Rib tumors are uncommon. Osteosarcoma (OSA) is the most common rib tumor accounting for 73% of rib tumors. Other types of rib tumors include chondrosarcoma (CSA), fibrosarcoma (FSA), hemangiosarcoma (HSA), and infiltrative lipoma. There are no breed or sex predispositions, but rib tumors tend to occur in large breed dogs.

Rib tumors usually occur in the distal third of the rib adjacent to the costochondral junction. A palpable firm and fixed mass is the most common presenting sign, although pain and dyspnea are also reported. Radiographic changes include lysis, sclerosis, or a mixture of lytic and blastic patterns, with displacement of adjacent ribs and intrathoracic structures, such as the heart and lungs, and medial displacement of the parietal pleura resulting in an extrapleural sign (Fig. 1). Intrathoracic extension and invasion of adjacent pericardium and lung lobes are relatively common. CT scans are recommended to determine the location and extent of the tumor, planning of the surgical resection, and clinical staging for pulmonary metastasis (Fig. 2).

Three-view thoracic radiographs and perhaps CT scans are recommended for the evaluation of pulmonary metastasis in dogs with rib tumors. Pulmonary metastasis is common, particularly with telangiectatic OSA, and up to 45% of dogs with rib OSA have metastatic disease at the time of diagnosis. Metastasis is detected in 100% of dogs with rib OSA, 53%-57% with CSA, 67% with HSA, and 100% of dogs with rib FSA at the time of death.

Fig. 1. A ventrodorsal thoracic radiograph of a dog with a rib chondrosarcoma. Radiographic changes are typical of bone tumors, but displacement of adjacent structures is also common because of the intrathoracic component of the tumor.

An incisional biopsy is recommended for definitive diagnosis of tumor type. A knowledge of tumor type does not change the recommended treatment of chest wall resection, but it may change the owner's willingness to pursue aggressive surgical management because of the difference in survival times in dogs with rib OSA and CSA.

Surgery

Chest wall resection is recommended for excision of rib tumors. The surgical approach is the same as a lateral intercostal thoracotomy. The caudal and cranial and dorsal and ventral margins are determined from preoperative imaging and intraoperative palpation. Caudal and cranial margins include a minimum of one intercostal space and rib, while ventral and dorsal margins should be a minimum of 3 cm from the tumor. The caudal intercostal thoracotomy should be performed first because this permits the easiest evaluation of the
intrathoracic extent of the tumor (Fig. 3). The ribs are then transected along the preplanned ventral and dorsal margins with rib cutters. Regional nerve blocks of the intercostal nerve and ligation of the intercostal artery and vein should be performed prior to rib transection to improve pain control and minimise intraoperative blood loss, respectively. The ribs are sequentially transected and the intercostal muscles incised to the level of the cranial intercostal thoracotomy to complete excision of the tumor. Pericardecotomy and lung lobectomy are required if the rib tumors is adhered to the pericardium and lung lobes, respectively.

A knowledge of autogenous and prosthetic reconstruction techniques is important prior to surgery because most resections are large and closure is not simple (Fig. 4). Autogenous reconstruction techniques include the latissimus dorsi (Fig. 5) and external abdominal oblique muscles, and diaphragmatic advancement following resection of caudal rib tumors. Prosthetic reconstruction with non-absorbable polypropylene mesh, alone or in combination with autogenous techniques, is recommended for large defects (Fig. 6). Autogenous reconstruction is preferred in humans because of a high complication rate associated with prosthetic mesh, such as infection and herniation. These complications are rarely reported in dogs following chest wall reconstruction with prosthetic mesh.

**Fig. 3.** A chest wall resection is being performed for excision of a rib chondrosarcoma in a dog. Chest wall resections are started with a caudal intercostal thoracotomy a minimum of one rib and intercostal space away from the tumor. The lateral thoracotomy permits intraoperative assessment of the extent of the tumor and ventral and dorsal margins. In this dog, the sternum has been resected for ventral margins because of its proximity to the tumor. Rib resection is continued cranially with the cranial margins a minimum of one rib and intercostal space away from the tumor.

