Reclaiming Clinical Confidence

The Systolic Murmur

By incorporating time-honoured palpatory and auscultory examination techniques, the physician can draw from a wealth of clinical information to confidently answer clinical queries.

By T. K. Fenske, MD, FRCPC, FACC, FCCP

Mrs. Young’s Case

Mrs. Young, 74, has severe osteoarthritis in her left hip, and has led a sedentary life over the last few years. She has been slated for total hip replacement surgery next week and presents for routine pre-operative review. She denies any symptoms pertaining to her cardiovascular system, and, in particular, has not experienced any exertional chest pain, dyspnea or pre-syncopal symptoms. She has no other medical problems.

Physical Exam

• Heart rate is 62 regular beats per minute with a blood pressure of 146/92 mmHg.
• Her carotid upstroke is delayed, and the carotid volume is low.
• Palpation of her precordium reveals a sustained apical impulse, palpable medial to the mid-clavicular line with two fingers.
• Auscultation reveals a soft first heart sound, paradoxically split second heart sound, and a left-sided fourth heart sound.
• At the base of the heart there is a grade 3/6 late-peaking crescendo-decrescendo harsh systolic murmur that radiates to both clavicles, and extends along the left sternal border.
• At the apex, a high-frequency, musical mid-systolic murmur is noted which doesn’t change with Valsalva manoeuvre or handgrip.
• The remainder of her cardiovascular exam is normal.

What is causing the murmur and might it affect her scheduled surgery?
See case discussion on page 42.

In this article:
1. What are the key palpatory and auscultory techniques?
2. How can I use the physical exam to differentiate common systolic murmurs?
3. How can the physical exam determine the severity of the problem?
The stethoscope is an icon of clinical medicine, but do we as clinicians use the stethoscope to its full capacity and trust our clinical findings? Aside from assessing breath sounds and measuring blood pressure, many modern health-care professionals seem to use the stethoscope for little more than fashion apparel. In this age of technology, it’s hard to develop and maintain confidence in clinical skills, such as precordial auscultation. In recent years, proficiency in cardiac auscultation by physicians-in-training in major medical institutions has been waning. The adage, “if you don’t use it, you lose it,” couldn’t be more appropriately applied as to maintaining clinical skills. Echocardiography has taken the place of the thorough physical examination for many physicians where such technology is readily accessible. However, modern technology is not infallible, not always available, and its indiscriminate use is not as cost-effective as the physical examination. It has been demonstrated that the physical examination is a sensitive and highly specific method of screening for valvular heart disease.

By incorporating time-honoured palpatory and auscultatory examination techniques, the physician can draw from a wealth of clinical information to confidently answer clinical queries. The systolic murmur is a common clinical finding in family practice, with a broad differential diagnosis, ranging from benign flow to severe mitral insufficiency or critical aortic stenosis (Table 1). Since most systolic murmurs occur well within the normal hearing range (Figure 1), the challenge for the clinician is not so much detecting the murmur, but rather determining what the murmur represents in terms of its etiology and severity. While audiotapes of heart sounds and cardiac simulators may be helpful for introducing auscultation, there is no substitute for the examination of

Table 1
Differential diagnosis of the systolic murmur

<table>
<thead>
<tr>
<th>Common causes</th>
<th>Less common causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow murmur</td>
<td>Tricuspid insufficiency</td>
</tr>
<tr>
<td>Mitral insufficiency</td>
<td>Coarction of the aorta</td>
</tr>
<tr>
<td>Aortic sclerosis</td>
<td>Pulmonic stenosis</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>Ventricular septal defect</td>
</tr>
<tr>
<td>HOCM</td>
<td>Patent ductus arteriosus</td>
</tr>
<tr>
<td></td>
<td>Subvalvular/supravalvular aortic stenosis</td>
</tr>
</tbody>
</table>

HOCM: Hypertrophic obstructive cardiomyopathy

About the author...

Dr. Fenske is an assistant clinical professor at the University of Alberta and staff cardiologist, Royal Alexandra Hospital, Edmonton, Alberta.
patients, who remain as Osler suggested, “the physician’s teachers.”

This article will highlight key palpatory (Table 2) and auscultory techniques (Table 3) that can help differentiate the common systolic murmur in the adult patient, and underscore some of the severity determinants. These techniques include assessment of the carotid upstroke and the apical impulse, and review of the auscultation descriptors of a systolic murmur, including the effect of specific dynamic manoeuvres.

