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Chronic lead intoxication from eating wild-harvested game

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Clinical Significance

- Individuals eating wild game harvested with lead bullets are at risk of lead exposure;
- There are >13 million hunters in the US, 95% of whom use lead bullets, and hunters typically share meat with family and the wider community;
- Non-lead bullets are available and considered a premium ammunition for firearms;
- Using non-lead ammunition reduces the risk of lead exposure to all individuals eating firearm-harvested meat.

Abstract

Purpose: To determine if conversion from eating wild game harvested with lead-based ammunition to non-lead-based ammunition results in lower blood lead levels.

Background: Supersonic injection of toxin-leeching frangible projectiles into food is intuitively bad. As much as 95% of the ~13.7m hunters in the United States choose shrapnel-inducing lead bullets to kill game; in addition, not harvesting meat is an incarcerable crime. A lead ammunition ban on certain federal lands was recently rescinded and The National Rifle Association refutes any risk from eating lead bullet-harvested game.

Methods: A patient subsisting solely on lead-shot meat was converted to non-lead ammunition and his blood lead level tracked. Concomitant with his conversion to non-lead ammunition, a controlled experiment was performed using the patient's bullets to determine his daily lead intake from lead-shot meat.

Results: While eating lead-shot meat the patient was consuming 259.3±235.6 µg of lead daily and his blood lead level was 74.7 µg/dl. Conversion to non-lead ammunition was associated with a reduced blood lead level.

Conclusions: Unsafe blood lead levels can occur from eating game harvested with lead ammunition. Physicians should warn hunting patients of this potential risk and counsel them regarding the availability of non-lead ammunition alternatives.

Introduction

There are ~13.7 m hunters in the United States[1] and approximately 95% choose shrapnel-inducing[2] lead bullets to kill game;[3] in addition, not harvesting shot meat is an incarcerable crime in the US.[4] Non-lead ammunition alternatives are available,[5] but hunters are unaware or contest the risk of lead exposure posed by lead ammunition. The National Rifle Association similarly disputes that wild animals, at a population level, are at risk from eating carrion shot with lead bullets and opposes restrictions on donating meat harvested with lead bullets to food banks.[6] Furthermore, the policy to ban lead ammunition by 2022 on certain federal lands was approved by the United States Fish and Wildlife Service in January 2017 but was rescinded in March 2017, the first day the new United States Secretary of the Department of the Interior was in office.

Case report

While hunting in the New Zealand bush, one of us (EJB) encountered a hunter who reported eating only meat shot with copper-jacketed lead bullets. We offered to measure his blood lead level which was 74.7 µg/dl. As the blood lead level of concern in New Zealand (and the United States) is 5 µg/dl, the local public health organization investigated and established the lead exposure was not occupational, environmental or residential.

The patient, a 54-year-old man with a self-perceived carbohydrate and lactose intolerance, consumed a diet consisting almost entirely of meat for six years: the last three years exclusively self-harvested meat using lead-containing bullets. His only remarkable medical problem is gout of which he had multiple attacks over the past three years affecting large joints but only two

affecting small joints. He has unexplained weight loss of 15 kg over the last 5 years, 9 kg over last 12 months.

His medical and neurological examinations were normal. His serum uric acid was 0.48 mmols/L (normal 0.20-0.42), and total urinary porphyrins and red cell zinc protoporphyrin were increased. There was no basophilic stippling of red cells and the remainder of his laboratory assessments were normal.

Dietary History

He consumed two weighed meals per day of either 750g ground meat (goat, red deer, or fallow deer) or one entire hare. Except infrequent home-killed beef, he had no other food besides self-harvested meat.

Lead levels in meat

X-ray analysis of lead-shot meat provided by the patient revealed numerous metal fragments (Figure 1). As the hunter was using copper-jacketed lead bullets (Figure 1B) the X-ray analysis did not allow us to determine the type of metal contaminating the meat.

To determine lead mass in the meat the patient was consuming, a controlled experiment was performed. Three feral goats where shot using the hunter's bullets (Figure 2A and B). The four quarters of the animals were processed using the patient's usual practice including the removal of any large fragments of lead found (Figure 2C).

