Presumed Migration of an Intra-Abdominal Copper Fragment

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ABSTRACT

A 29-year-old male presented for evaluation of a persistently draining thigh wound three weeks after he was struck in the abdomen and left thigh by three one to two centimeter sized copper-containing casing fragments. He reported urinary urgency. Radiographs obtained of the abdomen and left thigh revealed two intra-abdominal fragments. Contrast computed tomography was ordered to further evaluate the location of the fragments and possible cause of urinary urgency. The fragments did not affect the ureters, abdominal vasculature, or other viscera. The patient then developed profuse, watery diarrhea presumed to be secondary to ingestion of contaminated water. Stool studies were positive for Giardia, and he was treated with metronidazole. The patient continued to have sporadic diarrhea and intermittent left lower quadrant discomfort. After further imaging, the left fragment position remained unchanged, but the right fragment was no longer present. There was no cecal deformity or evidence of fistula or abscess. This case is the first documented instance where a copper-containing body most likely eroded through the GI tract.

INTRODUCTION

In 1992, it was demonstrated that metallic copper reproducibly produces a significant inflammatory reaction in living tissue.1 The clinical significance of this finding was unclear at that time and remains so, except for when nervous tissue or the eye is involved. However, the intensity of the inflammatory reaction is sufficient enough that copper-containing bodies could theoretically erode into critical structures. The occurrence has been previously suggested by case reports of copper-containing objects migrating through the lung. We present here the first documented instance where this most likely occurred in the GI tract.

CASE PRESENTATION

A 29-year-old male was seen three weeks after being struck with three one to two centimeter sized casing fragments blown back from the breech of an incompletely closed 50mm
machine gun. One fragment hit the left medial upper thigh, and the other two entered the abdomen above the pelvis. He was initially evaluated at an aid station where he was found to be hemodynamically stable. His wounds were debrided and the abdominal injury was evaluated by peritoneal lavage, which was apparently negative since he received no treatment beyond dressing changes. He was sent to the medical area for care and wound evaluation. He was seen there during his convalescence, primarily to evaluate the persistently draining thigh wound. During evaluation, he reported a sensation of urinary urgency present since his evacuation. He denied suprapubic pain, dysuria, hematuria, and fever.

Examination showed a male patient who was in no distress with a tiny draining wound with some granulation on the left medial thigh. Two healed wounds, each was approximately a centimeter in size, were also noted on the abdomen. The wounds were located on a horizontal plane about one-third of the distance between the pubis and the umbilicus, the first near the left lateral to the midline, and the other about 4 cm to the right of midline. The remainder of the physical exam was unremarkable.

Radiographs were obtained of the abdomen and left thigh. In addition to a small fragment lying immediately adjacent to the femur, two intra-abdominal fragments were seen. One of these lay to the left of the midline deep in the pelvis, and the other lay in the right lower quadrant (Figure 1). Prompted by urinary urgency and the concern that the left fragment might be compromising the ureter, a contrast enhanced computed tomography (CT) scan was ordered to determine the location of the fragments. The military physician instructed the patient to return for further evaluation.

Two weeks later, he returned to clinic for follow up of the CT. At this time urinary symptoms had resolved without treatment and the leg wound had closed completely. During this period, he developed profuse, watery diarrhea. Considering the patient may have been exposed to contaminated water while performing his military duties, stool cultures were ordered. Stool studies were positive for Giardia, and the diarrhea improved after a course of metronidazole. The CT showed the right fragment lying immediately beneath the cecum, without evidence of wall deformity or intrusion (Figure 2). The left fragment was lying on the pelvic wall, well away from the ureter or any other significant structures such as major vessels (Figure 3). When the right fragment’s retrocecal position and proximity to the bowel was initially discovered, its high copper content did raise concern. Removal at that time, however, seemed extreme since the potential for injury was at best theoretical. The reviewing radiologist had recommended further evaluation with a water contrast enema at the time of the CT and both were performed.

Figure 1. Two fragments are visible in the original film obtained three weeks post injury.
He was then briefly lost to follow-up. When he returned to clinic twelve weeks post-injury and six weeks post-CT, he was still experiencing sporadic diarrhea. In addition, he now reported daily episodes of intermittent left lower quadrant discomfort. The discomfort worsened with exercise and was relieved by rest. The discomfort was not associated with any gastrointestinal dysfunction. It was decided this discomfort was unlikely to be related to either of the fragments.

After another series of delays secondary to problems with patient follow-up, the water contrast enema was accomplished six weeks after the CT. The left fragment had remained in the same position and was grossly unchanged in size. The right fragment, however, was absent (Figure 4A, 4B). There was no cecal deformity and no evidence of either a fistula or an abscess. By this time, all of his symptoms including his diarrhea had resolved, and he had returned to duty with no further medical intervention.

**DISCUSSION**

The degree of the tissue reaction produced by exposure to copper is not commonly appreciated. Within hours of implantation, copper generates an intense inflammatory response in tissues in which it is lodged. This inflammatory reaction over the course of about three weeks progresses to form a stable “sterile abscess” filled with a greenish exudate.

This reaction and the lack of reaction to zinc, the other major component of military brass, has been previously described. The exact mechanism of action is unclear but has been suggested to be due to both the galvanic activity of the metal in physiologic solution and the production of toxic salts. Recent analysis of the exudate has shown it contains increased levels of lactate dehydrogenase (LDH). This finding suggests that whatever the mechanism, at least some of the toxic effect is on the cell membrane, leading to lysis.

In a standardized murine model, these lesions are remarkably uniform and well encapsulated no matter which tissue type is involved. The lesions are fully formed by three weeks and remain uniform in size for at least one year. There seems to be a very slow continuous leaching of copper from the specimen, but no other observable change occurs.

