Speculation on the origins of innocent murmurs began after the introduction of the stethoscope by Laennec - a physician, musician, and an expert in acoustics - in 1819 [1]. The stethoscope allowed auscultation and detection by palpation (a thrill or fremitus). In fact, the word murmur originally applied to low and indistinct speech, although current usage includes louder phenomena.

Murmurs are often equated with turbulence but this was disputed by McKusick [2], a physicist and a cardiologist. An attempt to quantify turbulence using the formula for the Reynolds number was comforting for those who wished to believe that murmurs were based on measurable variables resulting in objective decisions on murmurs. Unfortunately, textbooks provide a wide range of Reynolds numbers defining turbulence when exceeded. McKusick cautioned that "the Reynolds number provides information only of qualitative and descriptive nature and is largely of conceptual usefulness" (the formula is useful for identifying the factors involved in turbulence). The key factors are flow velocity and the viscosity of the fluid. For a cardiovascular system that has no anatomic abnormalities that produce no jets or obstruction, innocent murmurs reflect the direct effects of velocity and the inverse of viscosity.

An increase in velocity that produces a murmur is intuitively understandable in, for example, pulmonic stenosis. The normal ejection velocity in the pulmonary artery and aorta of children may be 1.5 times that of the adult normal velocity [3]. However, this may not result in an audible murmur in an adult with mild pulmonic stenosis. The child’s cardiovascular system has something else increasing the turbulence, low viscosity compared to an adult, primarily from a lower hematocrit. Adult males normally have a hematocrit of 45% and females 40%, whereas in childhood the normal hematocrit is only 37%. The combination of a relatively low viscosity and high ejection velocity is enough to create an audible murmur, but color Doppler does not show turbulence in normal children at the usual settings for echocardiograms. Why one can hear a murmur in children with no obvious Doppler turbulence, and what the source of the murmur is, are questions that are currently unanswered, but the source is likely at the pulmonary sinuses that are anterior to the aortic sinuses.

True anemia is well known to produce fairly loud systolic murmurs in structurally normal hearts. A similar situation exists during normal pregnancy when the hematocrit is lower and the velocity is higher, creating an innocent murmur. This raises the question whether non-pregnant adults ever have a truly innocent murmur, and a Doppler echocardiogram is probably indicated in that situation.

Predictably, polycythemia dampens turbulence so that pathological murmurs may become inaudible. For cyanotic patients with increased hematocrit the intensity of a murmur will be diminished, such as that of pulmonic stenosis in a tetrad of Fallot. The newborn, reflecting the normal fetal state of relative hypoxia, has a higher hematocrit, and they rarely have an innocent pulmonic ejection murmur in my experience.

The neonate has a murmur that could logically be considered innocent although not a pulmonic flow murmur in the usual sense described above. It has been shown [4] that when the infant arterial duct closes after birth it deforms the central end of the left branch of the pulmonary artery. We showed that this is associated with a doubling of the velocity there [5], compared to the main or right pulmonary artery. This produces a murmur audible in the pulmonic area and at the left axilla, and except for the latter may suggest to some that the duct is still open.

Another innocent murmur apt to be confused with a ductal murmur is the venous hum. These are rare in adults, but can be surprisingly loud when the child is sitting up, but not when lying. The murmur is
Murmurs over the carotid arteries in adults may suggest atherosclerotic disease, particularly if there are symptoms of cerebral ischemia, transient or permanent. When they are heard in children, transmission from an abnormal aortic valve must be considered. In 41 asymptomatic youngsters diagnosed by auscultation with precordial and carotid murmurs, aortic stenosis was concluded by physical examination in 30 patients [6]. We evaluated each child independently with Doppler echocardiography and peripheral vascular duplex scans. Aortic stenosis was diagnosed by Doppler echocardiography in 31, but three patients with pulmonic stenosis had carotid murmurs, and seven children with carotid turbulence had no detectable aortic or pulmonic valvular abnormalities. Obviously, some carotid murmurs are truly innocent since they were not transmitted from an intracardiac source. This was pointed out earlier by Leatham and colleagues [7]. We suggest that, when in doubt, it is worth performing a Doppler echocardiogram.

There are other differences, of course, among adults and children, particularly the thickness of tissues between the heart and the chest wall, and emphysema. Soft murmurs are much easier to hear in children and by the time a patient with a grade 4/6 murmur reaches even the twenties, the murmur will be one or two numbers less in amplitude. Having listened to quite a few medical students in the course of teaching physical diagnosis (an average age around 23), I have rarely heard any murmur, as a result of thicker tissues, higher hematocrit, and lower ejection velocity.

The innocent, musical murmur has provoked the most numerous explanations since it was first described by Dr. Still in 1909 [8]. This systolic murmur is heard best at the lower left sternal border or vibratory or resembling a "twangy string", heard better with the bell than the diaphragm. It is brief, mid-systolic in timing, and I recommend to medical students to try to hum it, characteristic of a musical note. The phenomena that may explain the this murmur starts with a consideration of analogies found in musical instruments, a perspective suggested by McKusick [2]. In his book, he concentrated more on abnormal musical murmurs, such as the ventrilated aortic cusp that he compared to a clarinet reed. He also mentioned the Aeolian harps that are placed in the windows of islands where the winds are almost constant. A cigar box is used as the resonator and the strings may be tuned; the result is pleasant, somewhat ethereal sound, varying in intensity with the wind. He speculated on the analog of the strings in the heart, and suggested false chords that may be seen randomly on autopsy and now, with echocardiography. His second suggestion was that the moderator band in the right ventricle was the origin of the sound.

But whatever the chord-like source may be, it must be under tension to make a sound, which effectively eliminates the false chords since they will be relaxed when the ventricles contract, and cannot provide a systolic murmur. Secondly, the chord must be more or less perpendicular to the left or right ventricular outflow tracts. The only chords that meet these requirements are those of the septal leaflet of the tricuspid valve that stretch across the right ventricular outflow, whereas the moderator band is oblique to the outflow tracts. The Still murmurs can be heard in the normal neonate as well as the child, however, a study of frequency and amplitude was found to decrease with age and ventricular dimensions but not with peak Doppler velocity [9]. This contradicts the opinion that the Still’s murmur is due to high velocity in a small aorta.[10]

In the aging subject, a new category of pathological murmur may occur, from sclerosis of the aortic valve, although it was earlier thought to be an innocent Still’s murmur.[11,12] Carotid bruits or murmurs that are innocent are real in healthy children, however In the child the possibility of a bicuspid aortic valve should be considered [6].

I gratefully acknowledge two great clinicians that shared their wisdom about auscultation with me in my early years, Sam Levine and Alex Nadas

Bibliography


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