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Mobile Encapsulated Adipose Tissue (MEAT) of Cows and Humans: A Distinct Nonneoplastic Entity

Walter H. C. Burgdorf, MD[1] and Mark A. Hurt, MD[2]

Abstract

Mobile encapsulated adipose tissue can be found in both the subcutis and peritoneal cavity. The cutaneous lesions are more common and better described; they are usually designated as "mobile encapsulated lipoma" or "nodular-cystic fat necrosis." The clinical name of *abacus tumor* describes best the small marble-like nodules that often can be moved freely through the subcutaneous tissue planes. Histopathologically, the nodules are composed of a dense fibrous capsule surrounding fat that may show varying degrees of necrosis, calcification, and lipomembranous changes. The peritoneal nodules are thought to originate from detached epiploic appendices. They are described occasionally in humans but more commonly in cows. Because these bovine mobile peritoneal bodies are clinically and histopathologically identical to the nodules in human subcutaneous tissue, the authors suggest that one can better understand both processes by comparing them. Because the lesions are reactive, not neoplastic, and necrosis is not an invariable feature, the authors suggest the neutral designation of mobile encapsulated adipose tissue.

Keywords

mobile encapsulated adipose tissue, abacus tumor, mobile encapsulated lipoma, nodular-cystic fat necrosis, peritoneal loose bodies

Introduction

When 2 lesions look identical both grossly and microscopically but arise in completely different clinical settings, one can attempt to learn from the similarities or simply ignore them, assuming there is not and cannot be a pathophysiologic connection. One such situation is the mobile encapsulated adipose tissue nodules encountered occasionally in both the subcutaneous tissue and peritoneal cavity of humans and cows. We review lesions identified in both of these contexts and speculate on how they might be related.

The Abacus Tumor

One of the truly puzzling cutaneous lesions encountered by clinicians is the "abacus tumor," a name coined by the Shelley and Shelley[1] to describe a marble-like, subcutaneous mass that is freely mobile, often over distances of several centimeters. Figure 1 is an exemplar of the phenomenon presenting over the ulnar aspect of the forearm, an area often exposed to trauma. This particular nodule had a range of mobility spanning about 15 cm.

Many colorful descriptive terms have been attached to such lesions, including "marble," "BB,"[2] "white Chinese go stone,"[3] "thigh mouse,"[4] and "hard-boiled egg."[5,6] Histological names have included "mobile encapsulated lipoma,"[7] "nodular-cystic fat necrosis,"[2,8] "encapsulated fat necrosis,"[9] and "encapsulated adiponecrosis."[10] We address in detail below this befuddling array of scientific names. The great puzzle has been and remains: How can a viable structure move so far? Does it have a thin tethering vascular supply, as Shelley and Shelley postulated, or can it be maintained by diffusion of essential nourishment from the surrounding tissues?

Abacus tumors in humans are usually on the extremities, less often the trunk, but generally in areas subjected to trauma. These nodules are usually less than 30 mm in diameter. Lesions often "pop out" of the skin through a simple incision. There is a white capsule apparent grossly; the cut surface is yellow, white, or mixed. The microscopic features are distinct. There is a fibrous capsule that

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Figure 1. Abacus tumor: mobile subcutaneous massive
Reproduced courtesy of E. Dorinda Shelley, MD.[1]

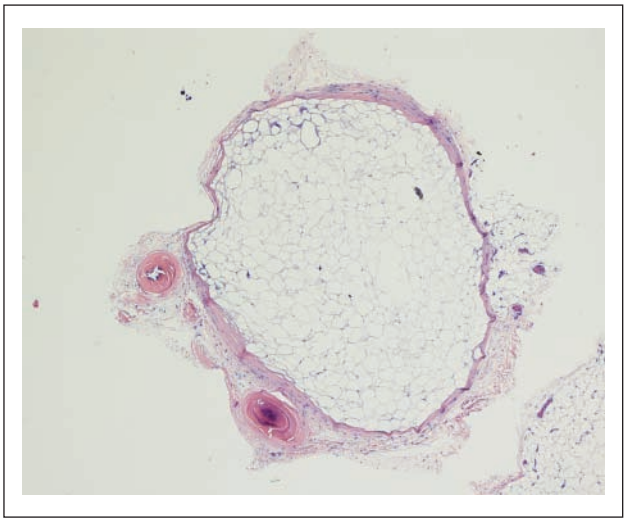

Figure 2. Mobile encapsulated adipose tissue
This lesion is composed of partly necrotic adipose tissue surrounded by a fibrous capsule. Although the adipose tissue looks viable at this magnification, it is necrotic at the periphery. Some of the lipocytes toward the center retain their nuclei.

