Imaging of the Posterior/ Paravertebral Mediastinum

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KEYWORDS

• Mediastinum • Compartments • CT • MR imaging • PET/CT • ITMIG

KEY POINTS

- A wide variety of neoplastic and non-neoplastic entities may originate from the paravertebral mediastinum.
- Neurogenic neoplasms are the most common paravertebral compartment masses and typically represent peripheral nerve sheath tumors, which manifest as smooth, round or oval masses in the paravertebral region on computed tomography.
- Non-neurogenic primary and secondary neoplasms are much less common than neurogenic tumors in the paravertebral mediastinum and may arise from osseous structures or soft tissues.
- Spinal infections typically are due to bacterial infections and result in ill-defined soft tissue, unorganized fluid, and/or loculated collections.
- Intrathoracic meningoceles are associated with neurofibromatosis type 1 and manifest as a unilocular mass of fluid attenuation, often associated with vertebral anomalies, such as hemivertebrae, butterfly vertebra, or spina bifida.

INTRODUCTION

The paravertebral mediastinal compartment contains several vascular and nonvascular organs and anatomic structures from which a wide variety of anatomic variants and abnormalities may arise. It has been well established that a combination of lesion localization, characterization with cross-sectional imaging modalities, and correlation with demographics and other clinical information typically enable the development of a focused differential diagnosis. The first step in this process is identifying the compartment from which a mediastinal mass originates, which can be accomplished by employing the mediastinal compartment classification scheme created by the International Thymic Malignancy Interest Group (ITMIG), which has been accepted as a standard.[1]

The following boundaries have been defined for the paravertebral mediastinal compartment[1]: superiorly, the thoracic inlet[2]; inferiorly, the diaphragm[3]; anteriorly, the posterior boundaries of the visceral compartment; and[4] posterolaterally, a vertical line along the posterior margin of the chest wall at the lateral aspect of the transverse processes. With these anatomic landmarks in mind, the most significant organs and anatomic structures contained in the paravertebral compartment include the thoracic spine and paravertebral soft tissues. The most common masses and other abnormalities originating from the paravertebral compartment are neurogenic neoplasms, non-neurogenic tumors, infections (discitis/osteomyelitis), and those related to trauma (hematoma), although a wide variety of miscellaneous lesions related to other underlying conditions (such as extramedullary hematopoiesis) are possible.

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IMAGING OF PARAVERTEBRAL ABNORMALITIES

General Considerations

Lesions in the paravertebral mediastinum typically originate from the thoracic spine and paravertebral soft tissues, the most common of which are neurogenic neoplasms. Primary lymphoma and bone tumors as well as metastatic disease are less common but may be seen. Non-neoplastic abnormalities include etiologies such as infections of the spine of the spine; cystic lesions, such as intrathoracic meningocele and neurenteric cyst; and extramedullary hematopoiesis. Although the composition, morphology, and other imaging features may be sufficient to make a specific diagnosis, in other cases, correlation with clinical information is necessary.

Neurogenic Neoplasms

Neurogenic neoplasms are the most common paravertebral compartment masses and represent 20% and 35% of all adult and pediatric mediastinal neoplasms, respectively.[2] Most of these lesions (70%–80%) are benign. Peripheral nerve sheath tumors originate from spinal or proximal intercostal nerves, less commonly from the vagus, recurrent laryngeal, or phrenic nerves, and represent 70% of mediastinal neurogenic neoplasms.[2] Multiple neurofibromas may be encountered in patients with neurofibromatosis type 1. On computed tomography (CT), peripheral nerve sheath neoplasms, such as neurofibroma or schwannomas, manifest as smooth, round or oval masses in the paravertebral region that may exhibit a dumbbell shape and communicate with the spinal canal (**Fig. 1**). Cystic changes or hemorrhage may result in regions of internal heterogeneity and are more common in schwannomas than in neurofibromas.[2] Although pressure erosion of adjacent ribs or vertebrae and enlargement of the neural foramina may be seen, these are benign findings and should be differentiated from bone invasion and destruction, which are typical of malignancies. MR imaging offers the advantage of showing the extent of intraspinal/extradural extension and may be used in some instances to distinguish between the types of peripheral nerve sheath tumors based on unique signs (**Figs. 2** and **3**). For example, multiple small, ringlike structures of low signal intensity representing fascicular bundles is known as the *fascicular sign* and typically is seen with schwannomas. On the other hand, the combination of central low signal intensity and surrounding peripheral high signal intensity is termed the *target sign,* and is seen more commonly with neurofibromas than with schwannomas.

