Interventional Radiology

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Introduction

Pediatric interventional radiology (IR) is an emerging specialty. When considering "tumors" broadly, to include non-neoplastic growths, pediatric interventional radiologists are centrally involved in all aspects of diagnosis, treatment, and symptom management. With regard to neoplastic disease, oncology-related pediatric IR procedures have traditionally been limited to diagnosis, management of complications, and procedures designed as auxiliaries to open surgery. Newer landmarks in pediatric therapeutic oncological interventions are under active development, but standards remain to be established. Although many broad principles in adult and pediatric interventions are the same, some specialized topics related to procedures in children deserve discussion, as enumerated below in this introductory section.

Informed Consent Since most pediatric patients of less than 18 years of age have legal guardians or parents, a detailed preprocedural discussion is necessary to educate them of the possible complications, sometimes remaining present throughout life. Many adolescent patients are able to participate actively in the decision-making process.

Sedation and Anesthesia Almost all children require general anesthesia or higher levels of sedation to minimize motion, tolerate pain better, and allow positioning during the procedure. Deep sedation or general anesthesia can provide some postprocedure amnesia unlike adults who can tolerate most procedures under mild sedation and local anesthesia.

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Equipment Most available devices are designed for use in adults. Hence, bench modifications of devices developed for adults are often performed to match the smaller body habitus of children.

Contrast and Radiation Limiting the contrast and radiation dose is essential in children. Carefully monitored volume of diluted nonionic contrast should be used to minimize renal toxicity. The risk of dialysis after receiving contrast significantly increases in patients with estimated GFR <30 ml/min/1.73 [1]. Given the small caliber of the vessels, extravasation of contrast or medication can occur during percutaneous access and may result in discomfort and compartment syndrome. Due to these limitations, goals must be accomplished using less contrast than might be employed in an adult.

Likewise, maximal efforts are directed to limit the radiation dose, as the cumulative effects of radiation are of major concern in children. Most interventional radiologists practicing in adult populations concern themselves largely with the deterministic effects of radiation, related to dose and time of exposure at time of procedure. These effects are usually manifest as damage to bone marrow, gastrointestinal mucosa, or skin. It is, however, the stochastic effects, those effects which are related to any exposure to any ionizing radiation, regardless of time or dose that are far more concerning in the pediatric population than the adult [2].There is no minimum threshold radiation dose for stochastic effects to occur, and stochastic exposure (primarily related to DNA damage) may not manifest itself for decades. It is specifically in young children, with many years of life to manifest the stochastic damage that these issues are of greatest concern. Additionally, many oncology patients are exposed to high-dose external beam radiation as part of their treatment protocol, adding to the risk. The "as low as reasonably achievable" (ALARA) concept of radiation exposure is ubiquitous in radiology, but is held to much higher standard in pediatric diagnostic imaging and pediatric IR, with risk of radiation exposure always weighed against the benefits of a given image-guided

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procedure, and every attempt made to the lowest possible radiation dose. Aggressive dose reduction methods including limiting fluoroscopy time, low-dose pulse fluoroscopy, aggressive coning and filtering applied to the smallest possible region of interest [2], and maximal utilization of imaging modalities which are nonionizing, such as ultrasound or magnetic resonance imaging (MRI). These are or should be standards of care routinely practiced in centers with large pediatric practices.

Physiologic Responses Physiologic responses to intervention can be different in a child versus an adult. For example, vasospasm is commonly seen in children, making simple access or further intravascular manipulation more challenging. Gentle massages around the vessel, warming the room temperature, the judicious use of vasodilators for spasm resolution are some options. Children react to fluid imbalances and medications more quickly. Therefore, a close monitoring of fluid balance and drug dosages based on weight or body surface area is mandatory; vigilant care on the part of specialized pediatric nurses and a pediatric anesthesia team are invaluable.

Disease Spectrum The differential diagnosis for a given head or neck tumor varies widely, depending on the patient's age. Conditions like vascular anomalies and congenital defects typically present early in life, and may require extended years of multi-session treatment spanning into adulthood. Degenerative diseases like atherosclerosis are practically nonexistent in the pediatric population.

Vascular Interventions

Introduction

Generally, endovascular interventions can be divided into two categories: (1) enlarging vascular channels (for example, balloon angioplasty of stenotic blood vessels) and (2) blocking vascular lumens (i.e., sclerotherapy and embolization). Most vascular intervention, either pediatric or adult, is concentrated on the latter category, with the goal of reducing blood flow to a given lesion to either make the pathologic target ischemic, to potentiate directly injected therapies, or to reduce the volume or flow through a vascular malformation.

We will focus the discussion on image-guided sclerotherapy and embolization, as this is by far the most common vascular intervention performed on pediatric head and neck tumors and malformations. We will discuss these procedures in the context of the more common diagnoses referred to us for these procedures.

Vascular Malformations and Vascular Tumors of the Head and Neck

These lesions can be categorized functionally as high-flow versus low-flow lesions.

High-Flow Lesions

These lesions have intrinsic arterio-venous shunting. They appear reddish, warm, firm, and pulsatile, with signs of skin ischemia, ulceration, and/or hemorrhage. Distribution of these lesions is classically seen in the cheek (31%) (Fig. 5.1a), followed by the ear (16%) and nose (11%) [1]. The symptoms are typically related to regional involvement such as macrotia (ear lesions), life threatening bleeding with dental procedures (mandibular or maxillary lesion), and bleeding with chewing (tongue lesions) in addition to the pain, bruit, or thrill that accompany high-flow vascular malformations anywhere in the body. The lesions often enlarge in response to hormonal changes (e.g., puberty or pregnancy) or trauma.