### How do I discern the carotid upstroke?

Ejection of blood from the left ventricle into the aorta causes systolic expansion of the carotid arteries, and represents the initial slope of the ejection phase of the cardiac cycle, referred to as the carotid upstroke. The best technique to discern this slope is to apply firm pressure with the thumb over the carotid pulse, located just medial to the sternocleidomastoid muscle, at the level of the thyroid cartilage (Figure 2). A normal carotid upstroke has a tapping quality, and can be referenced to the examiner’s own carotid pulse. If there is obstruction of the flow, the systolic ejection of blood is hampered and the carotid upstroke is delayed, perceived by the examining thumb as “taking its time” or “pushing” on the thumb, rather than “tapping.” The differential diagnosis for a delayed carotid upstroke includes significant aortic valve stenosis, subvalvular membrane, and supravalvular stenosis. Bradycardia can give the false impression of a delayed upstroke, since the entire carotid contour, rise and fall, is slowed. The amount of arterial expansion is referred to as the carotid pulse volume, and represents the arterial pulse pressure. A low pulse pressure, often present in severe left ventricular dysfunction, can reduce the carotid volume and make the carotid pulse difficult to palpate, and the slope difficult to discern. In such cases, one needs to have a high index of suspicion that the

**Table 2**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Flow murmur</th>
<th>Aortic stenosis</th>
<th>Mitral insufficiency</th>
<th>HOCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carotid uptake</td>
<td>Normal</td>
<td>delayed</td>
<td>brisk</td>
<td>brisk</td>
</tr>
<tr>
<td>Apical impulse</td>
<td>Normal</td>
<td>sustained</td>
<td>diffuse &amp; deviated</td>
<td>sustained</td>
</tr>
</tbody>
</table>

HOCM: Hypertrophic obstructive cardiomyopathy
upstroke may indeed be delayed. An exception would be in patients with thick necks, where the increase in tissue may interfere with carotid palpation.

By contrast, the examiner perceives a brisk or “fleeting” upstroke when the left ventricular volume is emptied more quickly. This can occur in significant mitral insufficiency when blood is ejected during systole into both the aorta and the left atrium. A brisk carotid upstroke can also occur in patients with ventricular septal defect (VSD), hypertrophic obstructive cardiomyopathy (HOCM), or any hyperdynamic state. Confidence in calling a carotid upstroke as either “normal,” “delayed,” or “brisk” requires experience, and is a skill perfected from examining as many patients as possible, and using the results of the echocardiography as feedback. Re-examining the patient after the echo results are available is one way to train one’s thumb to “memorize” what the upstroke feels like in various valvular pathologies.

The apical impulse is defined as the most inferolateral palpable precordial impulse and represents the isovolumetric contraction time (IVCT) of the cardiac cycle (Figure 3). To best palpate the apical impulse, apply firm pressure over the inframammary region of the precordium using the volar aspect of the mid-phalanges of the right hand, with the patient lying supine and to the left of the examiner. Sometimes palpating the apex with the patient in the left lateral decubitus position helps to make it more apparent, since the heart moves closer to the chest wall. The key features of the apical impulse include its location, size, and duration. If any of these features are abnormal in a patient with a systolic murmur, it is unlikely to be a benign murmur. While it is often impossible to feel the apex in muscular or overweight patients, the mere presence of a palpable apical impulse in such patients suggests cardiac enlargement and pathology.

The location and size of the apical impulse are both clinical indicators of heart size. A deviated and diffuse apex suggests a volume-overloaded heart, as occurring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Innocent flow murmur</th>
<th>Aortic stenosis</th>
<th>Mitral insufficiency</th>
<th>HOCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Diamond</td>
<td>Diamond</td>
<td>Flat</td>
<td>Diamond</td>
</tr>
<tr>
<td>Duration</td>
<td>Early systole</td>
<td>Early to late systole (depending on severity)</td>
<td>Pansystolic</td>
<td>Mid-systolic</td>
</tr>
<tr>
<td>Location</td>
<td>LSB to apex</td>
<td>Base to apex</td>
<td>LSB to apex</td>
<td>LSB to apex</td>
</tr>
<tr>
<td>Radiation</td>
<td>None</td>
<td>Clavicles and carotids with high frequency components to apex</td>
<td>Axilla (AMVL)</td>
<td>None</td>
</tr>
<tr>
<td>Intensity sitting upright</td>
<td>≤ Grade 2; softer when louder with longer R-R intervals</td>
<td>Changes with PVCs (louder with longer R-R intervals)</td>
<td>Increases with handgrip</td>
<td>Increases with Valsalva manoeuvre and standing; decreases with handgrip and squatting</td>
</tr>
</tbody>
</table>

in patients with chronic severe mitral insufficiency (Table 4). The normal apical impulse should measure within 10 cm of the midsternal line, or medial to the mid-clavicular line. The “10 cm rule” seems to hold regardless of the patient’s size, since the larger the patient, the more difficult it is to localize the most lateral aspect of the impulse.6 The size of the apical impulse should be no larger than the width of two fingertips and palpable in only a single intercostal space. If three fingertips can palpate the apex or if it is palpable in two separate intercostal spaces, then the impulse is diffuse and the heart is likely enlarged.

