

Forelimb amputation for treatment of a peripheral nerve sheath tumor in an African pygmy hedgehog

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Case Description—A 6-year-old female African pygmy hedgehog was evaluated because of a mass of unknown duration on the lateral aspect of the right shoulder region.

Clinical Findings—A fine-needle aspirate of the mass was collected for cytologic examination; findings were consistent with a spindle cell tumor. A CBC, plasma biochemical analyses, and whole-body radiography revealed no other abnormalities.

Treatment and Outcome—An initial surgery performed in an attempt to remove the mass with preservation of the limb failed in that tumor-free surgical margins were not obtained. Histologically, the mass was identified as a peripheral nerve sheath tumor (neurofibrosarcoma). A second surgery to amputate the forelimb was successful. After 1 year, there had been no further development of peripheral nerve sheath tumor at this or other sites.

Clinical Relevance—In African pygmy hedgehogs, potential differential diagnoses for a subcutaneous mass should include peripheral nerve sheath tumor. If necessary, forelimb amputation can be performed successfully in this species with procedures modified from those used in dogs. Information gathered during the treatment and recovery of the hedgehog of this report may assist practicing veterinarians in counseling owners of hedgehogs that are undergoing forelimb amputation with regard to the course of recovery that may be expected following this procedure. (*J Am Vet Med Assoc* 2006;229:706–710)

A 6-year-old female African pygmy hedgehog (*Atelerix albiventris*) was evaluated at the Colorado State University Veterinary Teaching Hospital because of a mass (of unknown duration) on the lateral aspect of the proximal portion of the right forelimb. The mass had been detected by the owner the previous day. The owner reported that there had been no change in attitude or gait and no evidence of polyuria or polydipsia and that the hedgehog had maintained a good appetite. The hedgehog was fed a diet of high-fiber commercial cat food and mealworms.

On physical examination, the hedgehog was bright, alert, and responsive. It weighed 335 g (0.74 lb) and was judged to be in good body condition. Heart rate was 140 beats/min, and no murmurs were auscultated.

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There was a slightly hemorrhagic, firm, raised mass (1 × 1 × 2 cm) on the lateral aspect of the proximal portion of the right forelimb, which was freely moveable and not attached to underlying soft tissue or bone. No other abnormalities were evident. Because of a high suspicion of a neoplastic process, a blood sample was collected from the cranial vena cava and submitted for a CBC and plasma biochemical analyses. A fine-needle aspirate of the mass was obtained for cytologic examination. Clinicopathologic variables were within reference limits.¹ The clinical techniques used to evaluate the hedgehog have been previously described.²

Cytologic examination of the mass revealed predominantly mesenchymal cells. These cells were spindle to polygonal with attenuated cytoplasmic borders, deeply basophilic cytoplasm, and centrally placed oval nuclei; nuclear chromatin was finely stippled with variably prominent nucleoli. Among the mesenchymal cells, there was moderate anisokaryosis and anisocytosis and occasional bi- and trinucleate forms; occasional mitotic figures were evident. A moderate number of eosinophils and well-granulated mast cells were also present. These findings were suggestive of a sarcoma that had developed and incorporated mast cells and eosinophils as a paraneoplastic phenomenon. However, without tissue architecture to examine, a mast cell tumor with substantial fibroplasia could not be ruled out.

Whole-body radiographic views were obtained to rule out metastatic spread of the neoplasm. Because the film was exposed while the hedgehog was exhaling, along with the presence of overlying spines and small size of the hedgehog, metastatic disease in the pulmonary structures could not be completely ruled out. However, there was no evidence of metastasis in the thoracic cavity on lateral or ventrodorsal radiographic views. Radiographically, the mass appeared as a soft tissue opacity overlying the right elbow. The margin of the mass appeared to extend along the lateral thoracic wall. An incidental finding was distraction of a separate center of ossification proximal to the left olecranon that may have represented chronic avulsion with dystrophic mineralization in the more proximal tissues.

