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Is a 'Cast Iron Stomach' Really That Strong?

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Abstract

The term '*cast iron stomach*' is reserved for people who never seem to succumb to the ill effects of bad food or drink. This paper assesses the credibility of having a cast iron stomach with respect to corrosion caused by gastric juices leading to potentially fatal symptoms. This point was taken to be when the cast iron stomach retained only 63% of its original mass whereby it is reasoned the stomach would rupture and likely lead to gastric juices leaking into the peritoneum. Through modelling the stomach to be a hollow sphere of stainless steel the time taken for corrosion to lead to gastric juices was found to be 34 days on average.

Introduction

A well-known English idiom is to say someone has a '*cast iron stomach*'. This refers to someone who has 'no problems, complications or ill effects with eating anything or drinking anything' [1]. It shall be discussed how long a '*cast iron stomach*' would last in the aqueous and strongly acidic stomach environment. This paper focuses on the corrosion of the iron and not on any increase in pressure brought about by the corrosive reactions that could lead to the cast iron stomach cracking in it's corroded state.

Assumptions

For the purposes of this discussion it is presumed that the '*cast iron stomach*' is a hollow sphere of stainless steel which surrounds a normal human stomach lumen, the gastric acid of which contains hydrochloric acid, potassium chloride and sodium chloride and will all contribute to the corrosion of the iron. As cast iron is an alloy of iron in itself, here it has been chosen to use stainless steel in place of cast iron for the following calculations as stainless steel represents the more corrosive resistant alloy of iron whilst remaining analogous to cast iron. This will therefore give the upper limit to what is survivable before the stomach ruptures.

The Corrosion of Iron

Iron corrodes faster in the presence of electrolytes, which accelerate the electrochemical reaction such as those shown in equation 1, provided by the aqueous solutions of salts present in the stomach. In the corrosive process iron is oxidised and a simple understanding of one of the corrosive reactions that would occur in gastric juice can be seen in equation 1.

$$Fe_s + 2HCl_{aq} \rightarrow FeCl_{2\,(aq)} + H_{2\,(g)} \qquad (1)$$

The corrosion of most metals is accelerated at lower pH and the acidic environment of the stomach has an average pH of 1.3 throughout the day [2].

Any iron or iron alloy (e.g. stainless steel and cast iron) will corrode and disintegrate in the presence of oxidants such as oxygen and water, or acids forming rust. Furthermore the layer of rust doesn't provide a protective barrier to the iron, unlike the oxidation of other metals such as copper or stainless steel.

The Corrosion of a Stainless Steel Stomach

Stainless steel is an alloy of iron that contains elements such as chromium (10%), which react with the oxygen in air and water to form a stable film, thus protecting the iron from corrosion, however the majority material remains iron and still corrodes. This is the alloy of iron that shall be modelled as the stomach wall where it is presumed the stainless steel stomach will have the same thickness as normal average gastric wall thickness value of 5.1±1.1 mm [3].

The length of time stainless steel takes to corrode was tested in simulated gastric juice in vitro and the results concluded that for stainless steel razor blades with a maximum thickness of 0.3 mm [4] only 63% of their original weight was intact after 24 hours and this resulted in the sample being at a point where it was liable to fracture due to being so fragile [5]. Therefore this degree of corrosion is the point taken to be when the stomach would rupture, as the integrity of the metal stomach would be compromised to such a great extent that if it were the thickness of the stainless steel stomach wall, the gastric acid would begin leaking into the peritoneum. This can cause internal bleeding, peritonitis and septicaemia [6]. As the oxidation of stainless steel is different to the deterioration of a real stomach wall due to the materials being so different the damage required to rupture a real stomach wall is not considered in this model.

As the corrosion described in this paper will occur from both sides of the 0.3 mm razor blades, it is presumed if only one side of the material was exposed to gastric acid (this being the inside of the hollow sphere for the model stomach), it would take 48 hours to achieve the same level of corrosion. Due to the stomach wall having an average thickness of 5.1 mm and presuming the corrosion proceeds at a constant rate, due to the continuous secretion of gastric juices, the length of time before the stomach wall would rupture is shown by equation 2.

$$\frac{5.1}{0.3} \times 48 = 816\ hours \qquad (2)$$

This is equivalent to 34 days for the average stomach wall thickness. However, within the normal range given for stomach wall thicknesses this could drop to as low as 26.7 days (as shown by equation 3) or climb as high as 41.3 days (as shown by equation 4).

$$\frac{4.0}{0.3} \times 48 = 640\ hours \qquad (3)$$

$$\frac{6.2}{0.3} \times 48 = 992\ hours \qquad (4)$$

Conclusion

This model of a spherical stainless steel stomach gives a range of 26.7 days to 41.3 days until the stomach wall would rupture and gastric acid begins leaking into the peritoneum. For a cast iron stomach this would be a shorter length of time, as it has less capability to resist corrosion than stainless steel due to the lack of chromium and other such elements that would protect the iron from corrosion. In addition to this equation 1 denotes the production of gaseous hydrogen. This would have the affect of increasing the pressure inside the stomach thereby potentially rupturing the stomach prior to the calculated time at which the corrosion achieves this. The calculated times shown therefore represent the maximum time one could hope to live through before the onset of a ruptured stomach.

Therefore this paper concludes that there are no health benefits to having a cast iron stomach in so far as digestive activity is concerned.

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