MRI provides the best spatial resolution for soft tissue, with computed tomography (CT) better delineating any osseous abnormality, when the lesion is in close association with the bone. Catheter angiography remains the gold standard in terms of providing the highest spatial resolution, as well as critical insight into the flow dynamics (Fig. 5.1b, c), though catheter-based procedures are usually performed as part of the therapeutic approach, rather than purely for diagnosis. High-flow vascular malformations are usually complex lesions where the therapeutic goal is symptom control, preservation of vital functions (e.g., vision, hearing, or mastication), or aesthetic restoration, rather than cure, although for focal lesions, a combination of single or multistage preoperative embolization followed by surgical resection can sometimes be curative [1, 3, 4].

Endovascular embolization is directed towards occlusion of the nidus and initial segment of the venous outflow. This can either be performed transarterially or by percutaneous direct access of the nidus or the draining vein. Preoperative embolization provides a dry surgical field and minimizes perioperative blood loss. Gelfoam powder, polyvinyl particles, or embospheres can be used for temporary preoperative embolization. For nonoperative candidates, embolization with permanent liquid agents capable of permeating the AVM nidus, such as absolute ethanol, n-Butyl Cyano Acrylate (glue), or Onyx, may be used (Fig. 5.1d–f).

Endovascular embolization can be highly effective in cases of arterio-venous fistulas, both for preoperative adjunctive treatment and as a stand-alone cure. In contrast, for focal AVMs with multiple, small feeders, nidal embolization followed by surgical resection is the usual treatment [5].

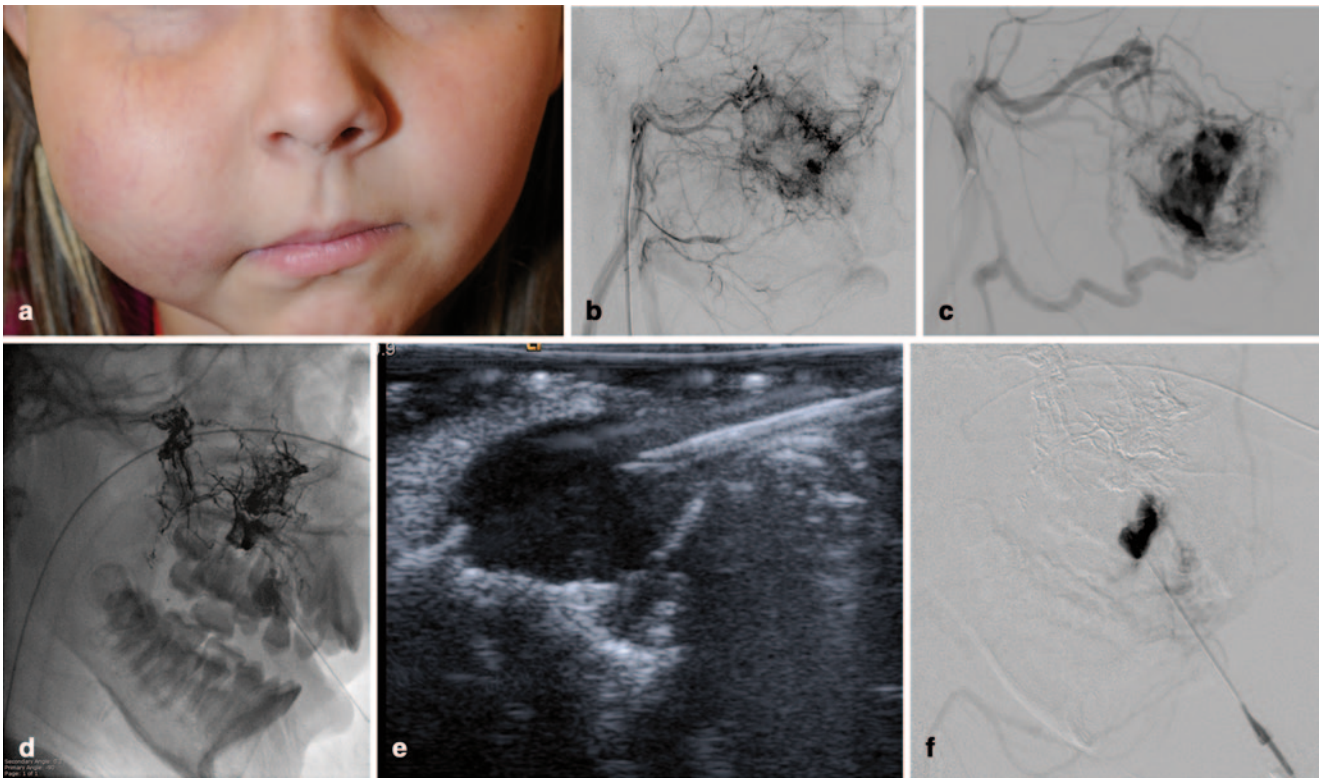

Fig. 5.1 Arteriovenous malformation (AVM): **a** Pulsatile mass of the right cheek. **b** Arterial and **c** venous phases of right external carotid angiogram demonstrating high-flow AVM with large draining veins. **d** Unsubtracted lateral fluoroscopic image demonstrating opacified Onyx embolic agent within the feeding vessels. **e** Ultrasound image of percutaneous needle access of abnormal vein. **f** Fluoroscopic image with subtraction of contrast injection of the abnormal vein

Low-Flow Malformations

These lesions are broadly classified as capillary, venous, or lymphatic malformations.