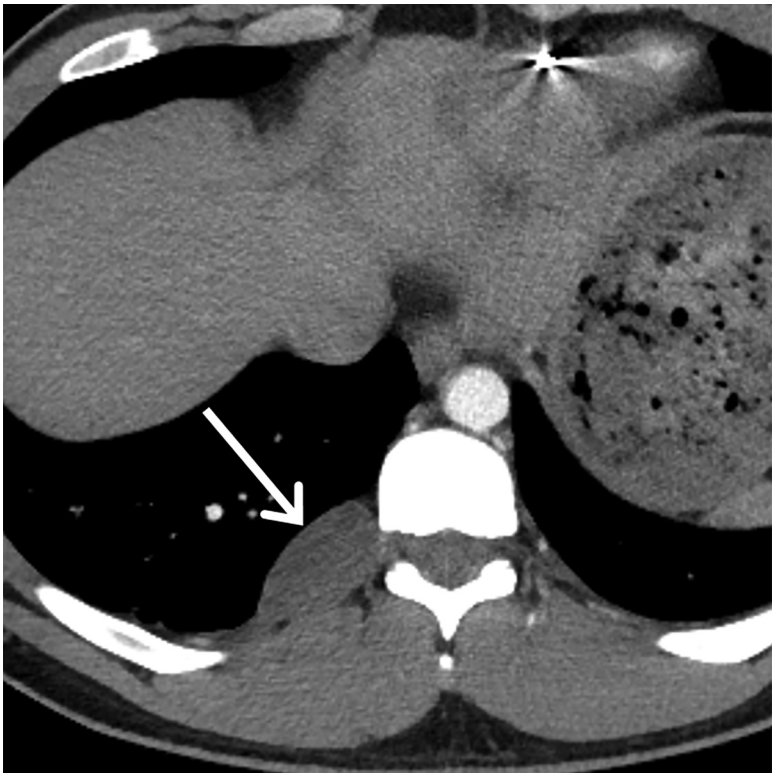

Fig. 1. Neurofibroma. Contrast-enhanced axial CT of the chest of a 43-year-old man demonstrates an elongate low-attenuation mass in the right paravertebral mediastinum (*arrow*). Biopsy revealed neurofibroma, a benign peripheral nerve sheath tumor that is one of the most common paravertebral masses.

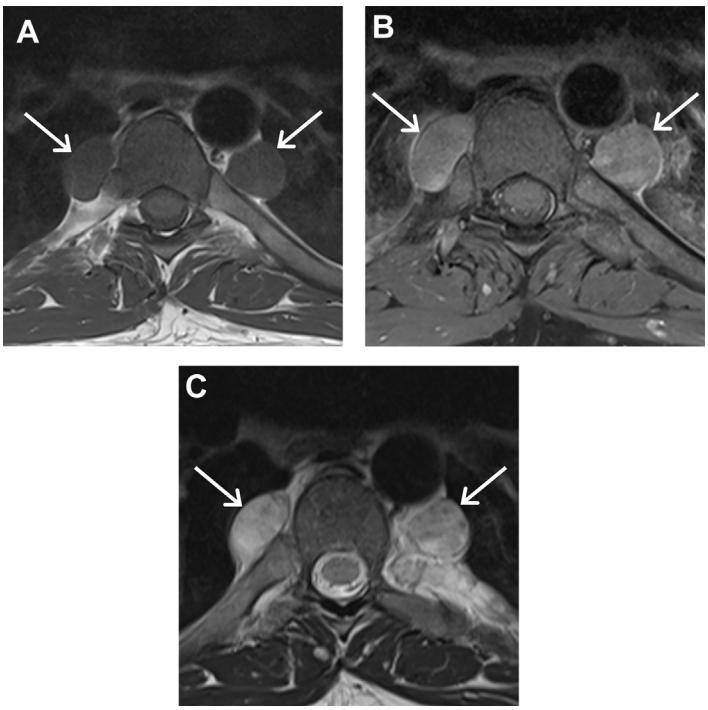

Fig. 2. Neurofibromas in neurofibromatosis type 1. (*A*) Axial T1-weighted, (*B*) postcontrast T1-weighted, and (*C*) T2-weighted MR images of a patient with neurofibromatosis type 1 demonstrate multiple paravertebral neurofibromas (*arrows*) that enhance and show predominantly high T2 signal intensity although internal regions of low T2 signal also are present.