Treatment options presented to the owner included surgery (either mass removal or forelimb amputation), radiation therapy, or benign neglect. The owner elected surgical removal of the mass on the basis of cost and best probable outcome. However, if grossly tumor-free margins could not be obtained, the plan was to subsequently perform amputation of the affected forelimb. Radiation therapy was declined because of the unknown response of hedgehogs to radiation.

Surgery was scheduled for the following day. Prior to surgery, the hedgehog was premedicated with oxy-

morphine (0.05 mg/kg [0.02 mg/lb]) and atropine (0.023 mg/kg [0.009 mg/lb]) administered SC. Induction of anesthesia was achieved by placing the hedgehog in a closed chamber supplied with isoflurane in 100% oxygen. The hedgehog was intubated with a 5-F urinary catheter fashioned as an endotracheal tube. Anesthesia was maintained via inhalation of isoflurane in 100% oxygen throughout the procedure. An IV catheter was placed in the left cephalic vein, and lactated Ringer's solution was administered perioperatively at a rate of 3.3 mL/h by use of a syringe pump. A pulse oximeter, capnograph, and ECG were used to monitor oxygen saturation, end-tidal carbon dioxide concentration, and heart rate and rhythm, respectively. To facilitate access to the surgical site, the spines over the right shoulder were clipped individually with scissors and the fur located over the right pectoral area was trimmed with clippers. After aseptic preparation, the surgical site was draped to exclude any and all spines or fur from entering the aseptic field. Because this was considered a clean surgery, no perioperative antimicrobials were administered.

An elliptical incision was made around the mass by use of a No. 15 blade, and electrocautery was used to achieve hemostasis. Grossly, the mass appeared to be well encapsulated, and 5-mm surgical margins were obtained on all sides. The subcutaneous tissue was closed with 5-0 synthetic monofilament absorbable suture^a in a simple interrupted pattern, and the skin was closed with 5-0 nylon suture^b in a simple continuous pattern. The mass was submitted for histologic examination.

After surgery, the hedgehog received oxymorphone (0.17 mg/kg [0.08 mg/lb], SC) and a swab soaked with lidocaine (2.0 mg/kg [0.9 mg/lb]) was dabbed over the skin sutures. The hedgehog recovered in the critical care unit. Overnight, the hedgehog received a constant rate IV infusion of balanced crystalloids (0.7 mL/h) and oxymorphone (0.01 to 0.02 mg/kg/h [0.005 to 0.009 mg/lb/h]). The hedgehog was discharged the following morning; the owner was instructed to administer meloxicam (0.1 mg/kg [0.05 mg/lb]) PO every 12 hours for 5 days; to observe the hedgehog for any discharge from the incision, swelling at the surgical site, or abnormal activity; and to return if any abnormalities were detected. During that 5-day interval, the hedgehog recovered well from anesthesia and surgery and was reported to be doing well at home.

Histologic examination of the excised tissue revealed an unencapsulated infiltrative mass composed of densely cellular pleomorphic cells arranged in interwoven bundles with varying amounts of intervening collagenous to mucinous stroma. Occasionally, whorls were present around collagen bundles. Neoplastic cells varied from thick to thin and were spindle-shaped, pyriform, and polygonal. The cells had variably abundant, finely fibrillar basophilic cytoplasm; round to ovoid nuclei with finely-clumped chromatin; and 1 to 2 nucleoli. There was marked anisocytosis and anisokaryosis with 3 to 4 mitotic figures/hpf and occasional atypical forms. The tumor was highly vascular with a central core of necrosis. The deep and peripheral margins consisted of a thin layer of connective tissue

and adipose. Tumor cells extended to the edge of the surgical margins and infiltrated the adjacent adipose. The histopathologic diagnosis was incomplete excision of a poorly differentiated soft tissue sarcoma (grade 3 or high grade, based on the National Cancer Institute's 3-part histologic grading system³), which was likely a peripheral nerve sheath tumor (neurofibrosarcoma; Figures 1 and 2)

