Lead Pellet Ingestion in First Nation Cree of the Western James Bay Region of Northern Ontario, Canada: Implications for a Nontoxic Shot Alternative

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ABSTRACT

Subsistence hunting for Cree of the western James Bay region of northern Ontario, Canada, is a way of life. In this study, it is shown that ~15% of the radiographic charts examined had evidence of pellets contained in the gastrointestinal system, intraluminally, and/or in the appendix. It is assumed that the consumption of game with lead shot embedded in the tissue was the source of the pellets. Because the presence of lead shot in the human gastrointestinal tract appears to increase the body burden of lead and considerable evidence is available on the occurrence of lead poisoning in waterfowl due to the ingestion of lead pellets, it is suggested that the use of lead shot should be discontinued nationwide in Canada. Although bismuth/gun shot has been growing in appeal because of several recent waterfowl studies demonstrating its nontoxic nature, caution is advised because of the uncertainty about the toxicity of bismuth in humans, especially when consumed as whole pellets or fragments in wildmeats. We maintain that the nontoxic alternative of choice at this time is steel shot.

INTRODUCTION

Recently, the use of lead shot for waterfowl hunting has been banned in the United States due to the deleterious effects of lead on waterfowl (U.S. Fish and Wildlife Service [USFWS] 1988). Moreover, lead shot has been banned for all types of hunting in Denmark and the Netherlands (Scheuhammer & Norris 1995). In Canada, authorities intend to ban nationwide the use of lead shot for hunting migratory game birds beginning in 1997 (A.M. Scheuhammer, unpublished information sheet distributed to First Nations, 1996). At present, there exists only a limited number of Canadian "nontoxic" zones where the use of lead shot is prohibited (DeStefano et al. 1991; Scheuhammer & Norris 1995). Indeed, Canadian authorities have little data on the effect of spent lead shot on migrant waterfowl while in Canada (Schwab & Daury 1989), except for several recent studies (e.g., Schwab & Daury 1989; DeStefano et al. 1991; Kennedy & Nadeau 1993; Scheuhammer & Norris 1995). Consequently, lead shot is still widely used by sport and native Canadian hunters.

The western James Bay region of northern Ontario is populated by native Cree (Canadians) who reside in six communities: Moose Factory, Moosonee, Fort Albany, Kashechewan, Attawapiskat, and Peawanuck. First Nation Cree of the James Bay area have hunted waterbirds on traditional hunting grounds for generations (Feit 1986). Large amounts of spent lead shot are deposited annually into the wetlands and muskeg of the region. Traditional hunting grounds are tracts of land used annually by individual family groups or an entire community. Hundreds of traditional grounds are found throughout the western James Bay region (B. Katapatuk, Moose Cree First Nation, Moose Factory, Ontario, pers. comm.). Subsistence hunting is a way of life to the Cree.

There has been growing concern among First Nations of the region that the lead shot used in

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hunting may be adversely affecting the environment, wildlife, and people of the region. Growing concern can be attributed to personal observations by the hunters and to date contained in four studies.

- Bortner et al. (1991) have related decreasing numbers of Canada geese in the region to poor productivity. This decrease, in part, may be lead related.

- In 1987, the Ontario Ministries of Health and the Environment (OMHE) conducted the Northern Ontario Blood Survey of children, which included the town of Moosonee as a remote site (OMHE 1989). The children of Moosonee were found to have higher blood lead levels than children in the other northern towns or urban centers. This result was unexpected because Moosonee is located in a remote area where water and soil lead levels were found to be very low and air lead levels were well below the Ontario Ambient Air Quality Criterion of $5 \mu g/m^3$ (OMHE 1989).

- A follow-up study was recently conducted in Moose Factory and Moosonee (Ontario Ministry of Health [OMH] 1993). Although blood lead levels were found to be reduced, likely due to the advent of unleaded gasoline, lead levels for these two communities were still comparable with southern Ontario urban centers (OMH 1993). The source of lead was not identified, although it was suggested that lead shot or lead-contaminated wildmeats might be a source (OMH 1993).

- In a study of environmental contaminants in the western James Bay region, preliminary findings indicated that cord and maternal blood lead correlate with the consumption of a traditional diet of wildgame (fowl and mammal). Cord and maternal blood lead levels were highly correlated and of similar magnitude. Thus, wildgame appears to be a significant source of lead exposure in adults (females) and during prenatal development (Hanning et al. 1996).

Three possible sources of lead exposure from the consumption of wildgame killed with lead pellets have been suggested for humans (Scheuhammer & Norris 1995): (1) ingestion of wildgame with tissue-bound lead (OMH 1993); (2) ingestion of wildgame containing lead pellet fragments (Frank 1986); and (3) ingestion of whole pellets embedded in wildmeats (Madsen et al. 1988).