Capillary Malformations (CM) These are flat, well demarcated, lesions showing ectatic blood vessels in the dermis associated with reduction in innervation, occurring most commonly in the trigeminal V1 distribution [6, 7]. They can be seen in association with syndromes like Sturge–Weber syndrome, Klippel–Trenaunay syndrome, Parkes Weber syndrome, macrocephaly-capillary malformation syndrome, and capillary malformation-arteriovenous malformation syndrome (CM-AVM). The standard treatment is pulsed-dye laser, although only 15–20 % of lesions clear completely [8].

Venous Malformations (VMs) These represent congenital anomalies, irregular endothelial-lined channels, with thin walls deficient in smooth muscle. They typically have a bluish purplish hue, and are soft and compressible. 40 % of these lesions are found in head, neck, and extremities [9]. Episodic focal thrombosis and occurrence of phleboliths may result in swelling and pain. Larger lesions on the face can cause facial asymmetry. Trauma or hormonal changes can induce enlargement of VM, and they can extend deeper intrafascially and cause mass effect in small anatomical spaces like the orbit and oral cavity. Syndromes like glomuvenous malformation, cutaneomucosal venous malformation, and blue rubber bleb nevus syndrome have VMs as part of their manifestation [10, 11]. VMs most characteristically enhance avidly but in a patchy, heterogeneous pattern on contrast enhanced MRI. Phleboliths are typically seen as hypointense defects on MRI or as calcified foci on CT scan images (Fig. 5.2d) [12].

Lymphatic Malformations (LM) These can be either macrocystic, microcystic, or of combined types. They are soft, noncompressible, translucent masses with overlying normal or bluish skin, often with superficial dry or weeping cutaneous vesicles. Macrocystic LMs have a predilection for the head and neck region. Sudden enlargement following infection or intralesional hemorrhage and spontaneous involution are common. Syndromes associated with LM include Klippel–Trenaunay, Turner, Noonan, and trisomies 13 and 18, and others [9]. On imaging, LMs show variably sized cysts in the macrocystic type, showing debris within or fluid–fluid levels with heterogeneous signal, due to repeated hemorrhages (Fig. 5.2a). Only the septae of macrocysts enhance. Microcystic disease on ultrasound is seen as an echogenic ill-defined mass with tiny, poorly visible cysts. On contrast

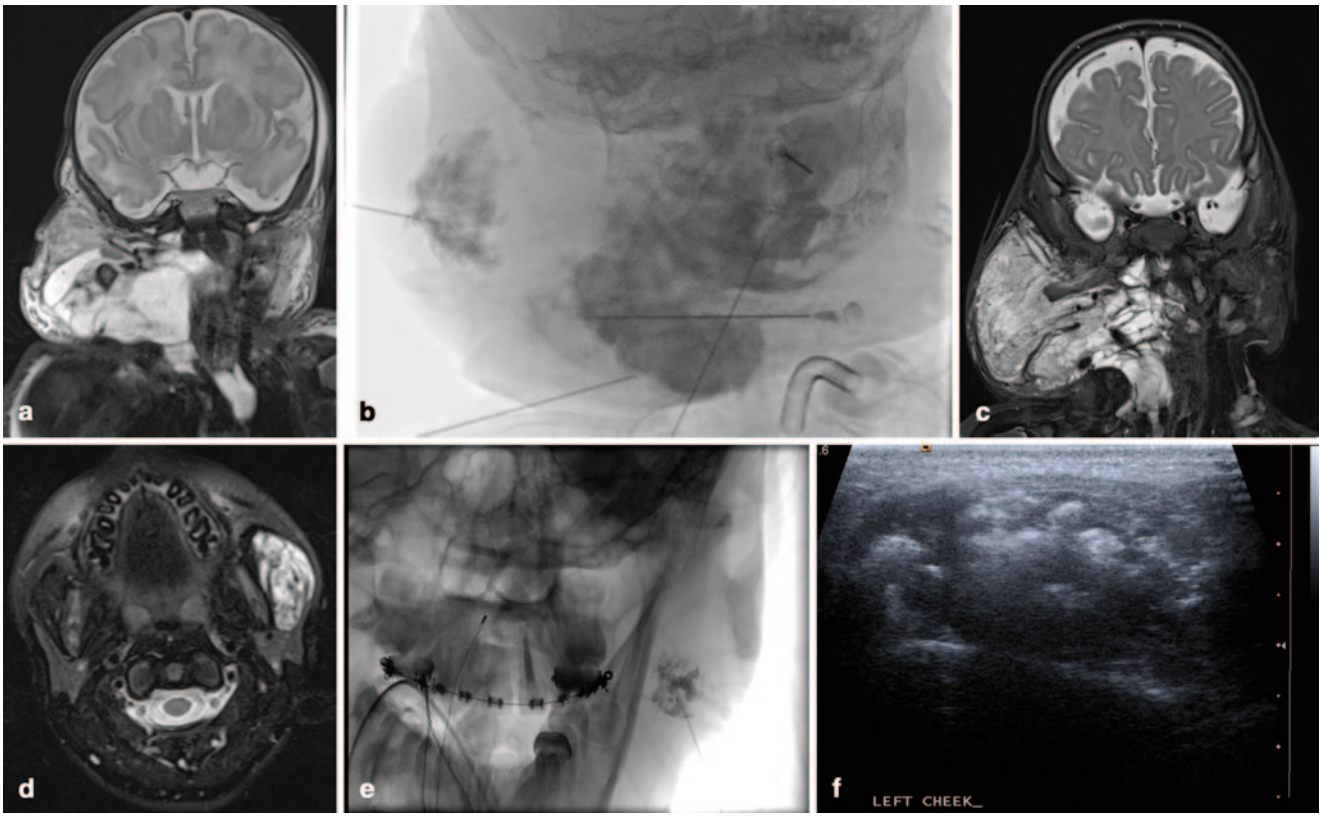

Fig. 5.2 Low-flow lesions: **a** Coronal T2-weighted MRI of newborn with large multicystic cervicofacial mass, consistent with macrocystic lymphatic malformation. **b** Anteroposterior (AP) fluoroscopic image of the neck during percutaneous sclerotherapy of multiple macrocysts. **c** Postsclerotherapy MRI demonstrating reduction of the macrocystic component and persistent microcystic disease. **d** Axial inversion-recovery MRI demonstrating VM of the left cheek. **e** AP fluoroscopic image during percutaneous sclerotherapy of the VM. **f** Ultrasound imaging of the VM after sclerotherapy injection. The echogenicity is secondary to air from foaming of the sclerosing agent

MRI, microcystic lesions may or may not enhance, with the likelihood of enhancement increased in the setting of inflammation or infection.