Because tumor cells extended to the deep surgical margin of the excised mass, thereby indicating a high likelihood for recurrence, the hedgehog was returned to the hospital 7 days later for right forelimb amputation. On physical examination, the hedgehog was bright, alert, and responsive. It weighed 340 g (0.75 lb) and had a 2-cm-long healing incision in the right shoulder region. No other abnormalities were detected. Once again, the owner declined the option of radiation

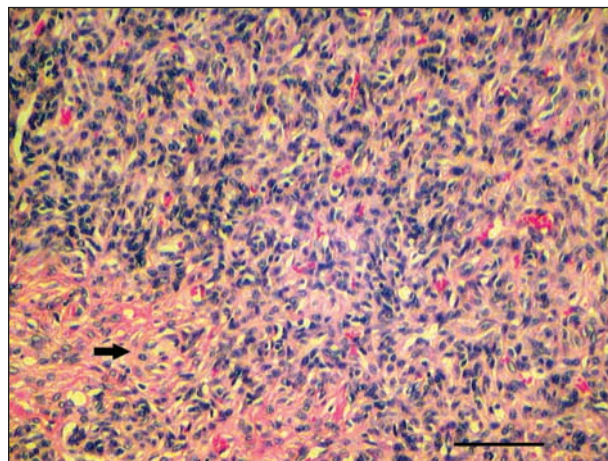


Figure 1—Photomicrograph of a section of a subcutaneous mass removed from the forelimb of an African pygmy hedgehog. Notice the dense population of pleomorphic cells arranged in interwoven bundles with various amounts of intervening collagenous to mucinous stroma. A whorl of neoplastic cells (arrow) is present around a collagen bundle in 1 area. H&E stain; bar = 100 μ m.

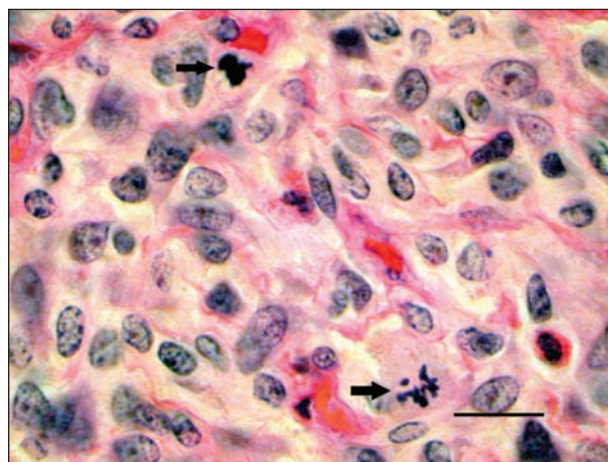


Figure 2—Photomicrograph of a section of subcutaneous mass removed from the forelimb of an African pygmy hedgehog. Notice that the neoplastic cells vary from thick to thin and from spindle-shaped to pyriform and polygonal. Those cells contain variably abundant, finely fibrillar, basophilic cytoplasm; round to ovoid nuclei with finely clumped chromatin; and 1 to 2 nucleoli. Two mitotic figures (arrows) can be seen in this image. H&E stain; bar = 20 μ m.

therapy because of financial concerns, risk of repeated anesthesia for a physically small animal, and the unknown response of hedgehogs to radiation.

