain response to the loss of his limbs. Thus the biggest danger to the knight is therefore blood loss, and the onset of Hypovolemic (Haemorrhage) shock [3].

The time that the Black Knight spent without each of his limbs was then counted using a clip of the movie (table 1). Given this timeframe the amount of blood loss can be calculated. For the loss of the limbs only the major arteries are going to be considered to account for blood loss. This will be done as the arteries correspond to the greatest flow rate of blood and are the least affected by vasoconstriction due to the pressure of the blood flow in them, capillaries and veins don't have the surface area, and blood flow to produce a significant difference.

Time (s)	Limbs Lost
0	Left Arm
21	Both arms
51	Both arms, Right leg
68	Both arms, Both legs
86	Scene ends

Table 1 – Times at which the Black Knight's limbs were removed in Monty Python and the Holy Grail. 0 s is when the first limb is removed and 86 s is when the scene fades to black [4].

In a healthy, exercising adult the blood flow in the brachial artery in the arms is approximately 300 mL/min [5]. The blood flow in the femoral artery in the leg immediately following exercise has a maximum of approximately 3250 mL/min [6]. It is assumed that the Black Knight is a fit individual due

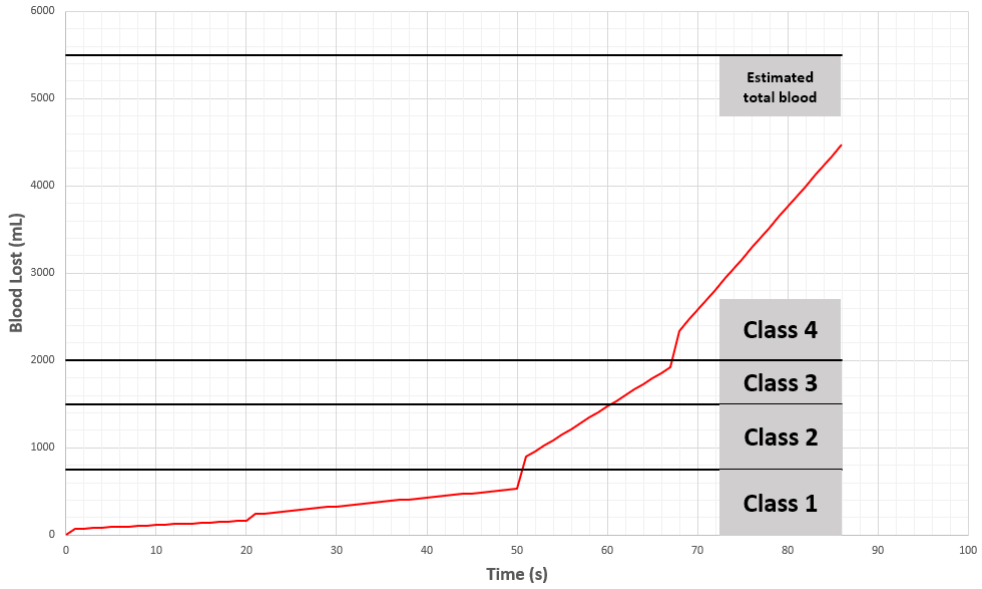

Figure 1 – The blood loss over time accumulated by the Black Knight. The thresholds for each class of haemorrhage are labelled along with the total estimated blood in the Black Knight. The jumps in the blood loss indicate where limbs are lost.

to a life filled with heavy exertions and so the maximum of a normal individual is taken. The blood that is present in the limbs at the time of severing is also considered, given that this volume is dependant on the size of the person and their current situation it can only be estimated. However, from experimental data, in an arm of volume 1200 mL there is approximately 65 mL of blood plasma [7], and in a normal leg the blood volume is approximately 300 mL [8]. Given this the blood loss over time is then calculated and shown in figure 1.