Treatment of Low-Flow Malformations: Percutaneous Sclerotherapy Most interventional-radiology-guided therapy of low-flow vascular malformations involves percutaneous sclerotherapy. Sclerotherapy is injection of a pharmacological agent that induces endothelial damage, elicits an avid inflammatory response, and finally leads to thrombosis (in VMs) and fibrosis. Image guidance, especially ultrasound in children, is most commonly used to gain access into the abnormal vascular channels. Digital subtraction angiograms using fluoroscopy prior to the actual injection of the sclerosant is performed to evaluate the position of the needle tip, the communications between the different components of the malformation, and the local vascular anatomy, including the hemodynamics of the venous drainage. Fluoroscopy can also help with estimation of the volume of sclerosant needed.

The sclerosant is usually reconstituted with a contrast agent, either water soluble, lipophilic (such as ethiodol), or negative contrast (air or carbon dioxide) to allow fluoroscopic and ultrasound monitoring of the injection [12] (Fig. 5.2b, e, f). Vigilantly watching for any extravasations during injection is mandatory, to prevent tissue or nerve damage. Applying direct pressure over venous drainage pathways during injection, using a tourniquet, or using double needle technique, which provides a low-pressure exit valve, can stop drainage to critical outflow veins. Escape of sclerosant into the venous drainage could potentially result in ophthalmic, cavernous, or intracranial venous thrombosis in head and neck lesions.

We most commonly use 3% sodium tetradecyl sulfate (STS), a detergent, as the sclerosant Foaming the solution prior to injection has been reported to increase efficacy, perhaps by maximizing the surface area contact between the agent and the lesional endothelium. Ethanol, the most potent sclerosant, and one we make regular but judicious use of as well, unfortunately, has the highest rate of reported serious complications such as skin necrosis, nerve damage, central nervous system depression, acute pulmonary hypertension, thromboembolism, disseminated intravascular coagulation (DIC), hyperthermia, cardiac arrhythmias, and

cardiovascular collapse and death [13]. However, STS and related detergents can cause serious adverse effects as well. Platinum coils or liquid embolics may serve as adjuncts to sclerotherapy in larger lesions, primarily to close prominent or recurrent venous channels. These agents are particularly effective in achieving preoperative short-term occlusion [12]. Bleomycin, an antibiotic with cytotoxic properties, can be of particular use in patients with intra-orbital and airway lesions, because of significantly less posttreatment edema than is seen with other agents [14]. Presclerotherapy steroids are imperative in orbital and airway malformations, for reducing postprocedural edema, which could result in increased intraocular pressure or airway compression. Sclerosants cause immediate local hemolysis and subsequent hemoglobinuria, though lesions in the head and neck are rarely large enough for the hemolysis to cause systemic problems. Generous hydration (doubling of the maintenance intravenous fluid for 4 h post procedure), monitoring of urinary output, and urinary alkalization with sodium bicarbonate intravenous fluid is recommended [12].

Localized VMs have the best responses to sclerotherapy. Diffuse malformations are less likely to have a complete response, and the treatment should, therefore, be targeted at the most symptomatic portions. For all but the smallest lesions, sclerotherapy is often repeated. Among the LMs, the macroystic variety typically responds well to sclerotherapy, whereas microcystic lesions are technically difficult to treat and show a poor response (Fig. 5.2c). Sclerosants reported for use in treating macrocystic LMs include ethanol, doxycycline, bleomycin, Ethibloc, and OK-432. Our first-line agent is most commonly doxycycline at a concentration of 10 mg/ml. For large cysts, a pigtail catheter aspiration of the contents and volume measurement is made, followed by injection and drainage of the cyst with the sclerosant. The sclerosant is allowed to dwell in the cyst for 2–3 h and then drained out. The procedure is repeated sequentially on days 2 and 3, through the indwelling catheters. It is important to disrupt the internal septations to increase the contact of the sclerosants within different compartments. Cyst involution can be assessed approximately 6 weeks after the procedure. For microcystic LM, sclerotherapy using bleomycin or OK-432 is often used. Other techniques using in-column electrocoagulation, carbon dioxide laser excision and radiofrequency ablation (RFA) have also been described [14–16]. The overall complication rate for sclerotherapy to treat VMs is 12% [13]. Peripheral neuropathy is seen in approximately 1%, but can be avoided if care is taken not to cause extravasation during injection; when it occurs, neuropathy is usually transient. Skin blistering and, in rare occurences, skin necrosis with permanent scarring can occur, particularly when the lesion has a more superficial component. For lesions involving the tongue, buccal surfaces, soft palate, or airway, marked postprocedural edema can cause transient dysphagia and breathing difficulties. Many such patients have a tracheostomy placed before commencing the procedure. Other lesser adverse effects include muscle atrophy and contracture if the sclerosant infiltrates the tissues [12].