The hedgehog was premedicated with atropine (0.02 mg/kg) and hydromorphone (0.05 mg/kg) administered SC. Anesthesia was induced and maintained as previously described. Perioperative fluid support and monitoring were as previously described. The hedgehog was placed in left lateral recumbency. The fur overlying the right pectoral region was clipped with clippers, and the spines over the right shoulder were cut short with scissors. After aseptic preparation, the surgical site was draped to exclude any and all spines or fur from entering the aseptic field. Because this was considered a clean surgery, perioperative administration of antimicrobials was not considered necessary. A skin incision was made over the scapular spine beginning at the dorsal rim of the scapula and continuing to the midhumeral region. The incision was continued circumferentially around the forelimb at the level of the axilla. Subcutaneous tissue was dissected via blunt and sharp dissection to reveal the trapezius muscle. The trapezius and omotraversarius muscles were transected at their sites of insertion on the spine of the scapula. Next, insertion of the rhomboideus muscle was transected. The limb was adducted, resulting in abduction of the proximal aspect of the scapula. The serratus ventralis muscle was elevated from the scapula by use of a small periosteal elevator to allow exposure of the vessels and nerves. The axillary artery and vein were each ligated separately with 2 encircling ligatures of 4-0 synthetic absorbable suture.^c These vessels were severed. Because of the size of the hedgehog and lack of available anatomic references, individual nerves and smaller vessels could not be identified by name. Lidocaine (total dose, 1 mg/kg [0.45 mg/lb]) was infused into the nerves as they were dissected; these nerves were then severed with Metzenbaum scissors. The smaller vessels were ligated with 4-0 synthetic monofilament absorbable suture^c as they were exposed. Following division of the brachial plexus, the brachiocephalicus, latissimus dorsi, and deep and superficial pectoral muscles were transected. Because of its close proximity to the surgical site and inability to disarticulate the forelimb with the bone in place, the lateral half of the right clavicular bone was removed with a rongeur. Following this, the axillary lymph node and accessory axillary lymph node were removed by blunt and sharp dissection. The forelimb was then removed. The remaining muscle bellies were closed with 4-0 synthetic monofilament absorbable suture^c in a simple continuous pattern. The pectoral muscles were sutured to the dorsally located muscles. The subcutaneous tissue was then closed with 4-0 synthetic monofilament absorbable suture^c in a simple continuous pattern, and the skin was closed with 4-0 nylon in a Ford interlocking pattern (Figure 3). Prior to closure of the incision site, regional anesthesia was provided by use of lidocaine (1 mg/kg) mixed with bupivacaine (1 mg/kg).

After surgery, the hedgehog received oxymorphone (0.17 mg/kg, SC) and recovered from anesthesia in the critical care unit. Overnight, the hedgehog received an IV constant rate infusion of balanced crys-



Figure 3—Photograph of an African pygmy hedgehog after amputation of the right forelimb to definitively remove a peripheral nerve sheath tumor. Notice that the surgical site was prepared by clipping spines in the area and shaving fur on the ventrum. The hedgehog's head is to the right of the image.

talloids (1 mL/h) and hydromorphone (0.01 mg/kg/h). The hedgehog was discharged the following morning; the owner was instructed to administer buprenorphine (0.01 mg/kg) PO every 8 hours for 3 days and meloxicam (0.3 mg/kg [0.14 mg/lb]) PO every 12 hours for 7 days; to observe the hedgehog for any discharge from the incision, swelling at the surgery site, or abnormal activity; and to return if any abnormalities were detected. The hedgehog recovered from anesthesia and surgery uneventfully.

Histologic examination of tissue from the previous surgical site revealed no neoplastic cells, and the microscopic changes were consistent with healing. The histopathologic diagnosis was granulation tissue with skeletal muscle degeneration and subsequent regeneration with moderate, chronic active inflammation.

Initially following surgery, the hedgehog's level of activity was low for several weeks, but it gradually returned to running on its exercise wheel within the first 2 months. Ambulation appeared labored at first, and the hedgehog would fall over to the right side periodically when walking. However, this also resolved during the first few months after surgery. One year after surgery, the owner reported that the hedgehog's activity had returned to normal and there appeared to be no adverse effects resulting from the forelimb amputation. However, some of the spines that had been clipped with scissors to facilitate access to the surgical sites had not regrown. There was also no evidence of recurrence of the neurofibrosarcoma.

