number of time-consuming, unnecessary, costly investigations and no improvement in patient outcomes.

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Noninvasive Imaging Modalities in Coarctation of the Aorta

Coarctation of the aorta is characterized by narrowing of the aorta just distal to the left subclavian artery. It has a male preponderance and is frequently associated with hypoplasia of the aortic arch and isthmus. Other associated conditions include bicuspid aortic valve, dilated aortic root, mitral valve abnormalities, and intracranial aneurysm. Bicuspid aortic valve is the most common associated lesion occurring in about half of the patients. Coarctation of the aorta imposes a pressure load on the left ventricle, resulting in proximal systemic hypertension that may persist after surgery if correction is performed beyond 5 years of age. Patients who have surgical correction for coarctation are at risk for long-term complications including death. There were 87 late deaths, with a mean age of death of 38 years in 646 such patients followed up at the Mayo Clinic. The most common cause of death was coronary artery disease, followed by sudden death, heart failure, stroke, and ruptured aortic aneurysm. Regular follow-up with aggressive treatment of risk factors for coronary artery disease is clearly necessary in these patients.

There are several surgical procedures for aortic coarctation, including resection with end-to-end anastomosis, resection with replacement by a tube graft, patch angioplasty, and bypass grafts. There is increasing interest in the endovascular management of coarctation by angioplasty alone or with stenting, particularly in adult patients with this condition. Residual abnormalities of the aorta both at the site of coarctation repair and elsewhere are common in patients who have undergone either surgery or percutaneous dilatation. Recoarctation can occur such that 15% of patients require repeat intervention in 5 years. Aortic aneurysm at the site of the surgical repair occurs in up to 5% of patients after surgical repair, and is also a significant complication in patients who have undergone percutaneous angioplasty. The development of recoarctation and aneurysm formation increases the risk of serious complications such as aortic dissection and rupture. Thus, these patients not only need comprehensive and regular follow-up to optimize the management of hypertension and other risk factors for coronary artery disease, but they also require long-term follow-up for aortic complications such as recoarctation and aneurysm formation.

Different noninvasive imaging modalities can be used in the assessment and follow-up of patients with native or repaired coarctation, and the advantages and limitations of echocardiography (transthoracic and transesophageal), CT, and MRI are summarized in Table 1. Transthoracic echocardiography is ideal for the initial assessment, since it provides comprehensive assessment of valvular and ventricular function, in addition to reliable assessment of the pressure gradient across the coarctation. It is widely available, although technical skill is required to...
obtain optimal velocity profile across the coarctation to calculate the pressure gradient.

Transesophageal echocardiography (TEE) has an important role in patients with native and repaired coarctation. The entire thoracic aorta can be imaged, except for a small segment of the ascending aorta, which is obscured by the trachea or right bronchus. It is our experience that endovascular stent can be adequately visualized by TEE, although optimal velocity profile at the site of coarctation cannot be obtained. We frequently used TEE in addition to CT in the follow-up of patients who have endovascular stent for coarctation. While MRI and CT are not suitable for intraoperative applications, TEE is ideal for this setting to monitor endovascular coarctation repair by angioplasty or stenting and to assess for procedural complications including dissection and stent dislodgement.9,10

High-resolution images of the entire aorta including the coarctation segment can be obtained by MRI, which provides detailed anatomic information for the planning of invasive intervention such as surgery or percutaneous angioplasty. By virtue of its ability to provide multiple oblique-sagittal planes of the aorta, MRI is particularly suited in the follow-up of patients who have undergone surgical repair for coarctation, since the aortic arch and proximal descending aorta in these patients tend to be tortuous and difficult to image in the proper long axis view.11 However, there are situations where MRI is not the imaging modality of choice. One obvious situation is in patients who cannot undergo MRI because they have metallic prostheses such as pacemakers. Optimal images cannot be obtained in patients who have had treatment with endovascular stents since the stent artifact generally obscures the aortic segment that has been stented. In these patients the location and morphology of the stent can best be assessed by using both CT and TEE. CT is less affected by the stent artifact and can provide high-resolution images in the transverse plane. Compared to MRI, the aortic arch is not as well seen by CT because it is imaged obliquely and reconstructed CT sagittal views have limited resolution.