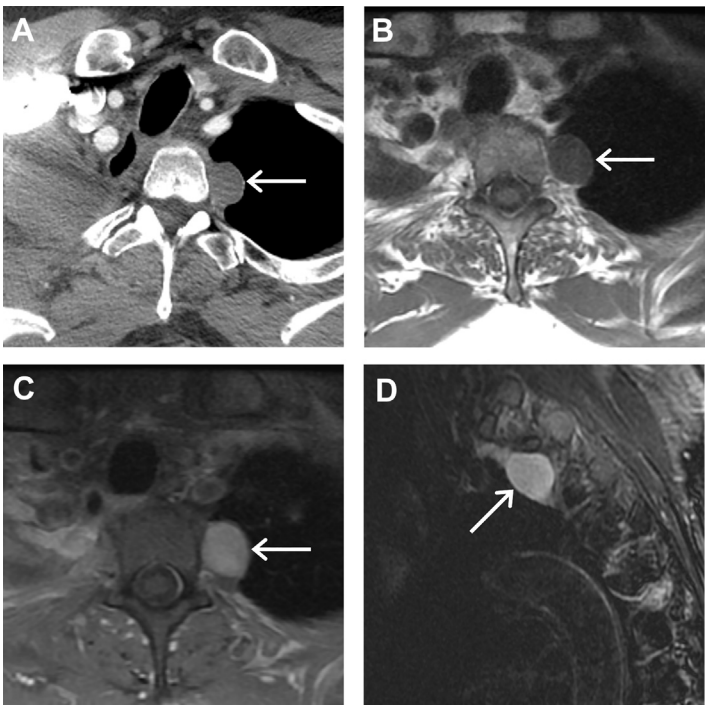

Fig. 3. Schwannoma. (*A*) Contrast-enhanced axial CT of the chest of a 56-year-old woman with a history of lung cancer shows a well-circumscribed low-attenuation lesion in the left paravertebral mediastinum (*arrow*). Axial T1-weighted (*B*) and postcontrast T1-weighted MR images (*C*) and sagittal T2-weighted MR image (*D*) demonstrate homogeneous enhancement and high T2 signal intensity (*arrows*). Biopsy revealed schwannoma.

For patients with neurofibromatosis type 1, there is a 10% lifetime risk of developing a malignant peripheral nerve sheath tumor. If a neurofibroma demonstrates imaging findings such as sudden increase in size, development of internal heterogeneity, and/or invasion of adjacent tissues, malignant transformation to a malignant peripheral nerve sheath neoplasm should be suspected. Differentiation between a malignant peripheral nerve sheath tumor and a benign neurofibroma may be accomplished with fluorodeoxyglucose PET/CT, with 1 study demonstrating sensitivity of 95% and specificity of 72%.[3] Warbey and colleagues[4] found sensitivity of 97% and specificity of 87% for the detection of malignant peripheral nerve sheath neoplasms. Additionally, the investigators suggested the following management based on maximum standardized uptake value (SUVmax): (1) lesions with SUVmax less than 2.5 should be considered benign; (2) masses with SUVmax greater than 3.5 should be considered malignant; and (3) lesions with SUVmax of 2.5 to 3.5 should undergo surveillance imaging.[4]

Sympathetic ganglion neoplasms, such as ganglioneuromas, ganglioneuroblastomas, and neuroblastomas, and neuroendocrine neoplasms, such as paragangliomas, are other neurogenic tumors that may arise in the paravertebral mediastinum; however, these are much less common than peripheral nerve sheath tumors and many of the imaging features of these tumors are nonspecific, necessitating histologic assessment for diagnosis. Paragangliomas arise from clusters of neuroendocrine cells called paraganglia and are classified by location and secretory function. On contrast-enhanced CT, paragangliomas demonstrate intense enhancement. On MR imaging, lesions exhibit a salt-and-pepper appearance from enhancing tumor and signal flow voids of blood vessels on T1-weighted imaging and high signal intensity (light bulb appearance) on T2-weighted imaging.[5]

Other Neoplasms

Non-neurogenic primary and secondary neoplasms also may be encountered in the paravertebral mediastinal compartment but are much less common than neurogenic tumors. The most common primary tumors to occur in this region may be classified as either osseous or soft tissue in origin, with chordoma and chondrosarcoma included in the former and lymphoma in the latter.