Preliminary studies have also shown that implanted copper does have a tendency to migrate when placed under one-sided pressure such as when trapped under an elastic area like
the skin. It will also migrate under the influence of gravity when placed in loose tissue such as the lung.\(^1\) No tendency toward erosion into adjacent tissues, especially bowel or vascular structures, has been demonstrated.\(^1\)

The literature is replete with anecdotal examples of foreign bodies that have migrated from their original locations.\(^3^-^9\) These have included reports of erosion into bronchi,\(^4^-^6\) as well as one incident of probable erosion into the bladder.\(^7\) No suggestion of erosion and subsequent migration into bowel has ever appeared in the literature. The actual composition of these migrators is seldom found in the reports.

If the foreign body is specifically noted to be a bullet of military origin, one may assume it contains significant copper content, since for the last 100 years most military ammunition, including that produced in the United States, has been jacketed with some form of gilding metal. Military gilding metals and jewelry bronze, which is used when civilian projectiles are jacketed, are a combination of mainly copper and zinc, with a majority of the alloy being copper.

As an example, in a report of erosion into a bronchus by Langer et al., the reader can clearly see from the photograph of the projectile that it is a jacketed military type bullet casing.\(^4\) Some low velocity civilian projectiles, especially those used in police work, are likewise jacketed. A report of one such projectile that had eroded into a bronchus and was subsequently expectorated did indeed involve bronze jacketing per the reporting author; however these examples are the exception. More commonly the composition of the offending fragment can only be guessed.

The likelihood of a copper-containing object either migrating and/or eroding seems to be in
part dependent on the makeup of the tissue. A copper-containing foreign body is more likely to migrate in less dense tissues such as the lung. This seems to be at least in part due to pressure imparted by gravity. Copper migration through nervous tissue is also well known.\(^{10-12}\) No reports of migration have been published concerning copper fragments located in more dense tissues like the liver.

Erosion into tissues with a significant muscular component, such as the cardiovascular system, also seems to be rare. In 1966, Bland and Beebe reviewed 40 cases of soldiers with metallic foreign bodies embedded in the cardiac muscle 20 years after being wounded in WWII.\(^{13}\) Of these 40 foreign bodies, five were recorded as “bullets,” and, presumably, were jacketed since the injuries occurred in combat. The patients in this study were followed through the Veterans Affairs (VA) hospital. All the individuals in the study were able to be located at the 20-year review. No fragment, copper-containing or not, had migrated or eroded during the period reviewed.

In contrast to erosion, bullet embolization through the vascular tree has been frequently reported. When this has occurred it has almost always been during or shortly after the traumatic event and most likely represents partial or complete traumatic entry into the vessel.\(^{5,8,14,15}\) Only two contrary reports are found in a review of the literature. In the first report, a copper BB is noted to have embolized in the carotid artery several days after initial injury. No hemorrhage occurred in conjunction with this event; however the time period involved makes it more likely to be at least partially due to erosion rather than simply a traumatic entry.\(^{16}\) In a second case, a projectile was likewise reported as eroding into the carotid artery and embolizing at least three days following the initial injury, again without hemorrhage occurring. In this case, however, the fragment was an airgun pellet and almost certainly composed mainly of unjacketed lead.\(^{17}\)

It would seem that dense and/or muscular structures are at least somewhat less susceptible despite the presence of inflammation. Even in the lung, where migration is not unusual, erosion into the bronchi is still relatively rare. When erosion has occurred in these circumstances, it has characteristically been attributed to infection.

Erosion from laparotomy pads and other retained foreign bodies into the bowel following surgical procedures is well known.\(^{18}\) Erosion from metal fragments, on the other hand, has never been reported, although one might reasonably expect that it also may occur. While in the case presented here it is impossible to prove that this is indeed what happened, it is difficult to postulate any other mechanism for the events as they occurred. The fragment may have dissolved, eroded externally, or eroded into an adjacent structure and excreted in order to disappear as it did. The first possibility is particularly unlikely in light of the lack of change in the remaining fragment. Likewise, had it eroded externally and been expelled at skin level, the patient would certainly have been expected to notice. Additionally, there should have been a visible wound where it exited. Given its location, lack of proximity to any major vessel, and the lack of any localizing findings, erosion into the vascular system and subsequent embolization does not seem probable. Erosion into and passage through the bowel is the most reasonable explanation. The role the copper content of the fragment played in the whole process is unknown at present, but given the known reaction and its behavior elsewhere, it should to be considered.

The appropriate clinical course for the clinician faced with a foreign body of probable copper composition remains unclear. While the limited laboratory evidence suggests that there is no risk
of any untoward results from leaving it in place, clinical experience is beginning to suggest otherwise. With the exception of the central nervous system and the eye, there is no incident in the literature where a catastrophe occurred as the result of such a fragment not being removed. In the case cited here, where erosion into the bowel is the most likely occurrence, it was a benign event. That may in part have been due to its protected retrocecal position. The question of whether a leak and spillage would have occurred if the fragment had instead come to rest on the peritoneal surface of the bowel is not answerable at present.

In conclusion, the presence of a copper-containing foreign body in a location of potential harm may require consideration for removal. Even though current laboratory models suggest no risk, better models may be warranted to aid our understandings of the consequences of leaving cooper fragments in the body. For the time being the decision remains strictly based on individual circumstances and the surgeon’s judgment.

**REFERENCES**


**LEARNING POINTS**

1. The body’s reaction to copper-containing foreign bodies may warrant further investigative studies to determine the best clinical course.

2. The tissue reaction produced by exposure to copper generates an intense inflammatory response in tissues in which it is lodged.