Juvenile Naso-Pharyngeal Angiofibroma (JNA)

JNA is a benign vascular tumor composed of a rich vascular network within a fibrous stroma [17]. It most commonly arises in the posterolateral nasopharynx of prepubertal and adolescent males (Fig. 5.3a). JNA can behave aggressively and tend to bleed frequently. They can expand commonly beyond the nasopharynx into the cranium, nose, and paranasal sinuses [17, 18]. Profuse intraoperative bleeding leading to incomplete resection and tumor recurrence can occur, and preoperatively transarterial tumor embolization can greatly facilitate resection. JNAs are primarily fed from distal internal maxillary artery branches (Fig. 5.3b), and may recruit arterial supply from any nearby ipsilateral or contralateral vessel, requiring bilateral internal and external carotid arteriography for elucidation. Anastomosis between branches of the external and internal carotid artery and vascular spasm has to be considered when planning superselective embolization. Silastic spheres, Gelfoam, dura mater, and polyvinyl alcohol (PVA) particles (Fig. 5.3c) have been used to embolize the tumor bed and the feeding vessels [19], with PVA particles often preferred, as they are efficient and cost effective. Nontarget embolization of particles to the ophthalmic artery, the internal carotid, or vertebral arteries via anastomosis or reflux of particles injected in the external carotid artery may cause retinal or brain ischemic deficits, and thus preembolization and intraprocedural angiography must be scrupulously studied.

Glomus Tumors

Paragangliomas, also called glomus tumors, are highly vascularized tumors of neural crest origin that are derived from chemoreceptor organs in the walls of blood vessels or specific nerves in the head and neck area. They can develop in the middle ear (glomus tympanicum), the jugular foramen of the skull base (glomus jugulare), or other head and neck areas (glomus caroticum, glomus vagale). They are usually benign but locally destructive [20–23]. Preoperative embolization for devascularization greatly reduces the perioperative blood loss by a factor of 2–3, with reduction of need of transfusion in the postoperative period to less than 50% [24]. However, extreme caution is warranted during embolization of these lesions. In particular, during embolization of carotid body tumors, particles can escape into the internal carotid artery and result in stroke, especially if particles < 150 μm in size are used. As in the case of JNA, vigilant angiographic search for anastomosis between the intra- and extracranial circulation is imperative. Collaterals between the vertebral artery and the C1, C2, and C3 musculoskeletal branches are

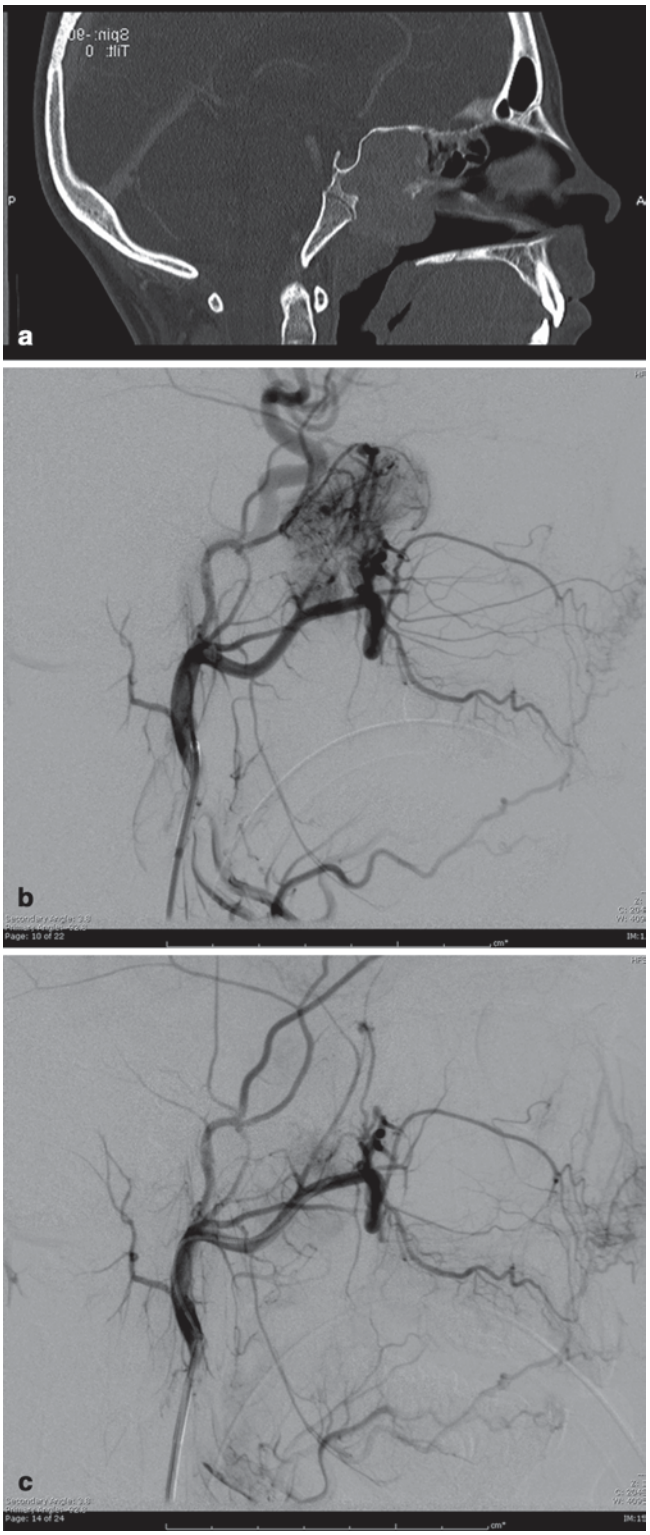

Fig. 5.3 Juvenile nasopharyngeal angiofibroma (JNA): **a** Sagittal CT-reconstructed image of the head demonstrates large enhancing nasopharyngeal mass. **b** Selective internal maxillary artery injection demonstrating hypervascular nasopharyngeal mass. **c** After selective embolization with PVA particles, there is near-complete cessation of flow to the mass with preservation of the normal circulation

