The Death of King Charles XII of Sweden revisited

Juho-Antti Junno1,2, Markku Niskanen1, Heli Maijanen1, Jaakko Niimimäki3,4, Alina Junno1, Petteri Oura3,5,6

1 Department of Archaeology, Faculty of Humanities, University of Oulu, Finland
2 Department of Anatomy, Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Finland
3 Faculty of Medicine, Research Unit of Medical Imaging, Physics and Technology, University of Oulu, Finland
4 Department of Diagnostic Radiology, Oulu University Hospital, Finland
5 Department of Forensic Medicine, University of Helsinki, Finland.
6 Forensic Medicine Unit, Finnish Institute for Health and Welfare, Helsinki, Finland

Corresponding author:
Juho-Antti Junno, Department of Archaeology, University of Oulu 90014 Oulun Yliopisto, Finland.
email: juho-antti.junno@oulu.fi

Conflict of interest: Authors have no conflict of interest

Abstract

The death of King Charles XII of Sweden has been a topic of great interest and debate for more than three centuries. Was he assassinated by his own men or killed by the enemy fire? It seems clear that Charles was killed by a projectile perforating his skull from left to right. Clear consensus about the deadly projectile and its origin is still lacking although three autopsies and latest research techniques such as DNA-analyses are experimented to enlighten the case.

In this study we utilized a Synbone ballistic skull phantom and modern radiological imaging to clarify the factors and potential projectile behind the observed head injuries. In particular, we aimed to examine whether an ordinary musket ball fired from the enemy lines would be the most potential subject.

Our experiments with a leaden 19.5mm musket ball demonstrated that at 200-250m/s velocities it could cause similar type of head injuries as those observed in the remains of King Charles XII. This would have been a realistic velocity for a projectile shot from the enemy lines approximately 200m away. In case of assassination the projectile velocity would have been much higher and the head injuries more prominent.

The radiological imaging of the skull models supported the theory that the projectile in question was not leaden, as we could detect remnants of lead inside the wound channel unlike in Charles’ case. We could thus relatively reliably demonstrate that the projectile was not an ordinary musket ball but of some harder metal. In addition, our experiments showed that a musket ball of 19.5mm in diameter produces a hole considerably smaller than caliber into a felt material. Additional experiments with a 25.4mm steel ball indicated that a projectile of that diameter produces approximately 20mm hole in the felt. The main evidence supporting 19-19.5mm projectile size has been the hole of similar size in a hat that Charles was wearing during his death. As we could conclude that our musket ball experiments also resulted in considerably smaller cranial injuries than those in Charles’ case, it seems plausible that the projectile that killed Charles was not leaden and was larger than 19.5mm in diameter. Our findings thus support the theory that King Charles was potentially killed by an iron cartouche ball that was shot from the enemy lines.
Introduction

In November 1718, during the siege of Fredriksten, King Charles XII of Sweden was killed by a projectile fully perforating his skull. For 300 years the exact course of events has remained as a mystery. Several autopsies (in 1746, 1859 and 1917) have concluded that Charles died of a single projectile travelling through his head from left to right (Figure 1). Undisputed evidence about the projectile is however lacking (Key-Åberg & Stille 1918).

Although several theories suggest assassination (e.g. Nordling 1998, Clason 2001), a more natural explanation would be enemy fire (Grenander 1988). Many of these theories and even relatively recent scientific work are flavored with folklore and speculation (e.g. Nordling 1998) even though already Ahnlund (1926) criticized the use of folklore in this particular case.

The most recent autopsy was performed in 1917 (Key-Åberg & Stille 1918). Detailed external and internal examinations revealed major soft tissue and bone damage on the left and right sides of the head, corresponding to entrance and exit sites, respectively. Soft tissue damage on the left side took an oval shape with axes 47 mm and 37 mm. On the right side, soft tissue damage followed the shape of a circular segment, with a basis 30 mm and height 20 mm. The bony defect on the left was relatively circular with diameters 55-63 mm, while the defect on the right had an uneven shape and larger size with diagonals 55-75 mm.

The 1917 autopsy was supplemented with radiological imaging. As radiographs showed no traces of lead (Figure 2), it was argued that the projectile was of some harder metal (e.g. Nordling 1998). Iron for example was used in cartouche shots of cannons. In addition, a so-called bullet-button hypothesis (Sandklef 1941) suggesting that the projectile was originally a button shot from a musket, has gained popularity among scholars (e.g. Klein 1971). Even DNA-analyses have been performed on the button to enlighten its role as a deadly projectile (Petterson & Allen 2004).