Blood loss is categorized into four classes, these classes are determined by levels of blood loss: class 1 <750 mL (<15 %), class 2 750-1500 mL (15-30 %), class 3 1500-2000 mL (30-40 %) and class 4 >2000 mL (>40 %) [3]. Where the severity increases with class of blood loss, class 1 is a non-shock state, class 4 is a severe condition requiring immediate treatment. All of these different classes are displayed in figure 1 at the blood loss levels they represent.

Conclusion

From figure 1 it can be seen that the Black Knight's blood loss only really begins to become an issue once the legs are removed. This makes sense as the legs are much larger and require much more blood flow than the arms. The fact that the Black Knight does not enter the more serious class 2 haemorrhage before the removal of his leg is initially surprising, yet on the timescale considered this is logical, given another few minutes with no treatment of the arm wounds would still lead to an extreme state of blood loss.

In this paper the effect of reduced blood flow to the affected limbs has not been considered. This would naturally decrease as the blood pressure decreased from blood loss. However, given that the time over which this occurs is so short and that the decrease in flow rate would likely produce negligible results compared to the overall blood loss it has been ignored.

Given the total blood loss the Black Knight is undergoing an extreme case of class 4 haemorrhaging. By the end of the scene he would be undergoing the symptoms of lethargy, confusion along with a high heart rate and high breathing rate. However, the final blood loss is just under 4500mL, with a total estimated blood volume of 5500mL and the brain requiring 750mL of blood [9] then it is feasible that he would be able to tell King Arthur that he would bite off his legs. However, immediately following the scene fading to black he would collapse and bleed out due to no blood reaching his brain. This is considering the best-case scenario however, as the most likely probability is that the Black Knight would have passed out due to blood loss only a few seconds after he lost the second leg, although this can't be predicted as the tolerance to blood loss is different for everyone.

References

[1] Monty Python and the Holy Grail (1975) Directed by Terry Gilliam and Terry Jones. [Film] UK: EMI Films.

[2] Ozbarlas, N., Sarikayalar, F. & Kale, G. (1993) *Congenital insensitivity to pain with anhidrosis*. Cutis, 51 (5), pp. 373–374.

[3] Gutierrez, G., Reines, H.D. & Wulf-Gutierrez, M.E> (2004) *Clinical review: hemorrhagic shock*. Critical Care, 8 (5), pp. 373–81. DOI: 10.1186/cc2851

[4] Monty Python (2008) *Black Knight - Monty Python and The Holy Grail*. YouTube. Available at: https://www.youtube.com/watch?v=dhRUe-gz690 [Accessed 28th February 2018].

[5] Padilla, J., Simmons, G.H., Vianna, L.C., Davis, M.J., Laughlin, M.H. & Fadel, P.J. (2011) *Brachial artery vasodilatation during prolonged lower limb exercise: role of shear rate*. Experimental Physiology, 96 (10), pp. 1019–1027. DOI: 10.1113/expphysiol.2011.059584

[6] Hussain, S.T. (1997) *Blood flow measurements in lower limb arteries using duplex ultrasound*. Annals of The Royal College of Surgeons of England, 79 (5), pp. 323–330.

[7] Andres, R., Zierler, K.L., Anderson, H.M., Stainsby, W.N., Cader, G., Ghrayyib, A.S. & Lilienthal, J.L. Jr (1954) *Measurement of blood flow and volume in the forearm of man; with notes on the theory of indicator-dilution and on production of turbulence, hemolysis, and vasodilatation by intra-vascular injection*. The Journal of Clinical Investigation, 33 (4), pp. 482–504. DOI: 10.1172/JCI102919

[8] Karpeles, L.M. & Huff, R.L. (1955) *Blood Volume of Representative Portions of the Musculoskeletal System in Man*. Circulation Research, 3 (5), pp. 483–489. DOI: 10.1161/01.RES.3.5.483

[9] Joyner, M.J. & Casey, D.P. (2015) *Regulation of Increased Blood Flow (Hyperemia) to Muscles During Exercise: A Hierarchy of Competing Physiological Needs*. Physiological Reviews, 95 (2), pp. 549–601. DOI: 10.1152/physrev.00035.2013