Although chordomas of the vertebral bodies are rare, they are the second most common primary malignancy in the spine following lymphoproliferative neoplasms.[6]

The thoracic spine is the most infrequent portion of the spine involved, following the cervical and lumbar spine. On CT, chordomas typically manifest as well circumscribed destructive lytic lesions that may be heterogeneous due to the presence of necrosis and/or hemorrhage. The associated expansile soft tissue mass is often much larger than the osseous abnormality.

Internal foci of high attenuation appearing as intratumoral calcifications may be present, which are thought to represent sequestra of normal bone. On MR imaging, chordomas demonstrate intermediate to low signal intensity on T1-weighted imaging, high signal intensity on T2-weighted imaging, and heterogeneous enhancement with a honeycomb appearance following the administration of intravenous gadolinium contrast material. Chordomas tend to involve more than 1 vertebral body via extension across the intervertebral disc space and may spread to the epidural space, compressing the spinal cord or along the nerve roots, resulting in neural foraminal expansion.

Chondrosarcomas are malignant tumors of cartilaginous origin that represent approximately 25% of all primary malignant neoplasms of bone, although involvement of the spine accounts for only approximately 7% of cases.[7] The thoracic spine is the most frequent portion of the spine affected. The posterior elements and vertebral body are involved in 45% of cases whereas location within the posterior elements only (40%) or the vertebral body only (15%) is less common. On CT, tumors are lytic approximately 50% of the time and contain internal calcifications that may be in a rings and arcs pattern or popcorn morphology. Endosteal scalloping may be present and affects greater than two-thirds of the cortical thickness of the bone affected. Higher-grade tumors may demonstrate a permeative pattern of bone destruction. On MR imaging, lesions demonstrate low to intermediate signal on T1-weighted imaging, high signal intensity in the regions without mineralization on T2-weighted imaging, and heterogeneous enhancement following the administration of intravenous gadolinium contrast material.

Non-neurogenic soft tissue tumors affecting the paravertebral mediastinum are uncommon and tend to represent lymphoma, metastatic disease, or a variety of unusual neoplasms. When lymphoma arises from the mediastinum as a primary malignant neoplasm, the paravertebral compartment is the least common site of involvement (**Fig. 4**). A wide variety of neoplasms may metastasize to the paravertebral mediastinum and typically demonstrate the imaging characteristics of

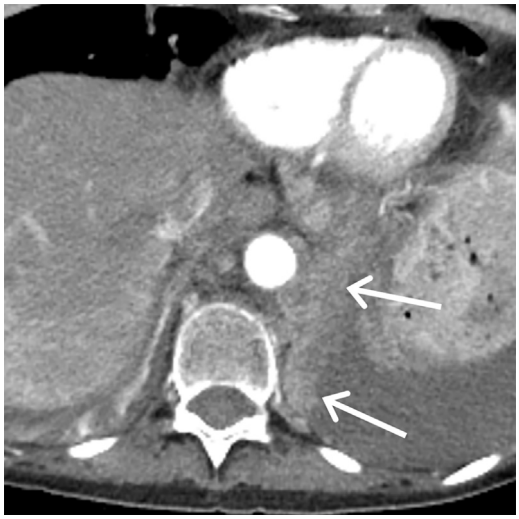

Fig. 4. Lymphoma. Contrast-enhanced axial CT of the chest of a 62-year-old man with a remote history of primary mediastinal (thymic) lymphoma demonstrates extensive lobular soft tissue in the left paravertebral mediastinum (*arrows*) representing recurrent disease and spread to the other mediastinal compartments.

the primary tumor and metastases elsewhere in the body (**Fig. 5**).