encases adipose tissue (Figure 2). The adipose tissue inside can be normal, but often there are areas of necrosis,

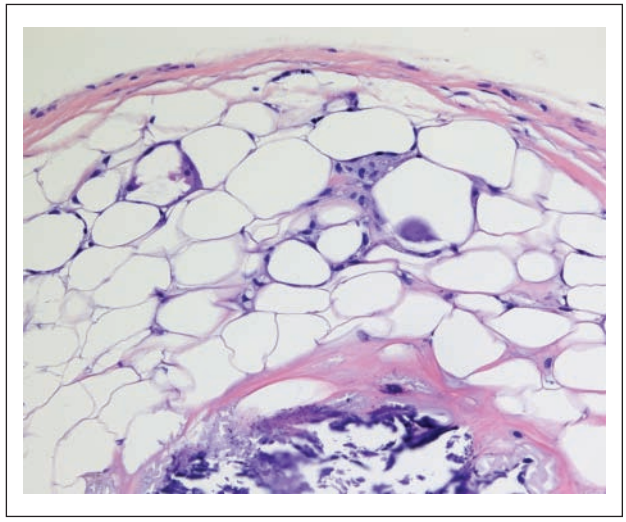

Figure 3. Mobile encapsulated adipose tissue
The periphery is encapsulated, and the lipocytes are necrotic, mostly maintaining their outlines with a few macrophages. Note the calcification at the bottom; this is dystrophic calcification within the necrotic adipose tissue.

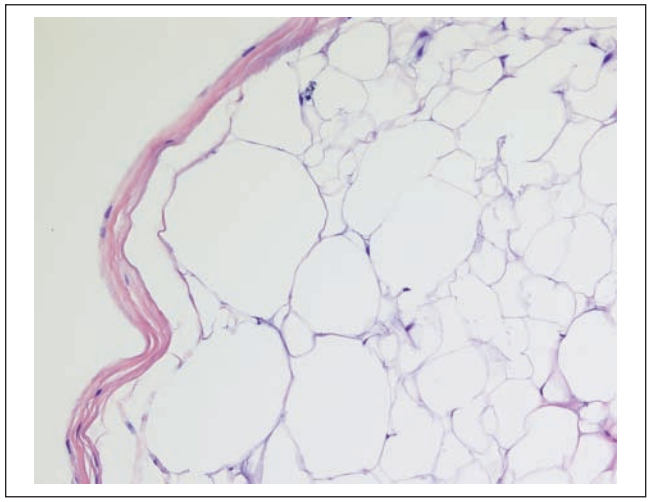

Figure 4. Mobile encapsulated adipose tissue
The lesion is surrounded by a thin, fibrous capsule. Some of the lipocytes are larger, but most of them retain their nuclei. This is, presumably, an early lesion because of the relative viability of the lipocytes. Some are, however, necrotic.

inflammation, fibrosis, calcification (Figure 3), and lipomembranous changes (Figure 4). Neither gross nor microscopic examination reveals a feeder vessel.

The history of these lesions in humans is complex. There have been a number of articles addressing mobile fat bodies, but few contain photomicrographs of sufficient quality to allow interpretation. Although Bowen[11] has been credited with describing such lesions in humans in 1912, his report is probably that of an angiolipoma with some of the lesions being entirely vascular. Another report by Graham

Little[12] a year later, clearly described angiolipomas. After these 2 early efforts, little was published for almost 50 years. When encapsulated fatty bodies were described, they were confused with angiolipomas and other lipomatous tumors.

The first major article aimed at organizing the subject of angiolipomas was that of Howard and Helwig,[13] who reviewed 288 angiolipomas from the Armed Forces Institute of Pathology. Although they describe an encapsulated tumor, they stated that angiolipomas were similar to lipomas but with a variable vascular component. In 1974, Lin and Lin[14] reviewed 25 angiolipomas, which they divided into encapsulated and infiltrative. The former were said to have a thin capsule and were always painful; thus clinically they were quite different from abacus tumors.