Although it has been suggested that it is a relatively common occurrence to see radiographic evidence of lead shot in the gastrointestinal tract of native people or others who regularly eat wildgame (Carey 1977; Weeneebayko General Hospital, Radiology Department, pers. comm.), it has never been shown quantitatively. Such data are of considerable importance because it has been shown that blood levels were elevated relative to controls ($P < 0.02$) in patients with lead shot retained in the appendix (Madsen et al. 1988). Further, Madsen et al. (1988) report that such individuals had elevated blood lead levels. Moreover, there is evidence that lead objects that have been ingested and shown to be located intraluminally in the gastrointestinal tract can cause lead intoxication in children (Biehhusen & Pulaski 1956; Greensher et al. 1974). Thus, lead pellets do not have to be located in the appendix to be a source of lead exposure in humans. It appears that any ingested lead pellets can add to an individual’s body burden of lead.

In this article, we quantify the radiographic evidence for abdominally retained lead shot in First Nation Cree of the western James Bay region, northern Ontario, Canada. We also examine non-toxic shot alternatives in terms of human health concerns about the inadvertent consumption of pellets in wildmeat.

**METHODS**

Weeneebayko General Hospital is the regional health center for the western James Bay area, supplying services to the six coastal communities. Radiographs from all the communities are stored centrally at the hospital for 5 years and then destroyed. Approximately one-third of the radiographs archived for the years 1990–1995 were examined in this study for radiographic evidence of lead shot ingestion. Demographic data (age and sex) for the patients were also recorded. All radiographic charts were randomly selected from the inventory. Only views of the abdomen or of the kidney, ureter, and bladder were included in the study because these were the only views that provided an adequate representation of the digestive tract. Radiographs of children under the age of 3 months were excluded from the study because
wildmeat ingestion would naturally be minimal for this group. Exclusion on this basis amounted to 4% of the total radiographs examined. It should be noted that patients did not present for examination based on symptoms associated with lead intoxication. Thus, the finding of ingested lead shot in the radiographs was purely incidental.

The prevalence of ingested lead shot (the percentage of individuals examined with round radiopaque signatures, namely, small, circular, white spots) was calculated separately for intraluminal location (not in the appendix) and presence in the appendix. Data were analyzed using statistical routines contained in the SAS package (SAS Institute 1982). The age of individuals with or without radiographic evidence of lead shot ingestion was compared using a Wilcoxon rank-sum test.

TABLE 1
A comparison of age (Wilcoxon rank-sum test) for individuals with and without radiographic evidence of lead shot ingestion.

<table>
<thead>
<tr>
<th></th>
<th>Age (± sd; years)</th>
<th>Range</th>
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<tbody>
<tr>
<td>No lead shot</td>
<td>112</td>
<td>30 ± 21</td>
<td>2-88</td>
</tr>
<tr>
<td>With lead shot</td>
<td>20</td>
<td>47 ± 20</td>
<td>20-89</td>
</tr>
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1Significant at the P < 0.01 level.

RESULTS

Of the 132 radiographic charts examined (abdominal and/or kidney, ureter, bladder views), 64 were from female patients and 68 were from male patients. Radiographically, there was evidence that 15.2% of these subjects (total, n = 20; females, n = 9; males, n = 11) had ingested lead pellets (Figure 1). Approximately 8% of the total sample had lead pellets located intraluminally in the gastrointestinal tract, compared to ~7% in the appendix. The number of ingested lead pellets observed in a positive radiograph had a range of 1-4. Individuals without radiographic evidence of lead shot ingestion were significantly younger (P < 0.01) than those with such signature (Table 1).

DISCUSSION

In this article, it is clearly shown that the ingestion of pellets is common and related to age in the Cree of the western James Bay region of northern Ontario. Numerous studies (e.g., Horten 1933; Balch & Silver 1971; Reddy 1985; Durlach et al. 1986) have suggested that wildmeats impregnated with lead shot are the probable source of the lead pellets found in the human gastrointestinal tract. If one takes into account that >20% of previously wounded but "healthy" North American waterfowl (e.g., geese and ducks) contain embedded lead shot (USFWS 1986), then the probability that Cree are ingesting lead shot is high. Lead shot ingestion can be reduced if the wildgame is thoroughly chewed before swallowing (Durlach et al. 1986). However, this cannot always be accomplished if a person is partially edentulous (i.e., a decrease in proprioception), as is the case for a large portion of the native population in the western James Bay area (L.J.S. Tsuji, unpublished data). Presumably, this partially edentulous state enhances the probability of ingesting pellets. Furthermore, older individuals likely have an additional risk of doing so because among them the traditional diet is more common.