Lead level analysis (Hill Laboratories, Hamilton, New Zealand) revealed that the front quarters of the goats contained higher lead levels than the rear quarters (Mann-Whitney Rank Sum Test; P=0.009). Based on these concentrations of lead (Figure 2D), and the known mass of meat consumed per day, we estimate that the patient was consuming 259.3 ± 235.6 µg of lead per day.

Converting patient to non-lead ammunition

We hypothesized that changing to lead-free ammunition would reduce the patient's blood lead level. The remaining lead-shot meat in his freezer was discarded and the patient converted to hunting with lead-free ammunition. Since conversion to non-lead ammunition his blood lead level has dropped significantly (ANOVA, P<0.0001; Figure 3). It is estimated that it will take ~15.8 years for his blood lead level to fall to 5 µg/dl (logarithmic regression; R^2=0.896; Standard Error of Estimate=3.812).

Discussion

The potential for lead intoxication from contaminated wild-harvested game is widely unrecognized. Our patient shows that elevated blood lead levels can potentially result purely from ingestion of meat harvested from game shot with lead-containing bullets: no other lead source could be identified and the lead levels improved significantly simply by changing the type of bullets used by the patient. His gout mainly affected large joints suggesting saturnine gout.[7] Our patient's measuring of meat intake allowed us to determine the approximate amount of lead he was ingesting. His sustained high blood lead level is consistent with significant stores of lead in his mineralizing tissue.

Correlations between individuals eating lead-shot meat and elevated blood lead levels have been reported,[3,8,9] however mitigating elevated blood lead levels through conversion to non-lead ammunition is novel. As meat from shot animals must be harvested[4] and is typically fed to family and shared throughout the wider community,[10] this lead-shot meat has the potential to impact more individuals beyond the ~13.7m hunters in the United States.[1] Obviously the sensitivity of children to elevated lead levels are of particular concern.

Despite availability of suitable alternatives to lead ammunition for hunting (Figure 1B),[5] most hunters are either ignorant of, or unaccepting of, the risks of lead ammunition. While a blinded controlled study would be necessary to conclusively demonstrate causality between the use of lead ammunition and elevated blood lead levels [11] such a study is potentially unnecessary given the strong plausibility that lead bullets represent the cause. In fact, lead-free ammunition is as effective as lead ammunition[12] and often considered a premium product setting the standard for accuracy and lethality with minimal additional cost.[13] Thus, physicians should make their patients aware of the potential risks associated with using lead bullets in harvesting wild game for consumption and suggest using the available alternative of lead-free ammunition.

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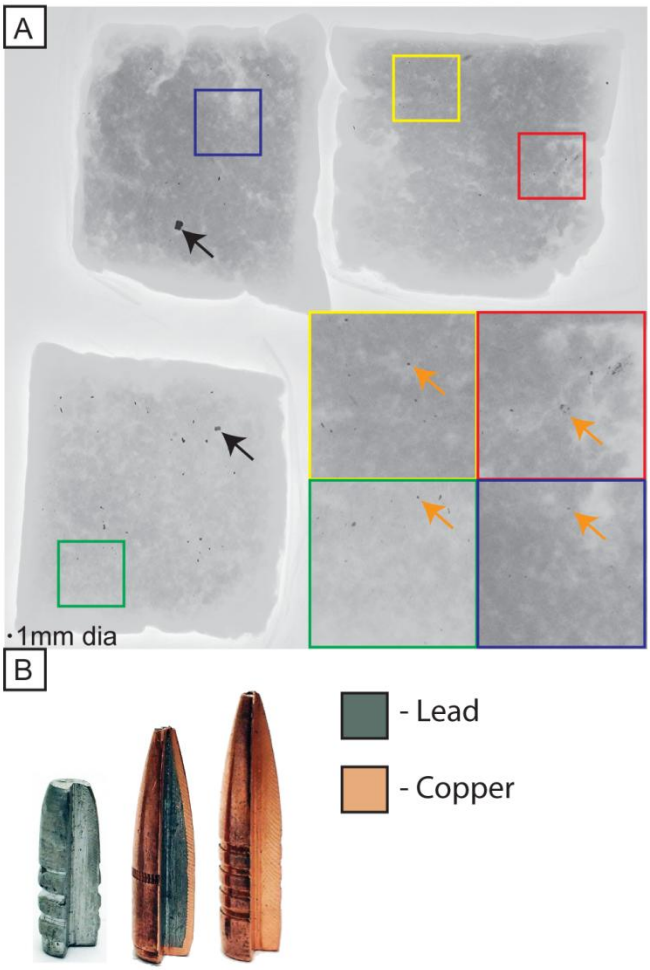
Figure 1. Samples of meat from the patient's freezer were analysed by X-ray to determine the presence of metal fragments. Two packages of ground deer meat (UL and UR) and one package of ground goat (LL) revealed a number of large metal fragments (black arrows) throughout the meat (Panel A). Each package of meat was approximately 1kg. Upon further examination at higher resolution it became clear that there were smaller metal fragments throughout the samples (orange arrows). When selecting bullets, hunters have a choice of materials. Three of the common options are lead bullets, lead-core copper-jacketed bullets or lead-free bullets (Panel B). All bullets shown are 165 grain, 30 calibre rifle bullets. Importantly, hunters may confuse the copper-jacketed lead bullets with bullets that are lead free as they have a copper jacket covering most of the lead core.