By definition, angiolipomas are composed histopathologically of increased numbers of small vessels within the fatty stroma; the small vessels at the periphery often contain fibrin thrombi. We do not believe that abacus tumors and encapsulated angiolipomas are different presentations of the same condition; rather, we believe they are easily distinguished separate entities.

The first publication that led to our current understanding of these lesions appeared as late as 1975, when Schmidt-Hermes and Loskant[15] described encapsulated calcified fat necrosis of the female breast, illustrating small fatty nodules with a thick capsule. The first article that addressed directly the cutaneous abacus tumor was that of Przyjemski and Schuster,[2] writing in the pediatric literature in 1977. They used the term *nodular-cystic fat necrosis* to describe the findings in 4 teenagers who had mobile subcutaneous masses in areas of trauma. Three of the 4 patients had solitary lesions, their size ranging from 40 to 120 mm. Microscopically, the lesions showed a thick capsule that enclosed pseudocystic spaces. No epithelial lining was identified. In one instance, there was fat necrosis with an inflammatory response.

A few months later, in 1978, Sahl[7] published similar cases. He used the phrase "mobile encapsulated lipoma" to report the findings in 2 patients—a young man with multiple mobile nodules, and an elderly man with a single lesion that was mobile with a range of 15 cm. He described firm, round ivory-colored nodules ranging in size from 5 to 35 mm, which had a firm yellow cut surface but no obvious connecting blood vessels (Figure 5). Histologic examination revealed a thick fibrous capsule enclosing a fatty core with few small vessels and no necrosis (Figure 6). Sahl emphasized that mobile encapsulated lipoma was not related to angiolipoma.

A decade later, Hurt and Santa Cruz[8] described 5 patients with similar lesions under the name of "nodular-cystic fat necrosis." Most of these lesions were associated with a history of trauma, and the nodules were removed easily. Their size varied from 1 to 15 mm. They identified lesions

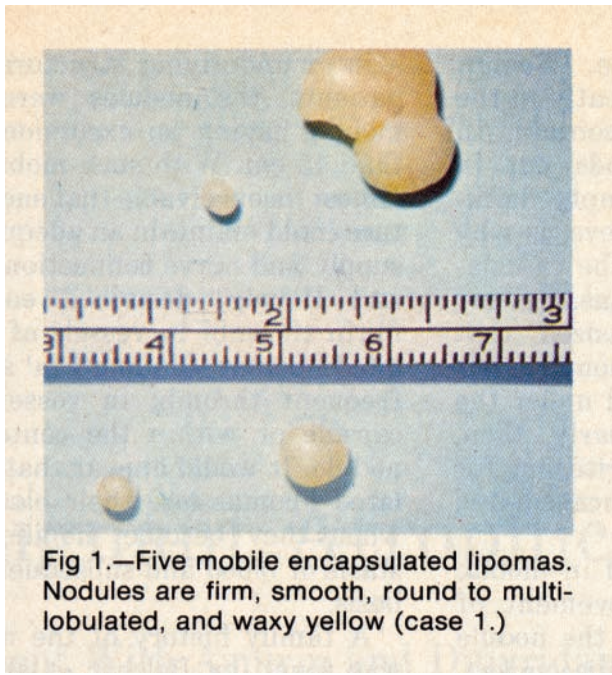

Figure 5. Gross photograph of 5 mobile encapsulated lipomas
Reproduced from Sahl's paper with permission from the American Medical Association.[7]

in various stages of evolution from clearly viable to apparently nonviable tissue. For instance, there were encapsulated lobules of adipose tissue with adipocytes containing nuclei juxtaposed to adipocytes without nuclei. Some areas contained zones of necrotic adipocytes without nuclei (Figure 7). They proposed a plausible pathophysiological mechanism—small lobules of adipose tissue might be traumatized, lose their vascular supply, and become separated from surrounding tissue—resulting in lesions developing ultimately into a mobile nodule with a capsule. They accepted the name "nodular-cystic fat necrosis" that was originated by Przyjemski and Schuster because of the fact that the lobules of fat necrosis popped out of a pseudocystic cavity when the skin over them was incised. Hisa et al[3] later built on Hurt and Santa Cruz's sequential description and suggested that the lesions might be absorbed as one possible endpoint of the natural history, but the thick fibrous capsule makes it seem unlikely to us that such lesions could disappear.