The duration of the apical impulse reflects the IVCT, which is prolonged with increased pressure loading on the left ventricle. Aortic stenosis, HOCM, and hypertensive heart disease can all prolong the IVCT and produce a sustained apical impulse. The normal apical impulse should be palpable before the carotid upstroke. To determine if the apical impulse is sustained, palpate the carotid upstroke and the apical impulse at the same time. A sustained apical impulse remains palpable during or even after the carotid upstroke is felt, and supports the diagnosis of significant aortic stenosis in a patient with a systolic murmur, particularly if the carotid upstroke is delayed.

Is it a systolic murmur?

The shape and location of a systolic murmur, including the radiation pattern, may be helpful in determining its etiology and severity. Ejection murmurs of aortic sclerosis, aortic stenosis or HOCM tend to have a diamond or crescendo-decrescendo shape, following the rise and fall of turbulent flow during the ejection phase of the cardiac cycle in parallel with the left ventricular/aortic pressure gradient. Aortic stenosis prolongs the ejection phase and delays the peak intensity of the murmur; where the later the murmur peaks in systole, the worse the stenosis. By contrast, murmurs caused by mitral insufficiency or VSD are often “flatter” in shape and tend to occupy most, if not all, of systole, often enveloping both the first and second heart sounds. Many variations in murmur shape are possible, and the examiner needs to keep an open mind as to judging etiology on this one finding alone (Table 5).6

Locating where the murmur is loudest over the precordium may also be helpful in determining etiology since aortic pathology is often loudest at the base of the heart and mitral pathology at the apex. However, referring to these areas of the precordium as the “aortic area” or “mitral area” respectively can be misleading. Murmurs of aortic stenosis can be heard along the entire left sternal border, from the clavicles to the apex, referred to as the “aortic sash,” and can overlap with the murmur of mitral insufficiency. And while the apex is often the best location to hear mitral insufficiency, particularly when the patient is in the left lateral decubitus position, many variations are possible. As well, the murmur of HOCM is often best heard at the apex, and may be misinterpreted as mitral insufficiency.

The radiation pattern of the murmur may aid in determining the etiology, but again can be quite vari-
able. Aortic stenosis murmurs tend to radiate from the base of the heart towards the carotids, whereas flow murmurs tend to be more localized to the precordium. Bone is an excellent transmitter of sound, rendering the clavicles an ideal location to listen for the radiation of an aortic stenosis murmur, even preferable to the carotids, where bruits can be mistaken for murmur radiation. In moderate-to-severe aortic stenosis, the harsher, broader frequencies are best heard at the base of the heart, while the lung-filtered, high-frequency components of the murmur tend to be best heard at the apex (Gallavardin phenomenon), which may give the impression of more than one valvular pathology. The radiation pattern of mitral insufficiency is often to the axilla, particularly in the case of anterior mitral valve leaflet prolapse. By contrast, mitral insufficiency murmurs secondary to posterior mitral valve leaflet prolapse can radiate towards the sternum and even to the base of the heart, and be confused with aortic stenosis. Lastly, ventricular septal defects tend to be heard broadly over the entire precordium, and occasionally even between the scapulas.

What about murmur intensity?

Murmur intensity, although intuitively considered to reflect valve lesion severity, is perhaps the least useful of the examination parameters. It can be affected by a variety of factors, including the patient’s anterior/posterior chest diameter, the amount of muscle or fat, the presence of lung disease, and the blood pressure. While murmurs ≥ grade 4 (loud with a palpable thrill) are pathologic, benign flow murmurs can be loud in a normal individual with a thin chest wall. By contrast, in a patient with a thick chest wall over the age of 50, the mere presence of a murmur indicates pathology.6

Systolic Murmur

### Table 5

<table>
<thead>
<tr>
<th>Severity markers of aortic stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Delayed carotid uptake</td>
</tr>
<tr>
<td>2. Sustained apex</td>
</tr>
<tr>
<td>3. Precordial systolic thrill</td>
</tr>
<tr>
<td>4. Harsh, loud, late-peaking diamond murmur</td>
</tr>
<tr>
<td>5. Fourth heart sound</td>
</tr>
<tr>
<td>6. Paradoxically-split second heart sound</td>
</tr>
</tbody>
</table>

Techniques to improve success in defining murmur shape include:

- palpating the carotid pulse while auscultating the precordium to help mark the onset of systole
- having the patient hold their breath during auscultation to reduce noise
- drawing the murmur afterwards to force oneself to make note of the auscultory subtleties.
Systolic Murmur

