Intimal Asteroid Bodies in Horses: Light and Electron Microscopic Observations

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Abstract. The morphology of asteroid bodies in equine arteries is demonstrated by light microscopy as well as by scanning and transmission electron microscopy combined with chemical analysis.

Asteroid bodies first occur in horses at four weeks of age in all investigated tissues except the esophagus and always are located in the subendothelial space. The number, shape, ultrastructure and chemical composition of asteroid bodies differ markedly—depending on the age of the horse. Asteroid bodies are round and smooth in foals, but are shaped irregularly and have several projections and marked stratified calcification in adult horses. Asteroid bodies probably originate from smooth muscle cells. No direct etiological connection between asteroid bodies and migrating Strongylus vulgaris could be verified.

Asteroid bodies in small arterial vessels in horses have been identified as intimal bodies, asteroid calcification, and asteroid degeneration; they were described first in 1869.1 When limitations of methods available in the middle of the last century are considered, Bollinger gave a precise and detailed description of asteroid bodies and said they occur in the submucosa of the intestinal tract.

Descriptions of asteroid bodies now have been published several times, and several causes, including post-mortem phenomena2 and senility,2 have been discussed.2,5,7–9,11 The etiology and pathogenesis of these asteroid bodies, which are detectable only in horses, still are unknown.

Materials and Methods

Fifty-one horses, including five fetuses, seven one- to 30-day-olds, five 31- to 90-day-olds, and 34 horses over 90 days old were necropsied. Light microscopy was done on formalin-fixed, paraffin-embedded tissues stained with hematoxylin and eosin, alcian blue, von Kossa’s and periodic acid-Schiff (PAS). The intestinal tract from three horses was fixed for 24 hours and cut into 5-mm sections. After washing out the agar, tissues were stained with alizarin red. Unstained semithin sections fixed on copper nets were used for the energy dispersive X-ray analysis by electron microscopy at 12.5 kv acceleration voltage.

Results

Asteroid bodies were found in 17 tissues in adult horses. The only tissue examined that was free of asteroid bodies was the esophagus (fig. 1). They are found most frequently in the gastrointestinal tract. Asteroid bodies were not found in fetuses, but were found in one four-week-old foal and always in horses over one month of age (fig. 2).

With the dissection microscope and alizarin red staining, black and spot-like structures were spread irregularly on the surface of the arteries (fig. 3). Only a few were found in foals, but there were many in adult horses.

Light microscopy

Asteroid bodies were clearly visible in the subendothelial space, particularly using PAS reaction in paraffin-embedded tissues or toluidine blue-stained semithin sections (fig. 4). In foals (fig. 4b), a mild splitting of the internal elastic lamina was apparent, especially when
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Fig. 1: Incidence of asteroid bodies in various tissues. Ordinate: percent incidence.

Fig. 2: Incidence of asteroid bodies at different ages. Shaded area = asteroid bodies present; white area = no asteroid bodies present; abscissa = age of horses in days; ordinate = number of horses investigated.

Fig. 3: Arteries with clear visible spot-like asteroid bodies; marked differences in number of bodies between foals (a) and adult horses (b). Alizarin red. Foal, ten weeks; horse, four years.

compared with normal areas (fig. 4a). The ovoid asteroid bodies bulged slightly into the lumen of the vessel. In adult horses the bodies were larger and had more prominent structures. The bodies seen in horses two months old and older always had a positive reaction with von Kossa’s stain, and the bodies possessed several radiating projections (fig. 4c). Hyperplasia of the tunica media often was detectable; sometimes there was an occlusion of arteries due to asteroid bodies (figs. 4d, 4e). Both findings were seen, particularly in horses older than ten years.

Electron microscopy

Scanning electron microscopy at low magnification revealed bodies evenly distributed at the intimal surface (fig. 5). Asteroid bodies from foals had round, dune-like vaults (fig. 6a), and borders of endothelial cells were easily visible. In adult horses, more irregular forms with projections and peaks were dominant (fig. 6b). These structures sometimes resulted in endothelial damage.

The earliest alterations seen with transmission electron microscopy were distinct activation and proliferation of smooth muscle cells, plus the splitting of the internal elastic lamina and a mild endothelial vacuolization and subendothelial edema. Cells were more polygonal and had projections towards the intima—sometimes they penetrated the elastic lamina (fig. 7).

Early stages of asteroid bodies had lamellar structures and fragments of nucleus-like figures in the center (fig. 8). They were limited by a small electron-dense border; the endothelium still was coherent. In some horses, mononuclear cells adhered to the endothelial surface and covered the asteroid bodies. In adult horses, a
Fig. 4: Light micrographs of asteroid bodies in horses. a: Normal section of artery. b: Ovoid asteroid body in foal. c: Asteroid body with radiated projection; adult horse. d: Cross section of artery with several asteroid bodies, hyperplasia of tunica media, and adventitial proliferation. e: Nearly total occlusion of vessel due to asteroid bodies and edema of media. a, b: Foal, three months; c: horse, six years; d, e: horse, 17 years. a, b, c: Toluidine blue. d, e: von Kossa’s.

concentric stratification of calcified rings appeared and the asteroid configuration was clear (fig. 9). Membranous structures no longer were found. Collagenous fibers increased in the tissue surrounding the bodies, and the elastic membrane was sometimes reorganized.