King Charles died late in the evening while inspecting trench digging near the fortress. There is no detailed information about his exact position, however the closest distance to enemy lines was estimated to be 175m (e.g. Hultkvist 1937). At that time muskets could produce muzzle velocity of more than 400 m/s (e.g. Miller et al. 2019, Roberts et al. 2008) and from that distance the velocity would have decreased roughly by 200m/s.

Several studies have aimed to enlighten the details regarding the course of events. Using ballistic calculations, Grenander (1988) concluded that King Charles was killed by the enemy fire. The experiments of Hultkvist (1937) suggested that the projectile had the same diameter as a musket ball and was shot by the Swedish.

The projectile that killed Charles also pierced his felt hat leaving a hole of 19-19.5mm in diameter (Key-Åberg & Stille 1918). As entrance and exit tissue defects cannot confirm exact projectile size (e.g. Berryman 2019), the hole in the hat has been interpreted as a direct measure of the projectile diameter. The hat has thus been taken as a direct piece of evidence supporting the bullet-button hypothesis as the hole and the famous button are relatively similar in diameter (Sandklef 1941).

In this experimental study, we approached the death of King Charles XII of Sweden in a multimodal manner with modern forensic methods to enlighten the course of events. We hypothesized that latest ballistic phantoms aided by modern radiological imaging (e.g. Folio et al. 2011) would provide us with new detailed information about the material, velocity and size of the projectile.
Materials and methods

Shooting experiment

Altogether 12 shots were fired in this experiment (Table 1). Four included ballistic skull phantoms and eight tested different projectiles and velocities on felt hole measurements. Synbone generic 5mm thick 190mm sphere with artificial skin served as the ballistic skull phantom. Synbone sphere is widely recognized as a substitute of human head in ballistic and forensic experiments (Henwood et al. 2020, Smith et al. 2015). Spheres were filled with 10% gelatin prepared according to Jussila (2004). We attached two layers of 4mm thick industrial felt in front and behind the sphere to replicate the hat of Charles XII.

Only one type of projectile was used in skull phantom experiments. A round musket ball (diameter 19.5mm) was selected based on previous literature and especially the 19-19.5mm hole in the hat of Charles (Key-Åberg & Stille 1918, Hultkivist 1937). Musket balls were casted from pure lead and their weight ranged from 43.2 to 43.5g.

Remington SP-10 shotgun with 30” barrel length was used to shoot musket balls. We aimed to test three speed categories according to previous research on potential projectile velocity in impact (Hultkvist 1937, Grenander 1988). We were most interested in the speed of approximately 200m/s as that would be a realistic velocity for a musket ball fired from the fortress of Fredriksten some 200 meters from the death scene. Three different powder loads were selected to achieve musket ball velocities of 150, 200 and over 250 meters per second.

Test firing was performed at an enclosed shooting range following adequate safety measures. Skull phantoms were positioned on a solid, wooden platform. Shots were fired from a distance of 5m and ball velocity measured with a Caldwell chronograph. Entrance and exit wounds were immediately documented and measured (Figure 3).

Experiments with felt

We quickly became aware that the musket ball wasn’t always producing a clear round hole in the felt material attached to the skull phantom. We thus expanded our initial experiment and fired musket balls at 4mm industrial felt as well as handmade 3-5mm thick wool felt. Several velocities were experimented aiming to produce a round 19-19.5mm hole into felt. We also utilized a 28mm cannon to shoot a 25.4mm steel ball to replicate an iron cartouche ball.

Radiological imaging

Following the experiments, ballistics phantoms were examined using biplanar digital x-ray (DigitalDiagnost C90, Philips, Netherlands) with pixel size 143 μm and computed tomography (Aquilion One, Toshiba Medical Systems Corp., Tokyo, Japan) with voxel size 500 μm. We aimed to study wound channels and potential remnants of lead inside them.