Figure 2. Feral goats harvested using the patient's lead bullets to estimate patient's lead intake. The entry (Panel A) and exit (Panel B) holes in each animal were documented. While processing the animals using the patient's standard protocol, large pieces of shrapnel found in the meat were removed (Panel C). Quantification of lead in the meat samples revealed a significant difference in the lead contamination in in the front quarters compared to the read quarters (Panel D). Based on the average lead concentration in the meat harvested and the patient's daily consumption of 1.5 kg of meat, the patient was consuming 259.3 +/- 235.6 µg of lead per day.

Figure 3. Patient blood lead levels (BLLs) dropped with conversion to non-lead ammunition. BLLs were monitored before and following the patient's conversion to using non-lead ammunition. Extrapolating these data, the patient's blood lead levels would reach 5 µg/dl in approximately 15.8 years.



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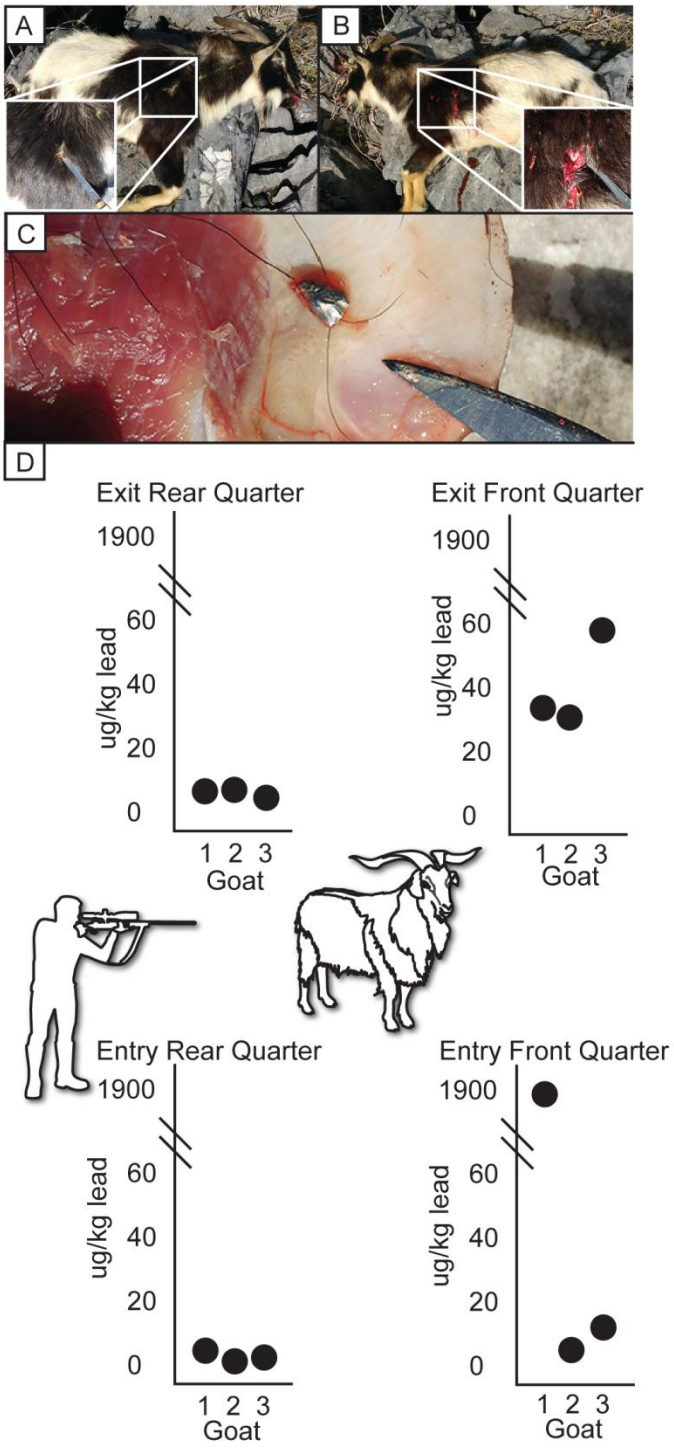

