Readers' Comments
The Digital Stethoscope —Two Senses Are Better Than One

"I hear and I forget. I see and I remember. I do and I understand"

Confucius

We read with great interest the recent article by Silverman and Balk,[1] and agree that the sound quality of the digital stethoscope is just as good, or superior to an analog stethoscope. This is important to today's practice of medicine where cardiovascular physical examinations are abridged, poorly executed, and minimal effort is undertaken to optimize the auscultatory milieu for a higher yield exam.[2] Amplification of sound does not necessarily result in clearer appreciation of heart sounds and murmurs as motion artifacts and surrounding noises are amplified as well (Figure 1).

In addition to the sound element, digital stethoscopes have the unique ability to incorporate the visual element of heart sounds and murmurs through phonocardiography. This can occur in real time, and in the palm of one's hand, thus greatly enhancing the examination experience for clinicians, trainees, and the patient. One does not even have to purchase a new stethoscope, but rather can purchase a stethoscope attachment, at a lower cost, which can digitalize the sound with the push of a button (e.g., the FDA cleared EKO Core stethoscope attachment, Berkeley, California).

Aside from murmur detection, phonocardiography has historically been the tool of choice to detect the third (s3) and fourth (s4) heart sounds,[3] and detection of these sounds by standard auscultation requires a certain level of experience.[4] The s3 and s4 are related to the echocardiographic Doppler indices of mitral inflow E and A wave velocities, respectively. This is relevant in the era of hand-held ultrasound devices where assessment of diastolic function is not possible, and volume assessment is focused mainly on the characteristics of the inferior vena cava.[5]

This is important clinically because the identification of these heart sounds is specific for diagnosing an elevated left ventricular end-diastolic pressure,[3] and this can be visualized clearly with the phonocardiogram feature of digital stethoscopes (Figure 2).

Recently, our group was able to better characterize the unique sounds produced by 3 FDA-approved durable left ventricular assist devices using phonocardiography.[6] Identifying changes in sound vibrations may be of theoretical benefit for detection of early pump thrombosis, which is something that echocardiography is not able to do.

Finally, until the price of a hand-held ultrasound device is reduced to that of a digital stethoscope, we believe that the digital stethoscope may be able to save the bedside cardiovascular exam, at least for now.

Disclosures

The authors have no conflicts of interest to disclose.

Faris G. Araj, MD[a,*]
Julie Cox, BSN, RN[b]
[a] University of Texas Southwestern Medical Center, Dallas, Texas
[b] Baylor Scott &White Health, Dallas, Texas
15 May 2019
23 May 2019

1. Silverman B, Balk M. Digital stethoscope-improved auscultation at the bedside. *Am J Cardiol* 2019;123:984–985.
2. Silverman B, Gertz A. Present role of the precordial examination in patient care. *Am J Cardiol* 2015;115:253–255.
3. Marcus G, Gerber I, McKeown B, Vessey J, Jordan M, Huddleston M, McCulloch C, Foster E, Chatterjee K, Michaels A. Association between phonocardiographic third and fourth heart sounds and objective measures of left ventricular function. *JAMA* 2005;293:2238–2244.
4. Marcus G, Vessey J, Jordan M, Huddleston M, McKeown B, Gerber I, Foster E, Chatterjee K, McMulloch C, Michaels A. Relationship between accurate auscultation of a clinically useful third heart sound and level of experience. *JAMA* 2006;166:617–622.
5. Marcon C, Moro E, Pillon L, Piccoli A. Prediction of the third and fourth heart sounds by Doppler echocardiography. *Echocardiography* 1997;14:425–433.