Discussion

In this report, we have described the successful surgical management of an African pygmy hedgehog with a peripheral nerve sheath tumor (neurofibrosarcoma) located on the lateral aspect of the right shoulder region. To our knowledge, there have been no reports of treatment of this tumor type or of forelimb amputation in hedgehogs. For the hedgehog of this report, amputation was chosen as a definitive treatment after histologic examination of the mass (excised in an initial attempt at treatment) revealed that tumor cells likely extended

beyond the surgical margins. Because forelimb amputation had not been described in hedgehogs previously, we used a modified version of the procedure in dogs.⁴ The area of the hedgehog's body that was prepared for surgery was smaller than the area prepared for a comparable surgery in a dog or cat because the spines of hedgehogs are slow to grow after clipping and each spine has to be cut individually with a pair of scissors, thereby prolonging the duration of anesthesia. The small size of the clipped area did not impede aseptic preparation, and the surgical site was completely draped during mass removal and forelimb amputation. Because both procedures were considered clean surgeries, no antimicrobials were administered to the hedgehog in either perioperative period.

Histologic examination of the amputated forelimb revealed no neoplastic cells at the site from which the mass had been removed. The absence of neoplastic cells could have been a result of removal of remaining cells by the immune system; it is also possible that neoplastic cells were not included in the tissue preparation or were overlooked during the histologic assessment. Despite this, further treatment of the hedgehog (amputation, surgical resection of the lumpectomy site, or radiation therapy) would have been indicated because of the high risk of local tumor recurrence with incomplete resection, as has been reported in other species.⁵⁻⁹ The owner of the hedgehog of this report chose to have forelimb amputation performed because it was the treatment most likely to definitively remove the tumor.

The African pygmy hedgehog has become an increasingly popular pet in the United States in the past decade likely because of its small size, tractable nature, and relative ease of care, compared with other exotic species. The species is susceptible to various diseases similar to those that affect domestic animals, such as fatty liver disease and gastritis, and many others including neoplasia. Neoplasms are common in hedgehogs. In 1 retrospective study,¹⁰ neoplastic disease was detected at necropsy in 24 of 74 (32%) African pygmy hedgehogs. In another retrospective study¹¹ involving data from the Veterinary Medical Diagnostic Laboratory in Columbia, Mo, neoplastic diseases comprised 15 of 40 (38%) of the histopathologic diagnoses made in hedgehogs. Peripheral nerve sheath tumors were identified in 2 African pygmy hedgehogs in that study. One of the 2 hedgehogs was a 4.5-month-old female African pygmy hedgehog that had a mass on the medial aspect of the right forelimb. The owner elected euthanasia. Histologic examination revealed an infiltrative mass associated with the dermis and subcutis, which was comprised of cells with indistinct cell boundaries, eosinophilic cytoplasm, and oval nuclei with reticulated chromatin and small or inapparent nucleoli. Immunohistochemical staining of the cells resulted in notable cytoplasmic reactions for vimentin, neuron-specific enolase, and CD10; a moderate reaction for laminin; and a weak reaction for smooth-muscle-specific actin. The other hedgehog was a 3-year-old female African pygmy hedgehog that had a mass in the skin of the right lumbar region. The mass was excised, and histologic examination revealed that it was partially encapsulated and contained cells with moderately

distinct cell limits, eosinophilic cytoplasm, and oval nuclei with reticulated chromatin and small or inapparent nucleoli. Immunohistochemical staining of the cells resulted in notable cytoplasmic reactions for vimentin and neuron-specific enolase and a weak reaction for CD10. Both masses from the 2 hedgehogs had features of peripheral nerve sheath tumors.¹¹