Although most ingested foreign bodies pass harmlessly through the gastrointestinal system, being eliminated with the feces (Hillman 1967), some objects (including lead pellets) can be retained intraluminally (Greensher et al. 1974). Because lead pellets are small, heavy, rounded objects, they are propelled by their own weight from the
semiliquid content of the cecum into the lowest portion of the cecum and the area of the appendix (Balch & Silver 1971; Reddy 1985). Normally, the mild peristaltic action of the appendix expels a foreign object. However, when the foreign body is small and heavy (as in lead shot), this action may not be sufficient for clearance (Balch & Silver 1971; Reddy 1985). Thus, lead pellets may partially or fully occlude the lumen of the appendix, which may result in the formation of a mucocoele or frank perforation (Balch & Silver 1971). Perforation of the appendix has been reported in native Canadians by Carey (1977). He describes two cases associated with lead shot seen during a 6-month period at Moose Factory General Hospital (now Weeneebayko General Hospital). In the first case (Inuit female, 56 years old), a mass within the upper rectum was removed that contained ~100 shot. The second case required an appendectomy to remove >500 pellets from the appendix. Although perforation of the appendix may require surgical intervention, no causal relationship has been shown to exist between the retention of lead pellets and appendicitis (Reddy 1985). The main human health concern from the ingestion of lead pellets appears to be related to the potential of systemic exposure to lead (Green- sher et al. 1974; Madsen et al. 1988). Interestingly, the Canadian Wildlife Service (CWS) has stated that “if a risk to human consumers of waterfowl were identified, this would be of primary importance in establishing further restrictions on lead” (Wendt & Kennedy 1992).

Increased body burdens of lead are of concern because lead has long been recognized as a developmental neurotoxin (U.S. Centers for Disease Control [USCDC] 1991). Numerous studies in children have shown that neuropsychological functions inversely correlate with lead levels even when confounding variables are controlled for (Needleman et al. 1979; Winneke et al. 1982; Lyngbye et al. 1990; Rabinowitz et al. 1991; International Programme on Chemical Safety [IPCS] 1995). Furthermore, evidence in children suggests that blood lead levels of ~0.5 µmol/L (100 µg/L), the level of medical concern as defined by the U.S. Centers for Disease Control (USCDC 1991), may impair hearing and nerve conduction in the auditory system (Schwartz & Otto 1991). Perhaps, there is no safe level of lead exposure, as has been suggested by several investigators (Flegal et al. 1990; USCDC 1991).

Lead has been shown to cause other systemic health effects in humans. Specifically, lead can exert its toxicity at the level of the kidneys, haem biosynthesis, reproduction, and pre- and postnatal development (Mushak et al. 1989; IPCS 1995). Zelkoff et al. (1993) have recently provided evidence from animals that inhalation of particulate lead not only reduces pulmonary macrophage function but also alters the activity of the tumor necrosis factor in the absence of “predictive” elevated blood lead levels. It should be noted that human hunters using lead shot are also exposed to airborne leads through the ignition of primer (lead stphynate) and from the mechanical abrasion of leaded ammunition as it passes through the barrel (Valway et al. 1989). Epidemiological evidence also suggests that chronic low-level lead exposure is linked to a slight elevation of blood pressure, although the role of confounding factors in this statistical association is not clear (Sharp et al. 1987; IPCS 1995). Clearly, there is growing evidence that the use of lead shot for all types of hunting should be discontinued, taking into account not only wildlife health concerns (reviewed in USFWS 1986) but also human health concerns. An ecosystem perspective is warranted in dealing with this case.

In the past, the recommended nontoxic alternative to lead shot in the United States and Canada (as well as other countries) has been steel (soft iron) shot (Scheuhammer & Norris 1995). Steel pellets are ~68% as dense as lead pellets of the same size (specific gravity of Pb, 11.3; Fe, 7.9) and are significantly harder than is lead shot (Brister 1992; Scheuhammer & Norris 1995). The hardness of steel pellets results in decreased pellet deformation, denser patterning, shorter shot strings, and increased probability of barrel damage (in thin barrelled guns) compared with lead pellets of the same size (Brister 1992; Scheuhammer & Norris 1995). Also, the lower density of steel pellets (important in retaining velocity and penetrating power) requires the use of steel pellets at least two sizes larger than the lead pellets normally used (Brister 1992). Steel shot is less “forgiving” than is lead shot, and its optimum use is sensitive to the technique used and the skill of the shooter. For this reason, steel shot has not been readily embraced by sport hunters, and alternatives continue to be sought (Brister 1992).

One alternative that has been receiving good reviews (e.g., Brister 1992) for having ballistic characteristics similar to lead is bismuth shot (specific gravity of Bi, 9.7). Moreover, recent waterfowl dosing studies with bismuth shot have provided favorable evidence that it is nontoxic to