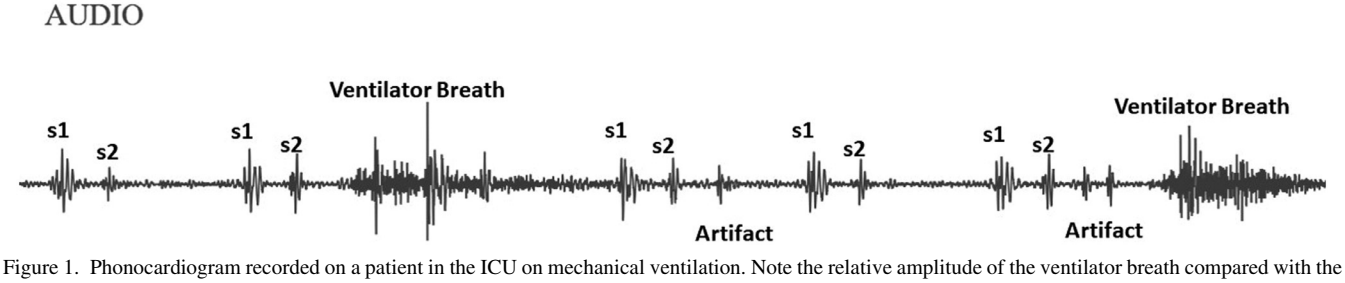

Figure 1. Phonocardiogram recorded on a patient in the ICU on mechanical ventilation. Note the relative amplitude of the ventilator breath compared with the native heart sounds. Artifact sound is also present. Recording was made using an EKO Core stethoscope attachment (EKO, Berkeley, California).

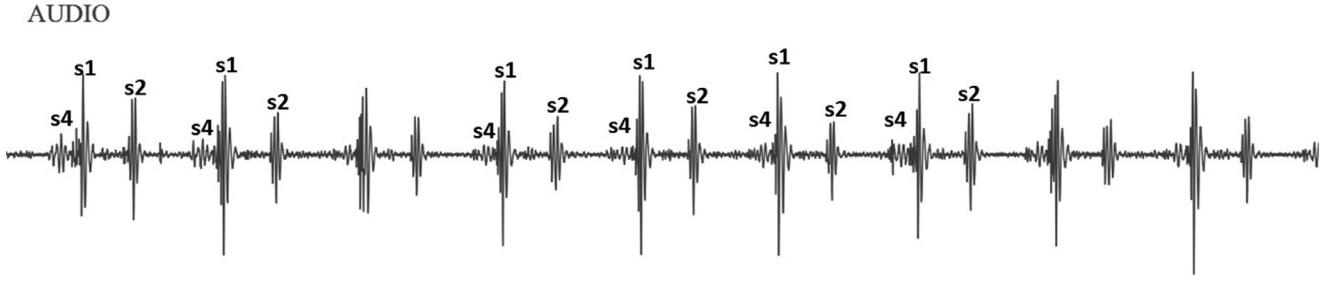

Figure 2. Phonocardiogram of an s4 in a young man with hypertrophic cardiomyopathy. An s4 is always a pathologic finding. Recording was made using an EKO Core stethoscope attachment (EKO, Berkeley, California).

6. Araj F, Amin A, Cox J, Mammen P. Refining auscultation of left ventricular assist devices: insights from phonocardiography. *VAD J* 2019;5:1–5.

https://doi.org/10.1016/j.amjcard.2019.05.042

Trial Sequential Analysis of Drug-Eluting Stents Versus Bare-Metal Stents in Saphenous Vein Graft Intervention

Implantation of drug-eluting stent (DES) compared with bare-metal stent (BMS) has emerged as an effective treatment for native coronary artery disease (CAD), even with a single month of dual antiplatelet therapy.[1] Contrary to native CAD, the pathophysiology of saphenous vein graft (SVG) lesions is characterized by a diffuse atherosclerotic burden coupled with a more rapid progression of the disease.[2] In a recent direct meta-analysis, Patel et al[2] reported the results of DES versus BMS implantation in SVG intervention. The results showed similar efficacy in both stent types with regard to the soft and hard clinical end points, specifically major adverse cardiovascular events, all-cause mortality, cardiovascular mortality, myocardial infarction, stent thrombosis, and target vessel revascularization (all $p > 0.05$).[2] However, only a few randomized controlled trials (RCTs; n = 6) with a limited sample size (n = 1,582 patients) were included in the analysis. As a consequence, the probability of type II errors (false negative) increases with consequent possible absence of statistical significance. Therefore, we performed a trial sequential analysis (TSA) to account for the risk of "chance findings" due to the lack of statistical power and precision.[3] We applied trial sequential monitoring boundaries using TSA software, Copenhagen Trial Unit, version 0.9.5.10 Beta, similar to that performed in interim analyses for RCTs.[3]

According to the available RCTs, the incidence of major adverse cardiovascular events in the BMS group was 43.3%.[2] To provide an 80% power to detect a relative risk reduction of 25% in the DES group at a 2-sided type α-error of 0.05, we estimated a diversity (D2)-adjusted information (sample) size of 4,157 participants (vs 1,582 in the current analysis). The cumulative Z-curve did not cross either traditional or trial sequential monitoring boundaries, indicating an "absence of evidence" (Figure 1). Similar inconclusive results were noted with regard to other clinical outcomes, such as all-cause and cardiovascular mortalities, myocardial infarction, stent thrombosis, and target vessel revascularization.