Spinal Infections

Infections of the bone and/or soft tissues of the spine usually result from bacterial organisms and are seen in patients with 1 or more risk factors, such as diabetes, autoimmune diseases, malignancy, immunosuppression, and intravenous drug use.[8] Tuberculosis should be considered in the setting of immunodeficiency, in particular, human immunodeficiency virus (HIV) infection. It is estimated that 60% of HIV-positive patients with tuberculosis have skeletal involvement, with the most commonly involved site the spine (in approximately 50% of cases).

On cross-sectional imaging, the most common abnormalities reported in spinal infections include ill-defined soft tissue, unorganized fluid, and/or loculated collections. One or more of these imaging findings typically are seen in combination with clinical symptoms such as back pain, fever, and malaise. On CT, early and late findings of spinal infection have been described, with soft tissue infiltration of the paravertebral fat and intervertebral disc hypoattenuation present in the former, and osseous erosion, disc space narrowing, and sequestrum formation seen in the latter.[8] In the setting of involvement of the posterior elements, a large soft tissue mass located in the prevertebral and paravertebral regions that is out of proportion to the extent of bone destruction, and intervertebral disc space narrowing, tuberculosis should be suspected as the causative agent and can help differentiate it from pyogenic infection. Additionally, Pott disease of the spine should be considered when calcification is present but new bone formation or sclerosis is absent.[9,10]

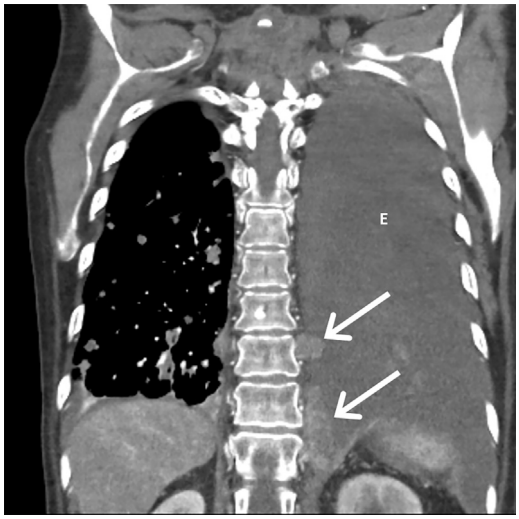

Fig. 5. Metastatic disease. Contrast-enhanced coronal CT of the chest of a 54-year-old man with metastatic renal cell carcinoma demonstrates numerous enhancing metastases in the left paravertebral mediastinum (*arrows*). Note the large left pleural effusion (E) and other bilateral metastases.

Intrathoracic Meningocele

An intrathoracic meningocele is formed from anomalous herniation of the leptomeninges through a defect in an intervertebral foramen or vertebral body defect.[11] These lesions are associated with neurofibromatosis type 1 and are more common in adults than children. On CT, a meningocele manifests as a unilocular mass of fluid attenuation and is associated with vertebral anomalies, such as hemivertebrae, butterfly vertebra, or spina bifida (**Fig. 6**). Although intrathoracic meningoceles may be difficult to distinguish from other low-attenuation abnormalities in the paravertebral mediastinum, such as neurenteric cysts and neurogenic neoplasms, correlation with clinical information, such as associated neurofibromatosis type 1, is helpful. When in doubt, CT, MR imaging, or myelography performed after intraspinal injection of contrast material can be used to demonstrate the presence of a meningocele.[12]

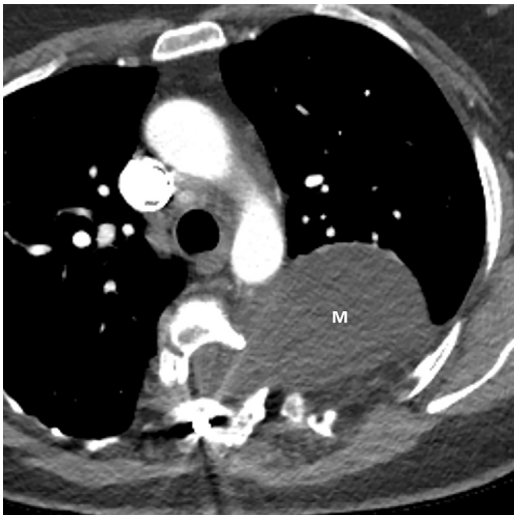

Fig. 6. Intrathoracic meningocele. Contrast-enhanced axial CT of the chest of a 39-year-old woman with neurofibromatosis type 1 shows a well-defined low-attenuation mass extending from the spinal canal into the left paravertebral mediastinum (M), representing an intrathoracic meningocele. Note the post-surgical changes in the spine.

