Unusual heart sounds associated with venous air embolism

Case report

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The "millwheel" murmur heard in pulmonary air embolism is due to the turbulent flow of blood mixed with air in the beating right ventricle.\(^1,4,5\) It has been induced experimentally with the intravenous injection of small amounts of air,\(^3\) and it has been found that the nature of heart sounds changes as the quantity of air injected increases.\(^7\)

Shivpuri and coworkers\(^6\) have shown experimentally that characteristic heart sounds precede the onset of the "millwheel" murmur. When air was introduced continuously by way of the femoral vein at the rate of 0.5 cc per sec in dogs in the supine position, after 10 to 15 sec the heart sounds became metallic and resonant in character and the heart rate increased. After 20 to 25 sec, with continued injection at 0.5 cc per sec, the sounds became drum-like. This characteristic metallic sound has been called the "drum sign" and has been considered pathognomonic of venous air embolism. The sound soon became rhythmic and louder, resembling the galloping of a horse on a wooden bridge. At 30 to 40 sec a systolic churning murmur, the "millwheel" murmur, first appeared. It completely replaced the precordial heart sounds at 50 to 60 sec. Thus, the "drum sign" may occur prior to the "millwheel" murmur.

On the other hand, Durant, et al., in their experiments\(^1,2\) found that the "millwheel" murmur was heard immediately after injection of air, coincident with air reaching the right side of the heart as demonstrated by angiocardiographic studies. This sound followed the injection of air into the femoral vein of dogs in both the supine and the left lateral position as a bolus of 5.0 to 7.5 cc of air per kilogram of body weight, considerably more than the initial amounts injected in the experiments eliciting the "drum sign."

The following case presented characteristic features of the "drum sign" observed in animals, and may help to correlate the work of Shivpuri and Durant.

Case Report

In June, 1966, a 44-year-old mechanic underwent cervical laminectomy with H\(_2\)O-Fluothane-O\(_2\) anesthesia in the sitting position for a herniated disc at the C6–7 interspace on the left. The ligamentum flavum was excised. Enlarged epidural veins were packed until they had collapsed. The inferior margin of the seventh cervical nerve root was exposed and removal of an underlying disc fragment was started. At this moment, the blood pressure and pulse became unobtainable and no heart sounds could be heard. Immediately, external cardiac massage was started in the sitting position. The drapes were quickly removed and the patient was

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placed on his left side. External massage was continued in this attitude, the patient being supported from behind. Dark cyanotic motting appeared over his entire body within minutes. After 7 or 8 minutes of cardiac massage, four individual observers heard spontaneous heart sounds through a stethoscope placed over the precordium; two described the sounds as "a loud, high-pitched tinkling," like peristalsis in a partially obstructed bowel. A third observer said they resembled "the crinkling of celophane" while the fourth doctor heard a metallic sound like "the clashing of a high-pitched cymbal," the maximal noise being synchronous with systole and gradually fading out in diastole. The four doctors who listened to the precordium all agreed that venous air embolism had occurred.

The tinkling or cymbal sounds lasted for several minutes. The blood pressure remained imperceptible, then a radial pulse of 140 was obtained. Aramine, 2 mg, was given intravenously, and about 7 minutes later the first blood pressure since the onset of the episode was obtained. This was in the preoperative range of 180/110. The patient was kept for some time on his left side, and the neck wound was closed. The blood pressure remained stable. Cyanosis persisted for about 30 minutes and only very gradually cleared. He soon responded verbally and obeyed simple commands. The next day he was coherent and alert, without neurological deficit.

Discussion

In the case presented, the heart sounds resembled those of the "drum sign" described by Shivpuri. It is believed to be the first reported clinical counterpart of this sign. Review of the literature has not revealed a report of a comparable finding. Nevertheless, there are some differences in this case from the experimental work described by Shivpuri. The distinctive sounds heard in this patient occurred a number of minutes after cardiac arrest and did not precede other clinical signs. The sounds apparently changed somewhat from moment to moment, this variation accounting for the diverseness of descriptions by the observers. Cessation of the sounds resembling the "drum sign" was followed by normal heart sounds and not by a "millwheel" murmur.

The amount of air and the rate of its intravenous infusion are probably important factors in determining the characteristics of the heart sounds heard in venous air embolism. It is known experimentally that the quality of the sounds changes with the volume of air injected. The difference in the sounds first heard following air embolism in the experiments of Durant and Shivpuri may have been due to the slower rate and smaller volume of injection in the work of the latter. The difference in the timing of the "drum sign" in the work of Shivpuri and of the heart sounds in our case could be explained by comparable variations in the rate and volume of air entry. The diversity of the sounds heard in our case may be due to a change in the volume and position of air in the right ventricle.

Apparently the heart sounds associated with venous air embolism vary considerably. A single sign cannot consistently be relied on for diagnosis; therefore, one must be aware of the different symptoms of this entity so that prompt treatment can be instituted. Thus, although the sounds we have described were heard after a serious stage of air embolism had been reached, they might actually be present early in the crisis and thus even be premonitory.

Summary

A case has been described in which characteristic metallic heart sounds were heard over the precordium following air embolism. These sounds resembled to a certain extent the so-called "drum sign" described in experimental work as pathognomonic of venous air embolism. This case is thought to be the first reported clinical analogy to the "drum sign."

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References

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