Although previous studies have shown beneficial short-term effects of DES implantation in SVG lesions compared with BMS likely due to restenosis prevention, long-term outcomes including target vessel revascularization were not impressive.[4] Although newer generation DESs have demonstrated improved outcomes in native CAD, they did not show advantages over BMS in a recent RCT for SVG intervention.[5]

Our TSA raises the distinct possibility that the publication by Patel et al and Brilakis et al are underpowered to answer the question of whether DES is superior to BMS in the treatment of patients who underwent SVG interventions. For now,

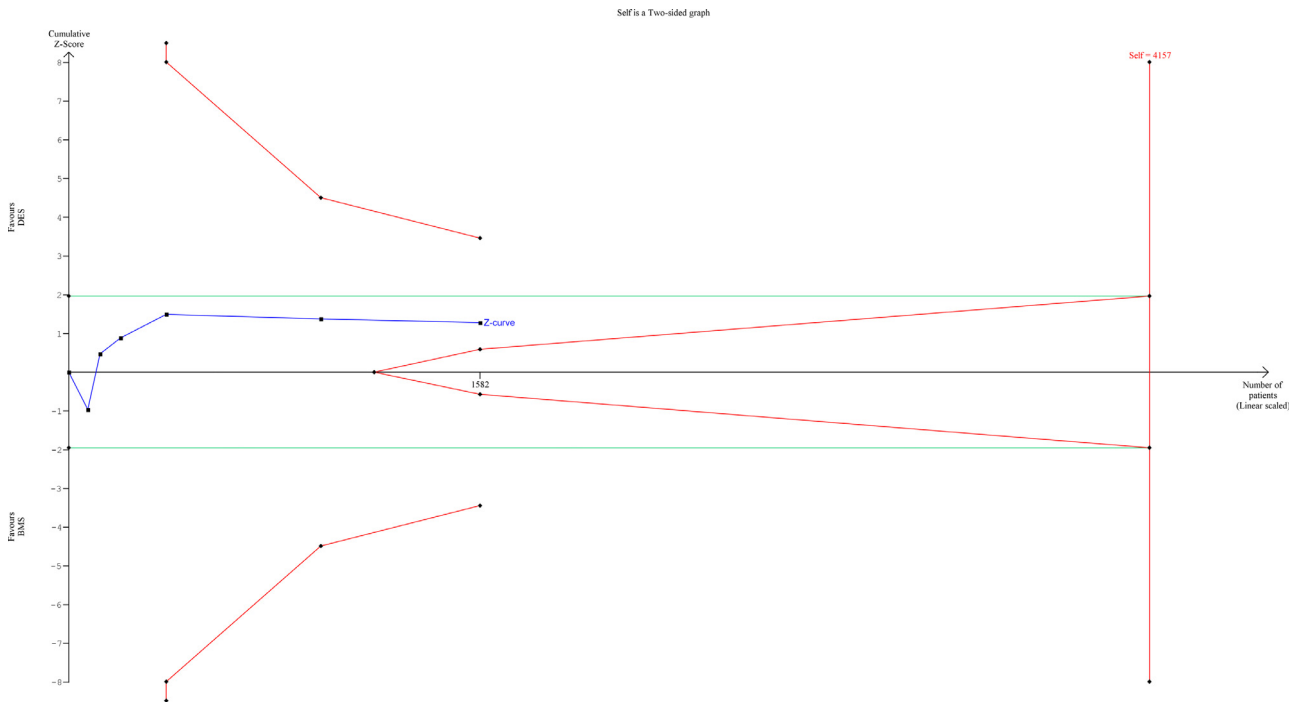

Figure 1. Trial sequential analysis for major adverse cardiovascular events. The diversity-adjusted information size equal to 4,157 (*vertical red line*). The cumulative Z-curve (*blue line* with *small black squares* representing each trial) does not cross the traditional boundary (*horizontal green line*), trial sequential monitoring boundaries (*concave red lines*), or the futility boundaries (*convex red lines*), indicating absence of evidence (inconclusive result). (Color version of figure is available online.)