Chemical analysis

Results of the energy dispersive-X-ray analysis showed that the asteroid bodies of adult horses (fig. 10) consisted primarily of phosphorus and calcium, while the calcium content in foals is low (fig. 10a). The chlorine detected resulted from epon in the semithin section (fig. 10d). Figure 10c shows the measurement of the arterial wall with no asteroid body.

Discussion

The dissecting microscope is very useful for orientation to study tiny calcifications in blood vessels stained with alizarin-red. The spot-like structure of asteroid bodies was very evident with this method.

The appearance of the bodies by light microscopy corresponded to previous descriptions. Morphologic differences in asteroid bodies are seen most clearly in toluidine blue-stained semithin sections. Shape, size and distribution of asteroid bodies on the surface of the artery and their bulging towards the lumen could be seen best by scanning electron microscopy. This method had not been used prior to this study.

The structures visible in the center of asteroid bodies in foals may result from degenerating nuclear or cytoplasmic components—probably from smooth muscle cells. The first lesions detected in these arteries were subendothelial edema, and activation and proliferation of smooth muscle cells. Cells or parts of cells migrated through the gaps of the internal elastic lamina, and presumably formed the initial stages of asteroid bodies. We did not see these stages in the horses we investigated—perhaps because of the small number of horses studied by electron microscopy.

Repair after mechanical injury of arteries by migrating *Strongylus vulgaris* in horses included smooth muscle cells, which penetrated the internal elastic membrane near a thrombus caused by the larvae. No mineralization was mentioned by the authors. Similar findings have been described in aging dogs and were interpreted to result from deterioration of the metabolism of smooth muscle cells. This could be one reason for asteroid bodies in horses.

Chemical analysis of asteroid bodies was done for the first time in this study. Calcium and phosphorus were the primary components of the bodies. Compared with foals, the calcium rate increased in adult horses—an indication of a secondary calcification of asteroid bodies. Although calcification of so-called “ghost-bodies” that developed from aortic smooth muscle cells was described in monkeys, there probably is no connection to the pathogenesis of equine asteroid bodies, nor are asteroid bodies similar to calcinosis in horses.

Asteroid bodies were found only in horses four weeks of age or older and occurred in all tissues investigated with the exception of the esophagus. The number of bodies in the arteries, the light microscopic and ultrastructural morphology, and the chemical composition...
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Fig. 5: Scanning electron microscopic survey of artery with many asteroid bodies on surface. Horse, six years. Bar = 100 μm.

Fig. 6: High magnification of asteroid bodies. a: Foal, three months; clearly visible endothelial cell borders (arrow). b: Adult horse, six years; projections (P) directed towards lumen. Bar = 10 μm.

Fig. 7: Activated smooth muscle cells (M) with several pointed branches (arrows); sometimes passes internal elastic lamina (EL). L = arterial lumen; E = vacuolated endothelial cell. Foal, three months. Bar = 10 μm.

depend on age. By light microscopy, we found positive von Kossa’s staining only in horses two months of age or older—in contrast to others who reported that all bodies contained calcium.\(^1\)\(^1\)

Obviously asteroid bodies are not a postmortem phenomenon\(^2\) and, since they are detectable in foals, asteroid bodies surely are not a lesion of senility as was presumed.\(^2\) They probably result from degenerating smooth muscle cells or their processes that migrate through the split internal elastic lamina to the subendothelial space.

The etiology of asteroid bodies in horses is still unknown. The cause mentioned most frequently is invasion by *Strongylus vulgaris*,\(^3\),\(^5\),\(^7\) whose fourth stage larvae migrate along these arteries. The frequent appearance of asteroid bodies in the gastrointestinal tract may indicate parasitic origin. There probably are other etiological factors, for example, mechanical strain on the arteries or toxic influences. Furthermore, there may be a relationship to equine calcium metabolism. Horses have blood calcium values about 10% higher than many other species, and post-ileal secretion of calcium by unknown mechanisms has been reported in horses.\(^10\)

Future investigations with parasite-free foals should clarify the parasitic cause of asteroid bodies in horses. Calcium secretion should be investigated to find a possible relationship to origin and calcification of asteroid bodies.
Fig. 8: Asteroid body with thin endothelial covering (E) in foal; membranous and nucleus-like fragments (arrows). Foal, three months. Bar = 1 μm.

Fig. 9: Calcified asteroid body in adult horse; concentric stratification and radiated projections (P) surrounded by collagenous fibers (C); endothelial cells with vacuoles (arrow). M = smooth muscle cells; L = arterial lumen; E = endothelial cell. Horse, six years. Bar = 10 μm.

Fig. 10: Chemical analysis. a: Asteroid body in foal. b: Asteroid body in adult horse. c: Arterial wall with no asteroid body. d: Epon. Phosphorus is main component of asteroid bodies; calcium content low in foal (10a) and unaltered arterial wall (10c) but increased in adult horse (10b); high chlorine content from epon. VFS = vertical full scale; a. 256; b., c. 1 K = 1000; d. 128; CA = calcium; P = phosphorus; CL = chlorine; AL = aluminium; SI = silicon; K = potassium; MG = magnesium.
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References


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