Results

Experiment 1 provided a musket ball velocity of 193m/s. The ball weight reduced by 0.6g and its frontal half was clearly deformed. The ball perforated the felt and the phantom. The entrance wound was circular and approximately 21mm in diameter. The exit wound was more irregular, 25-30mm in diameter (Figure 4).
Experiment 2 produced a velocity of 194m/s. The ball deformation was similar to experiment 1. The entrance wound was circular, 20-22mm in diameter. Exit wound was larger, irregular and 25-35mm in diameter.

The ball velocity of experiment 3 was 265m/s. Ball deformation and weight reduction were similar to the previous experiments. However, the entrance wound was large and irregular with 50-55mm diameter. The exit wound on the other hand was smaller, just 20mm in size, but had clear fracture lines in a circular area approximately 50mm in diameter (Figure 5).

Experiment 4 produced a velocity of 152m/s. The ball weight reduced by 0.4g and the deformation was less visible than in previous shots. The ball perforated through the felt and the phantom, inflicting a circular entrance wound 20mm in diameter and an irregular exit wound approximately 25mm in diameter.

The additional experiments with different felt materials provided interesting results. A 19.5mm musket ball didn’t produce 19.5mm hole. The maximum hole diameter was just 17mm (Figure 6) and average diameter was 15mm. The hole shape was essentially round but somewhat irregular. Experiments with a cannon and a 25.4mm ball produced clearly larger, 20-21mm holes (Figure 7).

Radiological findings were clear and uniform with both biplanar and three-dimensional imaging. Remnants of lead were scattered all over the wound channel. In general, remnants were more concentrated around the entrance, but in the third shot a significant amount of remnant material was also near the exit. The amount of material was highest, and the size of individual remnants was smallest in the shot with 265m/s ball velocity (Figures 8-10).

**Discussion**

Our experiments supported previous conclusions that King Charles XII of Sweden was hit by a projectile that traveled approximately 200-250m/s. Although no remnants of lead were visually observed in the phantoms, lead material was clearly visible in radiography and CT. We could thus conclude that Charles was not killed by a leaden musket ball.

Entrance wounds in experiments 1 and 2 were round in shape and 21-22mm in diameter. Exit wounds were approximately 30mm in diameter and irregular due to large bone defects. Compared to the entrance and exit wound sizes observed in the 1917 autopsy (Key-Åberg & Stille 1918), our experiment produced clearly smaller wounds.

In experiment 3, entrance wound was much larger than in the two previous experiments. As such, an entrance wound could be larger than an exit wound if the projectile velocity in impact is high enough. In comparison to previous studies experimenting with animal skulls (Hultkvist 1937), experiment 4 indicated that even the musket ball velocity of under 150m/s was sufficiently high enough to perforate double felt and the skull phantom.

We could produce morphologically similar but smaller wounds compared to those observed in Charles’ head. The entrance and exit wounds in our experiments were considerably smaller than the ones measured from King Charles (Key-Åberg & Stille 1918). Although estimating caliber from a defect size is inaccurate (Berryman 2019, Ross 1996) our simulation suggests that the projectile in Charles’ case was larger than 19.5mm in diameter.
One of the most important pieces of evidence regarding projectile size has been the hat that Charles was wearing during his death (e.g. Sandklef 1941). A round hole of 19-19.5mm has been widely interpreted as the exact diameter of the projectile. Our experiments demonstrated that the hole in Charles’ hat was probably produced by a projectile significantly larger than 19.5mm.

The main strengths of this study are the usage of latest ballistic phantoms that provided us with homogenous and reliable test material, and use of CT for wound characteristics (e.g. Folio et al. 2011). Our study has also several weaknesses. Apart from excluding lead we could not confirm the projectile material. We are aware that an iron ball of larger diameter could produce injuries of different patterns and sizes, as it has different terminal ballistic behavior.

According to our findings, the most probable course of events leading to the death of King Charles XII of Sweden would be the following. A ball shaped projectile that was not leaden, travelled at a velocity of 200-250m/s and perforated through his skull. This velocity would be in line with muzzle velocities of 400-500m/s fired from a distance of approximately 200m. The round 19.5mm hole in his hat was at least slightly but potentially considerably smaller than the diameter of the projectile in question. Larger projectile size is also supported by the size of the bony defects in Charles’ skull.