**Fig. 4.** Chest wall resections can result in large defects that cannot be closed primarily, such as this defect after resection of six ribs, as well as the pericardium and a lung lobe, for a dog with a large rib chondrosarcoma. Reconstruction of the chest wall is required when three or more ribs are resected. Autogenous and prosthetic techniques, or a combination of both, can be used to reconstruct the chest wall. Up to six ribs can be resected without affecting respiratory function in dogs.
Fig. 5. An intraoperative image of the elevated latissimus dorsi muscle flap immediately prior to being used to reconstruct a chest wall defect following resection of rib osteosarcoma in a dog.

Fig. 6. Prosthetic polypropylene mesh reconstruction of a chest wall defect following resection of a rib fibrosarcoma. Prosthetic mesh can be combined with autogenous techniques for closure of large defects, such as the dog in Fig. 4. Autogenous reconstruction is preferred in humans because of a high complication rate associated with prosthetic mesh, such as infection and herniation. These complications are rarely reported in dogs following chest wall reconstruction with prosthetic mesh.

Postoperatively, monitoring of respiratory function, analgesia levels, and the thoracostomy tube are important. Oxygen supplementation, with either nasal cannula or oxygen cage, is recommended after surgery because respiratory function is often compromised by anaesthesia, surgical incision and postoperative bandages, and pain. Oxygenation should be monitored with pulse oximetry and blood gas analysis so that oxygen supplementation can be adjusted or discontinued if required. Chest wall resections are painful, as is the presence of the thoracostomy tube, and analgesia is mandatory to improve comfort levels, recovery time, and respiratory effort. Analgesic techniques include intrapleural lidocaine and non-steroidal anti-inflammatory drugs, opioids, NMDA antagonists such as ketamine, and incisional pain soaker catheters.

Adjuvant Therapy

Due to the similar biologic behavior of rib and appendicular OSA, rib OSA should be treated with rib resection and postoperative chemotherapy. The chemotherapy drugs and protocols are the same as those used for appendicular OSA. The role of chemotherapy in tumor types other than CSA is undefined but warrants consideration due to the high metastatic rate.
Prognosis

The prognosis for dogs with primary rib tumors depends on tumor type and completeness of excision. Local recurrence is significantly more likely following incomplete excision and, in turn, local recurrence significantly decreases median survival times (MST). The MST for dogs with rib OSA is 120 days with surgery alone and 240-290 days with surgery and adjunctive chemotherapy. The MST is significantly longer in dogs with rib CSA treated by surgery alone and ranges from 1080-1750 days to greater than 3820 days (MST not reached because less than 50% of dogs died because of tumor-related reasons) (Fig. 7).

![Fig. 7. A Kaplan-Meier survival curve for the effect of tumor type and treatment in dogs with primary rib tumors. Survival time is significantly better for dogs with rib chondrosarcomas than rib osteosarcomas. For dogs with osteosarcoma, survival is significantly better when treated with chest wall resection and chemotherapy compared to chest wall resection alone. (From Pirkey-Ehrhart et al, J Am Anim Hosp Assoc, 1995)](image)

Surgical margins are important as dogs with incomplete excision are 5.6 times more likely to develop local recurrence and possibly metastatic disease, and survival times are significantly decreased (Fig. 8).

![Fig. 8. A Kaplan-Meier survival curve for the effect of completeness of excision in dogs with primary rib tumors. Survival time is significantly better for dogs with completely resected rib tumors. Incomplete resection was also associated with a higher rate of local tumor recurrence and metastatic disease. (From Pirkey-Ehrhart et al, J Am Anim Hosp Assoc, 1995)](image)

Survival times for other tumor types are based on case reports and small case series, with survival times ranging from 120-450 days for rib FSA and 30-150 days for dogs with rib HSA treated with chest wall resection alone.