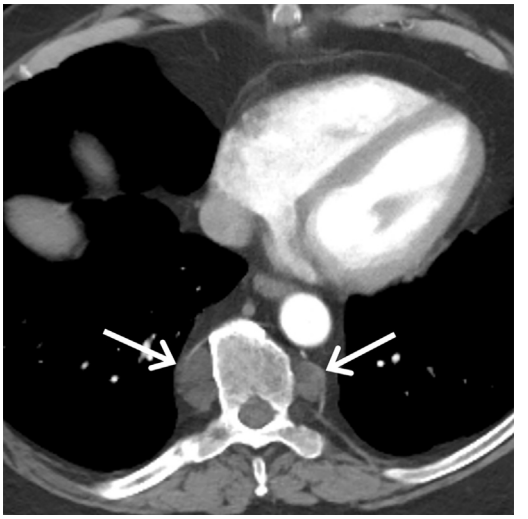

Fig. 7. Extramedullary hematopoiesis. Contrast-enhanced axial CT of the chest of a 43-year-old man with myelofibrosis demonstrates soft tissue masses (*arrows*) in the paravertebral mediastinum bilaterally, consistent with extramedullary hematopoiesis. Note the ill-defined regions of internal low-attenuation representing fat in these long-standing lesions.

Extramedullary Hematopoiesis

Extramedullary hematopoiesis is a process that is seen most commonly in the setting of a hematologic disorder resulting in bone marrow replacement, such as myelofibrosis or chronic myelogenous leukemia, or hemolytic anemia, including thalassemia, sickle cell anemia, and hereditary spherocytosis.[13] On CT, extramedullary hematopoiesis manifests as masses adjacent to thoracic vertebrae and/or ribs in the paravertebral mediastinum that are variable in size and number. Due to the high internal vascularity, these lesions typically enhance following the administration of intravenous iodinated contrast material. Heterogeneous attenuation and/or enhancement, however, may be encountered in the setting of iron deposition and fat infiltration in long-standing lesions[14] (**Fig. 7**). Due to the vascular nature of the lesions and the need to avoid biopsy in some cases, imaging with technetium Tc 99m sulfur colloid bone marrow scanning and single-photon emission CT/CT bone marrow scanning may be employed to confirm the presence of functioning hematopoietic tissue and confirm the diagnosis. Associated abnormalities, such as the presence of autosplenectomy in patients with sickle cell disease, are invaluable in suggesting the diagnosis.

Other Cystic Lesions

Several uncommon disease processes may result in cystic abnormalities in the paravertebral compartment and should be considered in the appropriate clinical scenario. On CT, mediastinal abscess should be considered when a low-attenuation mass is identified in a patient who has recently undergone surgery or who has a history of esophageal perforation. Internal foci of air and/or communication with coexisting subphrenic abscesses or empyema may be present.[15] When a diagnosis remains uncertain, percutaneous needle aspiration may be necessary to exclude other etiologies, such as postoperative seroma or hematoma. Pancreatic pseudocyst should be considered when a thin-walled low-attenuation or high-attenuation mass is present and develops over a short period of time in a patient with the clinical picture of pancreatitis.[16] These lesions contain pancreatic secretions, blood, and necrotic material and may result in the regions of high attenuation. Spread occurs through the esophageal or aortic hiatus although separate intra-abdominal pseudocysts may or may not be present.

SUMMARY

Paravertebral mediastinal masses include a wide range of benign and malignant entities, some of which may be identified incidentally on imaging examinations performed for unrelated reasons. Combining available tools, such as localizing mediastinal masses to the paravertebral compartment, characterizing them with cross-sectional

imaging techniques, and correlating the imaging findings with demographics and other clinical history, typically enable the radiologist to create a focused differential diagnosis. Clinical imagers, however, must be familiar with these concepts in order to help guide subsequent imaging and/or intervention and treatment planning for neoplasms and other abnormalities.

DISCLOSURE

Nothing to disclose for all authors.

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