Curiously, there has also been a veritable explosion of cases from Japan, starting with Kikuchi et al's[16] original report in 1984 and a letter in the same year where Kikuchi[10] suggested the term *encapsulated adiponecrosis*. A review by Kiryu et al[9] in 2000 identified 25 previous cases in the Japanese literature, to which they added 8 more cases. One year later, Azad et al[4] produced the most colorful term *thigh mouse* to describe a 2-cm thigh mass that was movable over a distance of 20 cm.

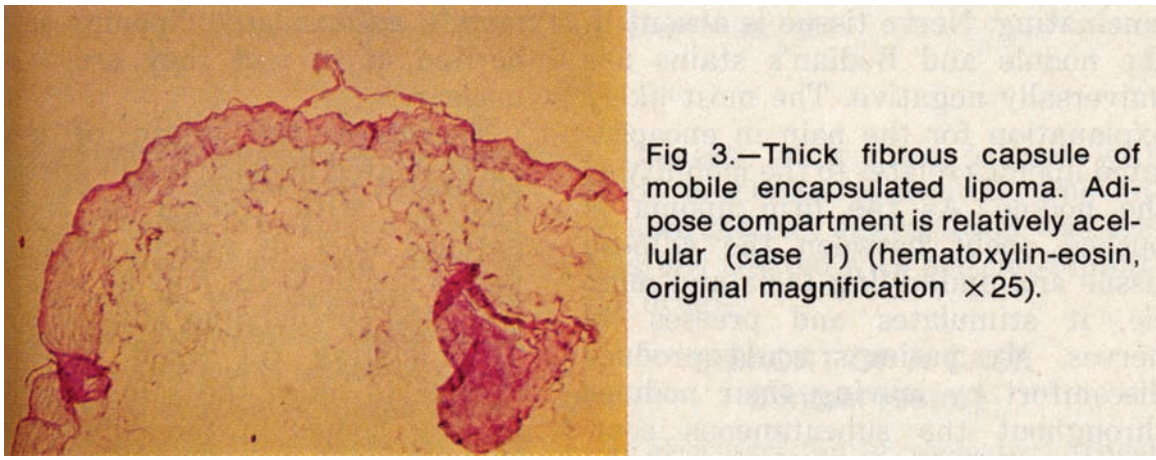
Fig 3.—Thick fibrous capsule of mobile encapsulated lipoma. Adipose compartment is relatively acellular (case 1) (hematoxylin-eosin, original magnification ×25).

Figure 6. Photomicrograph showing thick fibrous capsule and normal adipose tissue
Reproduced from Sahl's paper with permission from the American Medical Association.[7]

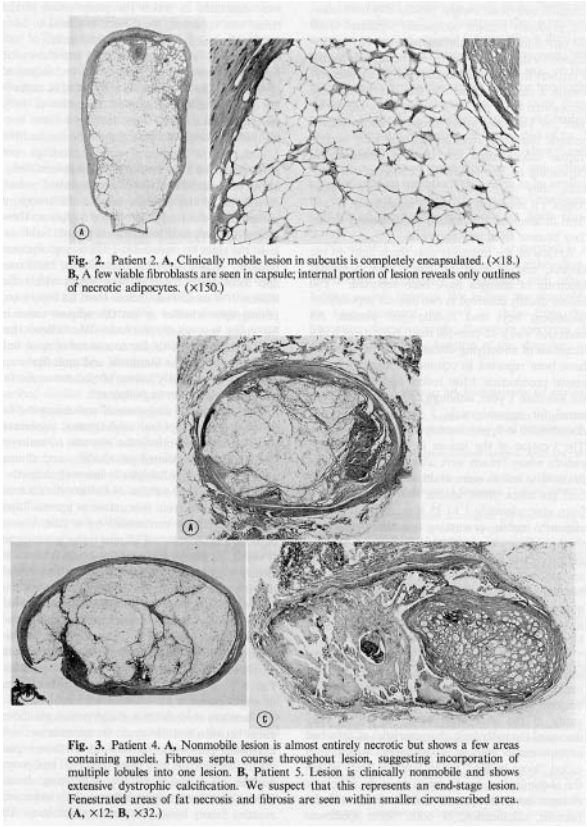
Fig. 2. Patient 2. A, Clinically mobile lesion in subcutis is completely encapsulated. (×18.) B, A few viable fibroblasts are seen in capsule; internal portion of lesion reveals only outlines of necrotic adipocytes. (×150.)