Peripheral nerve sheath tumor, schwannoma, neurofibrosarcoma, neurofibroma, and neurogenic sarcoma are terms that have been used to describe tumors originating from peripheral nerves or from components of the nerve sheath. Most commonly, these tumors develop from Schwann cells or fibroblasts associated with the endoneurium or epineurium.¹² This tumor type is not uncommon in domestic animals and has been described in dogs, cats, horses, and cattle.^{5,8,13,14} It has also been previously described in African pygmy hedgehogs.¹¹ In dogs, peripheral nerve sheath tumors are most commonly located in the brachial plexus and are typically associated with unilateral forelimb gait abnormalities, neurogenic muscular atrophy, proprioceptive deficits, and variable lower motor neuron deficits. A mass may be palpable in the axilla, and there are usually no signs of pain associated with the forelimb, but there may be signs of pain associated with the cervical region. Invasion of the vertebral canal can occur as the tumor develops, resulting in development of upper motor neuron deficits in the ipsilateral hind limb as well as ipsilateral Horner syndrome.¹²

Diagnosis of peripheral nerve sheath tumor on the basis of clinical signs alone is difficult and not always accurate. The most reliable diagnostic tool for definitive diagnosis is biopsy and histologic examination of tissue specimens. Because peripheral nerve sheath tumors may develop from multiple cell types (Schwann cells, fibroblasts, and perineural cells), findings of immunohistochemistry and electron microscopy can help to confirm the diagnosis.^{11,13} Immunohistochemically, most of the tumors contain distinctly vimentin-positive cells.¹¹ Another procedure that may aid in diagnosis is electromyography; detection of abnormal fibrillation potentials and positive sharp waves are highly suggestive of denervation. It is important to note that these changes can also be associated with certain myopathies or any process that involves lower motor neuron pathways.¹² Other diagnostic tools include magnetic resonance imaging and computed tomography,¹⁵ both of which may provide information regarding localization and extent of the tumor.

Treatment depends on the invasiveness of the tumor and usually involves amputation; resection of the involved plexus; and foraminotomy, laminectomy, or hemilaminectomy to remove the nerve root as close to the spinal cord as possible. These tumors are locally invasive but unlikely to metastasize. With incomplete excision, local recurrence in remaining neural tissue is highly likely.⁵⁻⁹

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- a. Biosyn, United States Surgical, Norwalk, Conn.
 - b. Ethilon, Johnson & Johnson, Somerville, NJ.
 - c. Maxon, United States Surgical, Norwalk, Conn.
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Correction: In “Comparison of results of computed tomography and radiography with histopathologic findings in tracheobronchial lymph nodes in dogs with primary lung tumors: 14 cases (1999–2002),” published June 1, 2006 (2006;228:1718–1722), Figure 1 and its legend were incorrect. The correct figure and legend appear below.

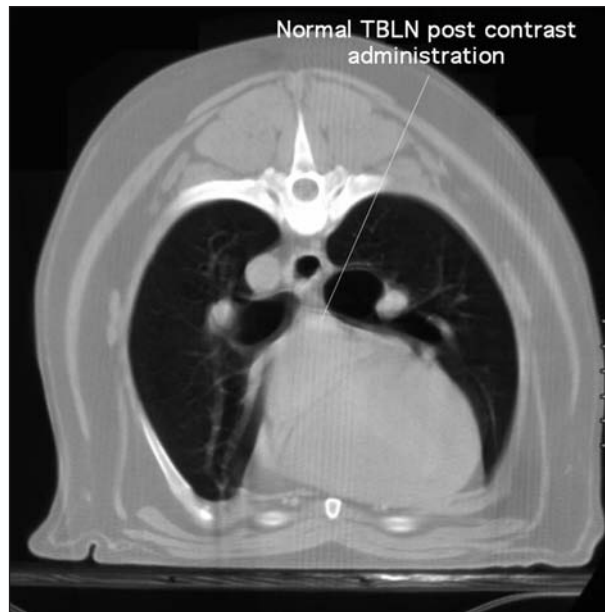


Figure 1—Computed tomographic image (after administration of contrast medium) of the thorax of a dog with normal TBLNs.