The utilization of modern techniques has aided the investigation of several historical forensic cases (e.g. Bogdanowicz et al. 2009, Louhelainen & Miller 2020). Our experiment was not an exception, as we could reliably exclude two projectiles, leaden musket ball and the so-called bullet-button. Additional experiments are still needed to clarify the exact diameter and material of the projectile. According to the wound size and shape observed in the 1917 autopsy and the results of our experiments, it appears that the potential projectile diameter would have been larger than 20mm. According to Clason (1940) the smallest iron projectiles of cartouche shot at the time had a diameter of 21.9mm.

References


Clason U. 2001 Karl XII föll sannolikt offer för en kula från de egna linjerna [Karl XII was probably a victim of a bullet from his own troops]. Lakartidningen 98:5928. Swedish. PMID: 11806276.


**Data Availability statement:** All data is included in the manuscript and/or supporting information.
Figure legends:

Figure 1. A radiograph from the latest autopsy (KeyÁberg & Stille 1918) showing the wound channel and direction of the projectile.
Figure 2. Radiographs from the latest autopsy performed in 1917 (Key-Åberg & Stille 1918) show no traces of lead in the wound channel or elsewhere in the cranium.

Figure 3. The diameter of the entrance and exit wounds were measured using standard digital calipers. Two perpendicular measurements were taken and their mean was then calculated.
Figure 4. Entrance (a) and exit (b) wounds of the experiment 1.

Figure 5. Entrance (a) and (b) exit wounds of the experiment 3.
Figure 6. Typical musket ball hole in felt material was approximately 15mm and largest 17mm.
Figure 7. Experiment with a cannon and a 25.4mm steel ball. With a ball velocity of 214m/s the hole was approximately 20-21mm in diameter.
Figure 8. Perpendicular maximum intensity projection CT-reconstructions of a Phantom after experiment 3 showing the clustering of remnants around entrance and exit holes of a projectile. Entrance hole is on the left.

Figure 9. Remnants in a radiograph were typically submillimeter of size. Largest streaky fragments in experiment 3 were around 3 mm in length.
Figure 10. Fragments sized up to 7 mm were seen in the radiograph of the phantom after experiment 1.

Table 1.

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>velocity (m/s)</th>
<th>Bullet weight (g)</th>
<th>Weight reduction (g)</th>
<th>Entrance wound (mm)</th>
<th>Exit wound (mm)</th>
<th>Hole size (felt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Synbone</td>
<td>193</td>
<td>43,2</td>
<td>0,6</td>
<td>21</td>
<td>25-30</td>
<td>12mm</td>
</tr>
<tr>
<td>2 Synbone</td>
<td>194</td>
<td>43,4</td>
<td>0,5</td>
<td>22</td>
<td>25-35</td>
<td>14mm</td>
</tr>
<tr>
<td>3 Synbone</td>
<td>265</td>
<td>43,5</td>
<td>0,8</td>
<td>50-55</td>
<td>20 (50)</td>
<td>17mm</td>
</tr>
<tr>
<td>4 Synbone</td>
<td>152</td>
<td>43,4</td>
<td>0,4</td>
<td>20</td>
<td>25</td>
<td>11mm</td>
</tr>
<tr>
<td>5 Felt 4mm</td>
<td>227</td>
<td></td>
<td></td>
<td></td>
<td>16mm</td>
<td></td>
</tr>
<tr>
<td>6 Felt 4mm</td>
<td>258</td>
<td></td>
<td></td>
<td></td>
<td>15mm</td>
<td></td>
</tr>
<tr>
<td>7 Felt wool</td>
<td>236</td>
<td></td>
<td></td>
<td></td>
<td>13mm</td>
<td></td>
</tr>
<tr>
<td>8 Felt wool</td>
<td>178</td>
<td></td>
<td></td>
<td></td>
<td>15mm</td>
<td></td>
</tr>
<tr>
<td>9 Cannon</td>
<td>380</td>
<td></td>
<td></td>
<td></td>
<td>20mm</td>
<td></td>
</tr>
<tr>
<td>10 Cannon</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td>21mm</td>
<td></td>
</tr>
<tr>
<td>11 Cannon</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td>21mm</td>
<td></td>
</tr>
<tr>
<td>12 Cannon</td>
<td>214</td>
<td></td>
<td></td>
<td></td>
<td>20mm</td>
<td></td>
</tr>
</tbody>
</table>

First eight experiments are with a 19,5mm leaden musket ball and last four with a 25,4mm steel ball. First four experiments included Synbone phantom + felt and last eight just felt.