Fig. 3. Patient 4. A, Nonmobile lesion is almost entirely necrotic but shows a few areas containing nuclei. Fibrous septa course throughout lesion, suggesting incorporation of multiple lobules into one lesion. B, Patient 5. Lesion is clinically nonmobile and shows extensive dystrophic calcification. We suspect that this represents an end-stage lesion. Fenestrated areas of fat necrosis and fibrosis are seen within smaller circumscribed area. (A, ×12; B, ×32.)

Figure 7. Multiple photomicrographs of several different nodules showing fibrous capsule surrounding fat with varying degrees of necrosis and calcification
Reproduced from the paper by Hurt et al with permission from Elsevier.[8]

Lipomembranous or membranocystic changes in encapsulated fat nodules were first identified by Pujol et al.[17] They detailed several cases where the fat contained cysts with crenellated hyaline membranes. This change is identified frequently in damaged fat, following trauma or impaired vascular supply, so it is not surprising that it can appear also in encapsulated fat necrosis when the vascular supply to a lobule is interrupted. Another common histologic finding is calcification; in a patient with Ehlers-Danlos syndrome, both calcification and lipomembranous changes were identified in numerous mobile nodules.[18] Oh and Kim[19] reported the findings in a Korean man who had 2 lesions on his shin, both of which showed extensive calcification and lipomembranous changes.

Larger mobile lesions, albeit less clearly encapsulated, have also been described. The most dramatic description was the so-called "battered buttock syndrome" in which large chunks of fat were detached from their subcutaneous anchoring after massive trauma to the buttocks. Here, necrosis dominated and no capsule was formed.[20] In another instance, a 14-cm mass was described adjacent to an appendectomy scar.[21] It featured cystic changes, prominent lipomembranous change, and recurred after simple excision. Another egg-sized mobile lesion was described under the anterior serratus muscle; it was proposed as a giant variant of the condition.[5]

Peritoneal Loose Bodies

There is very little literature on peritoneal loose bodies in humans. The most widely cited article is from the Mayo Clinic in 1956 by Lynn et al,[22] who speculated that the

epiploic appendices—small fat-filled peritoneal pouches along the distal colon and proximal rectum—could become detached and evolve into free-floating nodules. Rosai[23(p2396)] offers the same explanation, while Vuong et al[6] described a similar lesion. The most recent article on the subject by Huang et al[24] reported a patient with ileus and 30 loose bodies, which on microscopic examination revealed "many layers of laminated fibrous tissue with sparse cellular components."

In contrast with humans, peritoneal loose bodies appear to be quite common in cows. One of the authors visited the Clinic for Cattle at the University of Veterinary Medicine in Hannover, Germany: He was allowed to observe an intra-abdominal operation on a cow and was very surprised to see the surgeon extract a small ivory marble from the peritoneal cavity of the animal and dispose of it. He inquired about the object and was told such nodules were common and not submitted for pathological examination. Later his tour included a stop in the pathology department, where he mentioned that he had seen clinically identical lesions removed from the subcutaneous tissue of humans and they were invariably encapsulated collections of fat. A joint project was born.

Over the course of a year, we collected 14 lesions[25]; all were incidental findings during laparotomies that were performed for a variety of indications, including displacement of the abomasum (the fourth and final stomach of cows), rumenotomy because of an ingested foreign body in the rumen (first stomach), and Cesarean section. All the lesions were firm, mobile, ivory-colored nodules with a distinct capsule ranging in size from 6 to 80 mm; they were manually removed easily during exploration of the abdominal cavity. None showed bleeding or vascular connections. On gross sectioning, they were firm and had a yellow cut surface (Figure 8). Microscopically, they had a fibrous capsule usually surrounding fat, which showed varying degrees of necrosis and fibrosis (Figure 9). In some cases, the entire mass was fibrotic, just as the case of Huang et al.[24] Since cows have many epiploic appendices, we suspect these are the sources for their peritoneal loose bodies. We are not aware of any other reports on these relatively common bovine nodules.