Assessing the change in murmur intensity with simple bedside physiologic manoeuvres, including using the Valsalva manoeuvre, comparing standing to squatting, and use of isometric handgrip, can improve the diagnostic accuracy of clinical valve assessment.7 The Valsalva manoeuvre helps distinguish systolic murmurs of aortic valve pathology from dynamic outflow tract murmurs, occurring in patients with HOCM. The murmur intensity in HOCM is volume sensitive, softer when the blood volume in the left ventricle is increased, and louder when the blood volume is reduced. During the strain phase of the Valsalva manoeuvre, venous blood return to the heart is diminished and the lateral ventricle (LV) volume is relatively reduced. This effect augments the left ventricular outflow tract (LVOT) crowding by the hypertrophied septum and the systolic anterior motion of the anterior mitral valve leaflet, resulting in an increase in LVOT gradient and an intensified systolic murmur.8 The increase in murmur intensity is more easily appreciated if the examiner auscultates at the edge of the murmur’s radiation, where it is less audible, and then compares the murmur intensity with the patient performing the Valsalva manoeuvre.9 By contrast, murmurs of aortic stenosis, mitral insufficiency, or benign flow tend to diminish with the Valsalva manoeuvre since less blood is flowing across the respective valves. To have the patient perform the Valsalva manoeuvre, ask them to hold their breath and strain down, as if they were “lifting a heavy weight” or “having a baby.” The examiner may need to demonstrate the manoeuvre, particularly if there is a language or cultural barrier.

Case Discussion

This case illustrates the importance of a careful cardiovascular physical examination. Mrs. Young had physical findings consistent with severe aortic stenosis. Her elective hip surgery was cancelled, since aortic stenosis increases the operative risk substantially. She had an echocardiographic assessment, confirming critical aortic stenosis with a valve area estimated at 0.7 cm². Her lack of cardiac symptoms was likely due to her sedentary lifestyle caused by her arthritis. After a complete cardiology workup, she underwent successful aortic valve replacement surgery, and was later re-booked for her hip surgery.

Systolic Murmur

Take-home message

By incorporating time-honoured cardiac examination techniques including assessment of the carotid upstroke, the apical impulse, murmur description and dynamic auscultation, the clinician can be more confident in determining the significance of a patient’s systolic murmur.

**Carotid upstroke:** Apply firm pressure with the thumb over the carotid pulse, located just medial to the sternocleidomastoid muscle, at the level of the thyroid cartilage. A normal carotid upstroke has a “tapping quality,” whereas, if the carotid upstroke is delayed, the examining thumb will perceive the upstroke as “taking its time,” or “pushing on the thumb.”

**Apical impulse:** Apply firm pressure over the inframammary region of the precordium using the volar aspect of the mid-phalanges of the right hand, with the patient lying supine and to the left of the examiner. Pay attention to location, size, and duration.

**Systolic murmur:** Techniques to improve success in defining murmur shape include:
- Palpating the carotid pulse while auscultating the precordium to help mark the onset of systole.
- Having the patient hold their breath during auscultation to reduce noise.
- Drawing the murmur afterwards to force oneself to make note of the auscultatory subtleties.
Alternatively, the HOCM murmur can be differentiated from other systolic murmurs by having the patient squat from a standing position. Squatting increases blood flow back to the heart and simultaneously reduces afterload, resulting in diminished murmur intensity in HOCM, which then intensifies again when the patient stands, and the LV volume is lessened. To try this manoeuvre, the examiner should be sitting comfortably in front of the patient and auscultating over the precordium in the region where the murmur is best heard. The patient can hold onto the examining table for balance, and on cue can slowly squat in front of the examiner, allowing for comparison of the murmur's intensity between the two positions. Squatting to standing and vice versa has been shown to have 95% sensitivity, higher than the Valsalva manoeuvre.7

The isometric handgrip can be useful in differentiating murmurs of mitral insufficiency and VSD from murmurs of aortic stenosis and HOCM.7 Asking the patient to make a fist with both hands causes an increase in afterload on the heart, which tends to increase the amount of back flow in mitral insufficiency and left-to-right shunting in VSD. By contrast, increases in afterload help to “splint” the LVOT, and may diminish the murmur of HOCM. The murmur of aortic stenosis is less affected by handgrip and the intensity will likely not change.

By incorporating time-honoured cardiac examination techniques, including assessment of the carotid upstroke, the apical impulse, murmur description, and dynamic auscultation, the clinician can be more confident in determining the significance of a patient’s systolic murmur. This allows for a more discriminate use of echocardiography, which can then be used to further define valvular pathology for patients with suspicious physical findings and serve as a means of feedback for the clinical assessment.

References
1. Mangione S, Nieman LZ: Cardiac auscultatory skills of internal medicine and family practice trainees. JAMA 1997; 278(9):717.