Although both MRI and CT can give high-quality images, measurements of the aorta by MRI and CT are not interchangeable. In this issue of CHEST (see page 1169), Hager et al showed that the differences between the two techniques in aortic measurements can be as large as 9 mm. This is an important message to bear in mind when assessing for progression of aortic dilatation in patients with Marfan syndrome, repaired coarctation, or chronic aortic dissection. Ideally, only serial measurements by the same method should be compared to minimize variability, and even then it is important to be aware of the intraobserver and interobserver variabilities of the specific technique (whether it is echocardiography, MRI, or CT) in one’s own institution. We need to avoid basing management decision on “measurements of different investigators on different studies with perhaps different methods.”

Patients with native and repaired coarctation are at risk for long-term complications and require regular follow-up. Understanding the advantages and limitations of the noninvasive imaging modalities should lead to their proper use and result in an improved long-term outcome for these patients.

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Train-of-Four To Monitor Neuromuscular Blockade?

ICU-acquired weakness is an unfortunately common and serious occurrence among critically ill patients.1–6 ICU-acquired weakness has multiple causes1 but is generally attributed to the following three conditions: ICU-acquired polyneuropathy; ICU-acquired myopathy; and prolonged neuromuscular blockade.3 The latter two conditions may be attributable to the use of neuromuscular blocking agents (NMBAs). Monitoring of the depth and duration of chemical paralysis is important to optimize neuromuscular blockade for each individual patient and to avoid complications of therapy.1,2,7 In a 2002 clinical practice guideline,1 in previous guidelines,8 and in other reviews,2,3,7 the use of peripheral nerve stimulation testing by periodically evaluating the response to a “train-of-four” (TOF) stimulation is recommended, in combination with clinical assessment, for all patients receiving NMBAs. However, the added value of TOF monitoring has been critically examined in only a few controlled trials that directly compare TOF testing with clinical evaluation alone,9,10 and these studies have arrived at contrasting conclusions. In this issue of CHEST (see page 1267), Baumann and colleagues report the results of a single-center randomized, controlled trial that prospectively compared the titration of cisatracurium by TOF monitoring to clinical evaluation alone. They found no difference in recovery time after the cessation of NMBa administration or in the total NMBa dosage given. No cases of ICU-acquired weakness were observed. They concluded that TOF testing is unnecessary when careful clinical assessment is performed, but they limit this recommendation to patients who are receiving the agent they used, cisatracurium, and a related agent, atracurium.

The evaluation of neuromuscular blockade begins with the indication for therapeutic paralysis and the desired level of muscle relaxation. Although common indications include the control of intracranial pressure, the control of muscle spasm, the control of intractable agitation, and the reduction in oxygen consumption, the majority of patients, including those in the study by Baumann et al, receive NMBAs to optimize patient-ventilator synchrony1,9,10 and potentially to improve oxygenation.11 The depth of neuromuscular blockade that is necessary to achieve the desired clinical goals, which range from synchronous respiration, to apnea, or even complete paralysis, varies considerably. The goals of monitoring include measures of effectiveness (ie, how well we are achieving our clinical goals), as well as safety (ie, whether we are avoiding overdosage), and otherwise reducing the likelihood of prolonged neuromuscular blockade and/or ICU-acquired myopathy. Although both the clinical assessment and measurement of the TOF are routinely utilized, survey data from 10 to 15 years ago indicated the use of TOF monitoring in only 8.3 to 41% of ICUs.12–14

All patients who receive NMBAs should undergo periodic clinical assessment,1 but what exactly is meant by this term? Experts consider the observation of skeletal muscle movement and respiratory effort as the foundation of clinical assessment.1 Clinical evaluation could more precisely focus on the assessment of the adequacy of muscle relaxation to achieve specific goals (ie, the observation of synchronous breathing, apnea, or absence of movement) as measures of efficacy. In the study by Baumann et al, clinical assessment consisted of evaluating patient-ventilator dysynchrony, including “bucking” the ventilator or high peak airway pressures, which prompted the increasing of the NMBa dosage. Apnea was not the goal except in patients undergoing inverse ratio ventilation, and the frequency of the