Figure 8. Gross photograph of mobile encapsulate adipose tissue from peritoneum of a cow
Reproduced from the paper by Herzog et al with permission from Elsevier.[25]

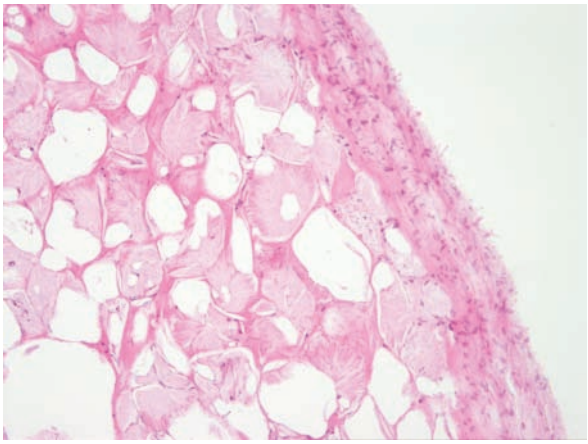

Figure 9. Lesion from a cow showing thick fibrous capsule and necrotic fat

Discussion

We were most struck by the identical gross and microscopic appearance of 2 totally unrelated lesions—displaced pieces of epiploic fat in the bovine peritoneal space and small encapsulated nodules of fat in the human subcutaneous tissue planes. One of us, an experienced dermatologist who had encountered just a handful of such cutaneous cases, was able to instantly identify the nature of the peritoneal loose body removed during the first bovine operation he witnessed. His host, an experienced bovine surgeon, had seen hundreds of such lesions over a 5-decade career but never worried about their origin.

We suggest that both subcutaneous and peritoneal mobile encapsulated adipose tissue arise in the same way. Small lobules of fat are separated from the neighboring tissue thus losing their vascular supply; these lobules are often damaged in the process. In time, they develop areas of inflammation, lipomembranous changes, or necrosis (or all of these), sometimes accompanied by calcification. The septal fibroblasts are still capable of proliferation and produce a fibrous capsule, which, over time, can become very thick. In some cases, especially in the peritoneum, the

lesions may become entirely fibrous, as described by Huang et al.[24] The process is easier to visualize and more common in cattle because of the numerous epiploic appendices that are relatively easily twisted and detached. In the subcutaneous tissue, trauma must lead to the breaking off of a lobule of fat which then can slide between subcutaneous planes.

We believe this process is different from the situation in which a foreign object such as a BB becomes entrapped in a fibrous bed. In the latter scenario, the tissue fibroblasts react to the foreign object, whereas in both abacus tumor and peritoneal loose bodies, the fibrous capsule most likely originates from the septal fibroblasts because the lesion is mobile with no attachment to the adjacent tissue. The lesions are present for so long that one can assume that they must acquire nutrients by diffusion, at least in some phases of their natural history. We are skeptical of the claims that they are resorbed or have elongated umbilicus-like feeder vessels.

We also reject the hypotheses that these lesions are related to angiolipomas or neoplastic in nature as suggested by Trapp and Baker,[26] who believed that the lesions were benign neoplastic proliferations of adipocytes with eccentrically placed nuclei and no necrosis. The presence of necrosis in some lesions is indisputable; whether it is an early event following whatever dislodges the fat mass and interrupts its vascular supply or whether it occurs later when supply of nutrients is perhaps tenuous remains unclear.

Finally, an appropriate name for these distinctive lesions remains a point of controversy; each of the proposed names for the skin nodules has a weakness, to wit:

- *Abacus tumor*[1] describes the lesion clinically, but it does not address the pathophysiology of the lesion.
- *Mobile encapsulated lipoma*[7] is technically incorrect, because we do not believe this lesion is a neoplasm but the result of separation of fat with secondary changes.
- *Nodular-cystic fat necrosis*[2,8] has been criticized because it is too easily confused linguistically with other forms of fatty inflammation, especially subcutaneous pancreatic fat necrosis. In addition, it does not emphasize the invariable capsule, and it overemphasizes the necrosis. The same applies to *encapsulated fat necrosis*[9] and *encapsulated adiponecrosis*.[10]
- *Mobile encapsulated bodies comprising fat necrosis and fibrous tissue* was the name demanded by the editor and reviewers of our recent article on the bovine lesions.[25] Although this phrase incorporates what is identified both clinically and histopathologically, it is not a crisp, catchy name.

As with the naming of any group of concrete findings under the banner of a concept, it must be done by its essential features. We are sure that most people will continue to refer to this fascinating lesion in the skin as a *mobile encapsulated lipoma*, but we propose the phrase *mobile encapsulated adipose tissue*, or *MEAT*, as a more accurate description. In addition, the same name could be applied equally well to the peritoneal free bodies.

Declaration of Conflicting Interests

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