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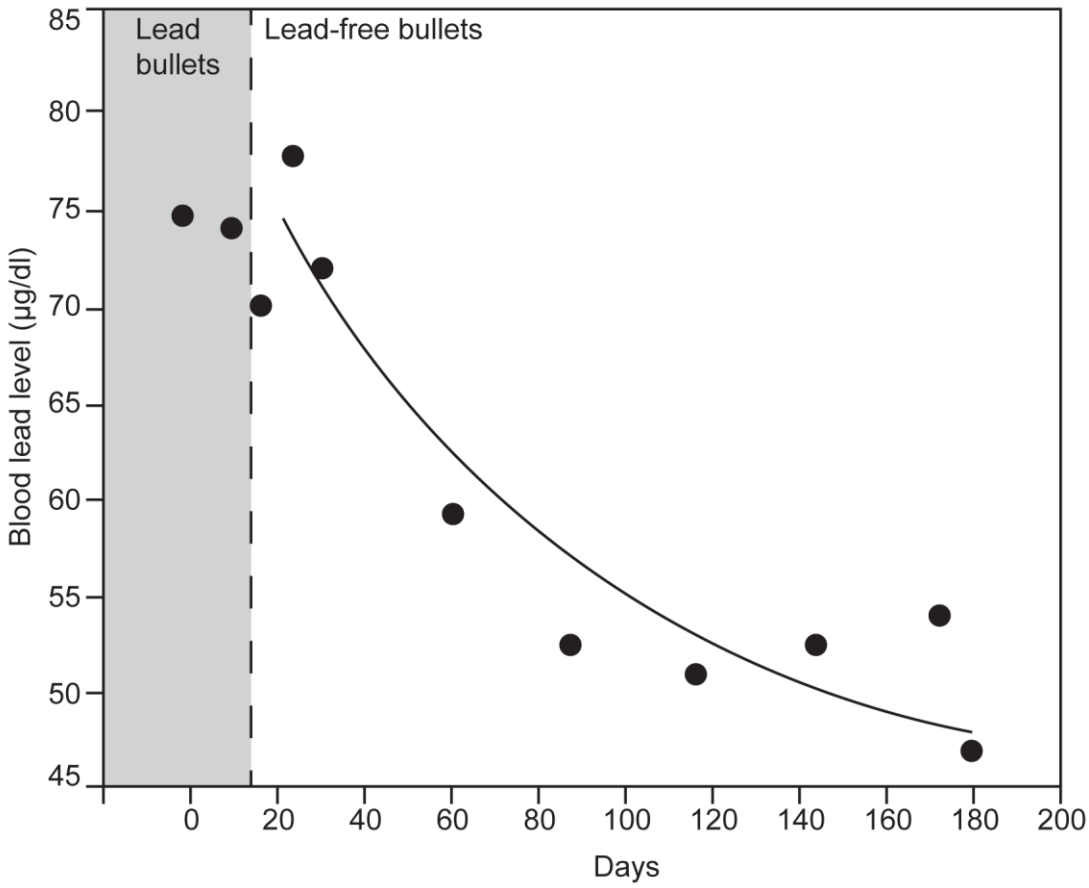

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