common. Lower cranial nerves, such as the facial nerve or hypoglossal nerve can undergo ischemia if the vaso nervorum is inadvertently embolized. When embolizing glomus tumors, preprocedural administration of an alfa-blocking agent is often necessary to reduce catecholaminergic activity. Not infrequently, complete arterial devascularization of the tumor bed is not achieved, and several groups have recently described direct puncture and the slow injection of acrylic glue to allow for permeation of the vascular tumor bed while avoiding its passage to the venous side or its reflux into normal arterial territory [25].

Nonvascular Interventions

Introduction

Image-guided procedures that do not involve endovascular access are more common than vascular procedures in most pediatric centers. In the case of pediatric head and neck tumors, these procedures can be divided into two categories: (1) obtaining tissue for diagnosis and (2) primary treatment of tumors or tumor-like conditions using minimally invasive, image-guided methods. The following are some of the more common examples in our practice.

Percutaneous Needle Biopsy

Almost any neck mass can initially be biopsied using percutaneous needle biopsy with ultrasound guidance. Automated or semi-automated cutting needles in the range of sizes between 14-gauge and 20-gauge are available. Ultrasound guidance is usually the choice modality, given its real-time capability. Most biopsy needles are sonographically visible, and precise real-time targeting of most masses is possible, even in locations adjacent to vital structures (Fig. 5.4a–c). Risks include bleeding, infection, and injury to the structures around the target, though these risks are small when compared to surgical approaches for biopsy in the neck. Other guidance modalities can be used for targeting, including CT and MRI (Fig. 5.4d–f); these almost invariably require general anesthesia. As mentioned above, radiation exposure in CT is a concern in the pediatric population.

The most commonly biopsied structures in the neck include lymph nodes, the thyroid and the parathyroid glands, as well as soft tissue and bony masses. Accessing the deep spaces of the head and neck can be challenging and potentially hazardous. Previously operated or irradiated tissues in the neck can pose radiographic diagnostic dilemmas and can be difficult to access when situated deep to the vascular, neural, and bony structures. Blind needle biopsies have a low yield and are potentially dangerous [26]. Challenging areas

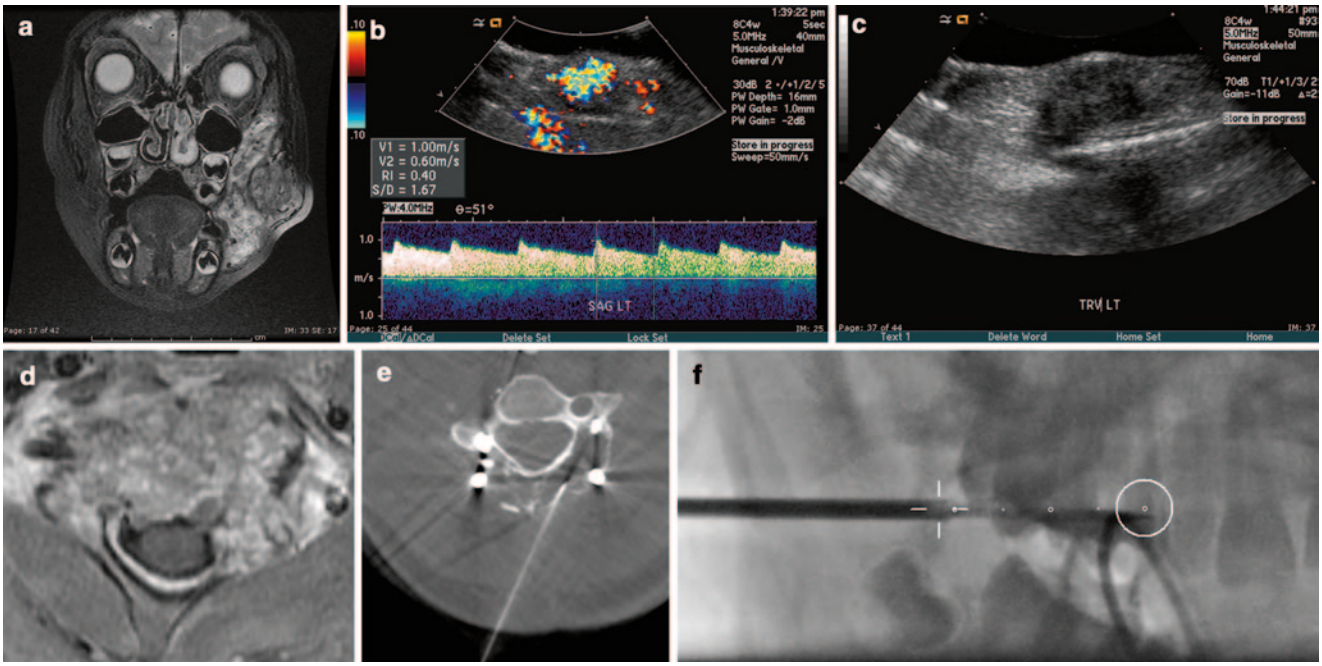

Fig. 5.4 Percutaneous image-guided needle biopsy: **a** Coronal T2 MRI of the head demonstrating large, heterogenous mass of the left face. **b** Ultrasound of the mass demonstrating moderate to high vascularity **c** Ultrasound-guided percutaneous needle biopsy with the needle (*white line*) targeting the less vascular portion of the lesion. The lesion was diagnosed as hamartoma. **d** Axial MRI of C2 with gadolinium demonstrating heterogenous mass involving the body and posterior elements with mass effect on the spinal canal. **e** CT- and **f** iGuide fluoroscopy-guided percutaneous needle biopsy of the lesion obtained tissue demonstrating the lesion to be aneurysmal bone cyst

for access include the infratemporal fossa, pterygopalatine fossa, pterygomaxillary fossa, parapharyngeal spaces, intraorbital, skull base, paralarngeotracheal and paraesophageal spaces, the retropharyngeal, parotid, thyroid, and paraspinous regions. But with cross-sectional imaging guidance, most lesions even in these areas can be sampled by core needle biopsy or fine needle aspiration (FNA). Lesions that can be visualized transorally, such as some parapharyngeal space lesions, can be approached through a transoral needle biopsy, with reported accuracy rates of 78–86 % [27–29]. Depending on different locations of the abnormality, various percutaneous approaches have been described such as the retromandibular, paramaxillary, submastoid, subzygomatic, transoral, posterior, posterolateral, and anterolateral approaches [30].

Bony lesions can be particularly challenging. Benign bone tumors commonly seen in the head and neck include bony "hemangiomas" (more accurately, VMs of bone), osteomas, dermoid and epidermoid tumors, and eosinophilic granulomas. Malignant tumors include sarcomas, chondromas, and metastatic lesions. Obtaining a sample from the soft tissue mass, bone mass, and its interface is most helpful. FNA can be obtained using a 20–22-gauge needle placed co-axially via an 18–19-gauge needle. An 11- or 13-gauge needle will permit the coaxial passage of a trephine Ackermann needle (15 and 16 gauge, respectively) to complete the bone biopsy. Smaller coaxial systems such as the Bonopty system are also available. MRI or fluorodeoxyglucose positron emission tomography (FDG PET) can be used to target viable segments of the tumor.

Radiofrequency Ablation

Radiofrequency ablation (RFA) involves localized delivery of electromagnetic energy, usually via a small needle probe, to induce thermal agitation resulting in induction of cytotoxic levels of heat in the surrounding target tissue to cause coagulation necrosis. RFA probes are usually placed percutaneously using image guidance, making the procedure common in IR. As mentioned above, RFA is often used in treatment of microcystic LM [15, 16]. In the context of outside vascular malformations, RFA is most commonly used to treat osteoid osteoma.

Osteoid osteoma (OO) is a benign bone tumor mainly seen in 10–30-year old male patients [31–33]. The cervical spine, followed by the lumbar spine are the most common levels of axial involvement [34]. Classic presenting symptoms include moderate to severe pain occurring mainly at night, typically relieved by nonsteroidal anti-inflammatory medication. The characteristic radiographic pattern is a nidus under 1 cm in diameter that is cortically based, within the bone.

Percutaneous RFA for OO is usually performed under CT guidance or fluoroscopy with Dyna CT capability, for optimal resolution of the bony lesion and needle trajectory,

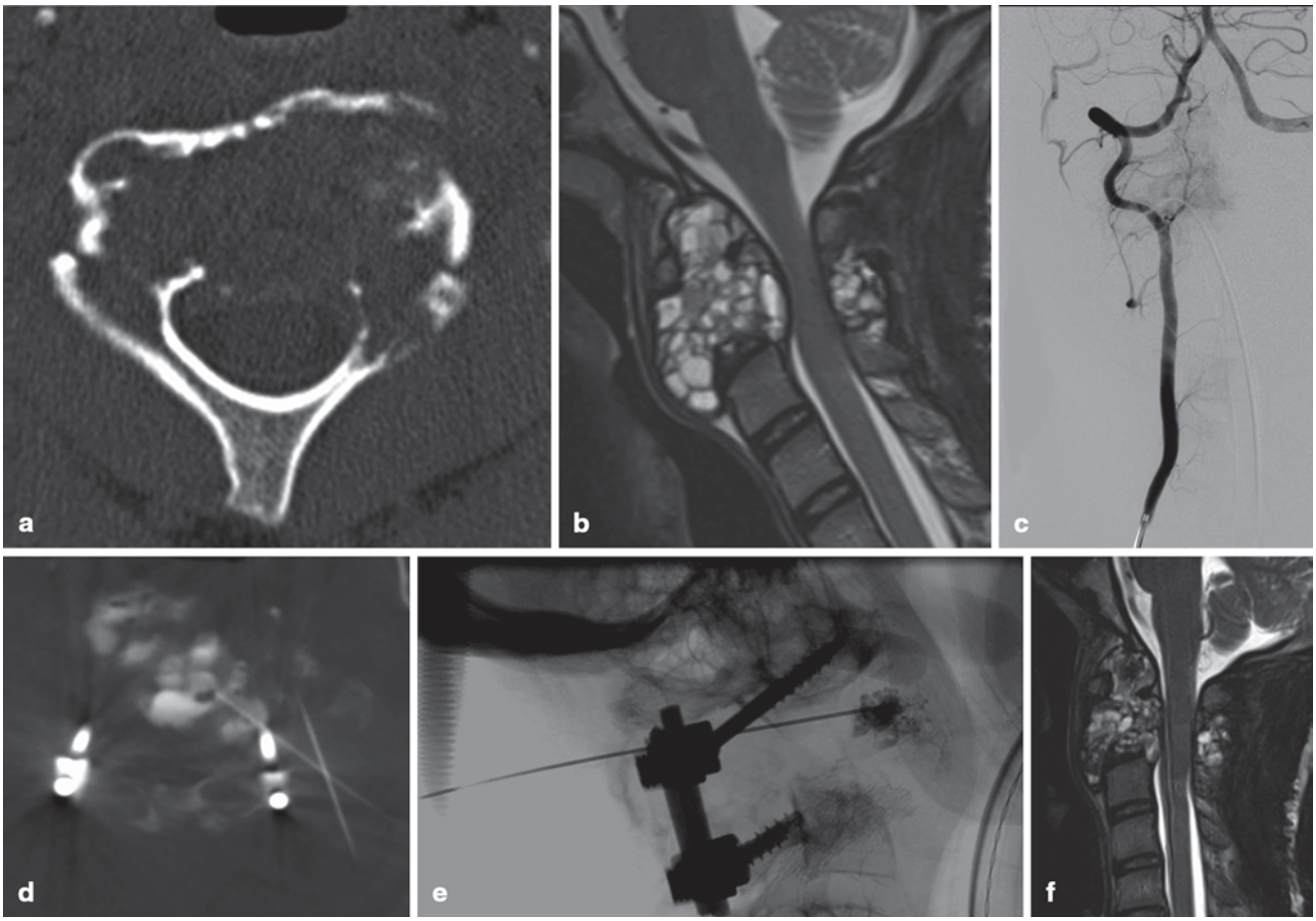

Fig. 5.5 Aneurysmal bone cyst of C2: **a** Axial CT demonstrating large expansile, lytic mass involving most of the body of C2. **b** Sagittal T2-weighted MRI demonstrating the multicystic nature of the lesion with some mass effect on the anterior spinal canal. **c** Right verterbral artery arteriogram demonstrating a small amount of vascularity. **d** dynaCT and **e** fluoroscopic-guided percutaneous sclerotherapy was performed on the lesion. **f** Follow-up MRI 4 weeks after procedure demonstrates interval improvement in the degree of mass effect on the spinal canal. There is also lower signal in the mass consistent with interval development of fibrous tissue post sclerotherapy.

with needle biopsy usually obtained at the same time. Proper placement of the grounding pads, in full contact with the skin without any air pockets, is necessary to avoid burns [35]. The target temperature is typically 90 °C. Under aseptic precautions, a small skin incision is made and an 11- or 13-gauge co-axial needle is passed under image guidance to the edge of the nidus. A 17-gauge, monopolar radiofrequency (RF) probe with a 7-mm or 1-cm active tip is placed through the coaxial needle and positioned with the active tip centered on the nidus. The coaxial needle is pulled back as far as possible on the probe to separate the coaxial needle from the active tip to avoid conduction of RF along the coaxial needle that may cause skin burns. The generator timer is set for a 6-min burn cycle and the energy is gradually increased over 1–2 min until the temperature at the probe tip registers 90 °C. Larger diameter nidus lesions may require multiple targets. Nearly all OO patients are pain-free by 2 weeks. In patients with inadequate clinical improvement, a review of procedural images to ascertain satisfactory position of the RF probe may be needed, as may a revising of the diagnosis of OO. The primary success rate for treatment of spinal OO has been cited as 76 % with a final success rate as high as 97 % [36].

Percutaneous Sclerotherapy for Aneurysmal Bone Cysts (ABC)

Sclerotherapy has been compared with gross resection for the management of ABC outside the head and neck [37]. In the head and neck, ABCs can occur in the cervical spine and result in pain, restricted neck movements and, critically, instability of the spine (Fig. 5.5a). These can be percutaneously accessed from posterior or postero-lateral approaches using cone beam CT (Fig. 5.5d) and ultrasound imaging to direct the needle into the cystic areas. Needle preference can range from 18-gauge spinal needles to 23-gauge Chiba needles, depending upon the ease of penetration through the bony cortex. Thinner needles reduce the possibility of reflux along the entry tract. If the outer cortex is difficult to penetrate, an18-gauge spinal needle is used coaxially with a

23-gauge inner needle that can be used to penetrate further into the cystic portion of the lesion. Different agents can be used for sclerotherapy, most commonly STS or doxycycline alone or in combination. Contrast injection into the cyst is performed first, to delineate the intralesional communication and the drainage pattern (Fig. 5.5e); particularly important in the neck, where drainage into veins that either drain or are in contiguity with the spinal and deep intracranial venous system is common. Extravasation into the spinal canal may result from insult to the bony margins by the expansile lesion or if the needle is partially located in the epidural space during injection. As cervical ABCs often present with significant baseline mass effect on the spinal cord (Fig. 5.5b), intraspinal injection, potentially increasing the mass effect, is of great concern, and intravenous steroids are liberally used in this setting. Moreover, we admit our patients to the intensive care unit (ICU) overnight following the procedure for careful neurologic assessment; patients understand that urgent decompression may be necessary in the setting of postprocedural edema. Another area of concern during sclerotherapy of cervical spinal ABCs is the inadvertent injury to the vertebral artery, potentially resulting in intra-arterial injection of sclerosant towards the brainstem [38] or causing vessel dissection and possible thrombosis and embolic infarct. Cervical CT angiography prior to the procedure helps to delineate the exact course and caliber of the vertebral artery in relation to the bony lesion (Fig. 5.5c). Baseline and postprocedure neurological examination are imperative. Response to treatment is evaluated by resolution of symptoms and follow-up cross-sectional imaging to look for interval fibrosis and osseous formation (Fig. 5.5f).

Conclusion

In sum, interventional radiologists are broadly involved in the management of patients with head and neck tumors, from diagnosis, to definitive treatment, treatments auxiliary to open surgery, and amelioration of symptoms. As novel, image-guided treatment approaches continue to develop, this close partnership between other specialists treating head and neck lesions and interventional radiologists will only grow and deepen.

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