discomfort for the patient when he or she lies on the tube. All the aforementioned problems may be associated with the use of the polyvinyl chloride tubes.³

We enjoyed very much Dr. Cooper's paper on lung volume reduction surgery and agree with the importance of proper patient selection and preoperative and postoperative care by which he has achieved his outstanding results. We hope this letter will prompt more consideration of this procedure from the health care payers.

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Assessment of the hemodynamic performance of small-size aortic valve prostheses

To the Editor:

We read with interest the recent paper by González-Juanatey and associates¹ investigating the influence of the size of aortic valve prostheses on hemodynamics and change in left ventricular mass. They concluded that 19 mm aortic prostheses continue to create significant obstruction of the left ventricular outflow tract and fail to bring about significant reduction in left ventricular hypertrophy.

One major point of criticism to this study is that each valve size group incorporated three very small subsets of patients receiving three different valve prostheses: two pericardial bioprostheses and one mechanical bileaflet prosthesis, yet the three subsets were grouped together when the hemodynamic variables were compared.

Doppler assessment of valve prostheses is complicated by an important phenomenon that greatly influences gradient and orifice area results—the nonuniform local velocities resulting from the unique geometry of each valve.² A good example is bileaflet prostheses, in which the two leaflets partition the orifice of the valve into three unequal smaller orifices with a nonuniform velocity distribution and a higher velocity jet between the two leaflets. This jet is detected by the Doppler beam, which records higher transvalvular gradients than those measured by a catheter. This, however, is not the case in bioprostheses, in which Doppler ultrasonography accurately measures transvalvular pressure drop.² It should be borne in mind,

therefore, that comparing studies of valves of different designs and flow patterns may not always be valid.

González-Juanatey and associates did report that there were no significant differences in the gradients between patients with mechanical prostheses and patients with bioprostheses. Nevertheless, the lack of a difference is likely due to higher gradients in the bioprosthesis group, bringing a balance to the Doppler-exaggerated gradients of mechanical valves. This theory is conceivable because bioprostheses are known to generate higher gradients than mechanical prostheses of equal size.³ It may also explain the significantly higher gradients reported by the authors for each size group compared with similar groups in previous studies.⁴⁻⁶

Another issue of concern is the simplistic use of gradients measured at rest in the assessment of prosthetic valve function. Such measurements may be misleading because, in addition to valve type and size, gradients are dependent on flow; hence small prostheses are known to produce high gradients at high cardiac outputs that are not seen at rest.⁷ Performance of a valve prosthesis should, therefore, be evaluated under a range of flow conditions, and hemodynamic alterations induced by exercise or dobutamine stress have been proposed as satisfactory approaches for assessing valvular function. Indeed, we have used the latter method to evaluate and compare the performance of small mechanical and bioprosthetic aortic valves.⁴⁻⁶ Not only was the performance of small prostheses found to be satisfactory, but we also demonstrated repeatedly that patient-prosthesis mismatch is not related to body surface area but primarily to cardiac output.

Although we entirely agree with the authors that a size 19 mm prosthesis should probably not be implanted in a physically active patient, our data disagree with their recommendation that it should be used only in patients with a body surface area less than 1.7 m². We look forward to the results of the exercise hemodynamics that González-Juanatey and associates are currently performing and hope that larger groups of patients will be studied and analyzed separately to make the data more informative.

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Reply to the Editor:

In their letter, Izzat and Yim essentially voice four criticisms of our results: first, that the transvalvular pressure drops that we report for mechanical prostheses are too high; second, that we should have taken measurements during exercise or after dobutamine infusion; third, that we should have investigated the dependence of patient-prosthesis mismatch on cardiac output rather than body surface area; and fourth (and presumably as a corollary of the first and third criticisms), that our recommendation that 19 mm valves not be implanted in patients with body surface areas greater than 1.7 m² is irrelevant.

Their first criticism is based on three points: a theoretical argument relating to the high-velocity central jet of bileaflet valves; the fact that we find no significant difference between the transvalvular pressure drops of bileaflet valves and bioprostheses (which they believe to have higher transvalvular pressure drops); and comparison with the transvalvular pressure drops reported in three papers authored by, among others, Izzat.

With regard to the first argument, we point out that, regardless of what the velocities of the lateral jets may be, that of the central jet is the result of a pressure that is a valid measure of ventricular effort and can be accurately calculated from the measured velocities (the value so calculated essentially does coincide with catheter measurements¹). With regard to the second point, we note that bioprostheses do not necessarily have similar hemodynamics^{2,3}; in all the small bioprostheses in our study the flaps were mounted outside the stent, and their hemodynamic performance is better than that of tilting disc valves and at least as good as that of bileaflet valves.¹⁻⁶ With regard to the third point, we frankly do not understand the transvalvular pressure drops reported in the papers they cite^{7,8} (e.g., mean transvalvular pressure drops of 3.12 ± 3.6 mm Hg for nine 21 mm St. Jude Medical valves [St. Jude Medical, Inc., St. Paul, Minn.], 4.87 ± 3.8 mm Hg for ten 21 mm CarboMedics valves [CarboMedics, Inc., Austin, Tex.], and 8.1 ± 8.4 mm Hg for eight 19 mm CarboMedics valves), which are between one half and one sixth of the values habitually found, not only by us, but by numerous other groups. For example, De Paulis and associates⁴ reported values of 20.1 ± 7.1 and 12.3 ± 3.4 mm Hg, respectively, for 19 and 21 mm CarboMedics valves; Franzen and colleagues,⁵ 17.0 ± 5.6 and 18.0 ± 7.7 mm Hg, respectively, for 21 mm CarboMedics and St.

Jude Medical valves; and Ihlen,¹ Chambers,⁶ and their coworkers, 17.1 ± 5.6 and 19.4 ± 5.6 mm Hg, respectively, for 19 mm CarboMedics valves.

In response to their second criticism, we have recently submitted for publication the exercise results obtained in the study that was mentioned in our article as still in progress. We do not believe that publication of the "disturbing" results obtained at rest with 19 mm valves should necessarily have awaited completion of the fuller study.

In response to their third criticism, transvalvular pressure drops are influenced by many interrelated factors, including valve area, systolic volume (and hence cardiac output), outflow tract anatomy, ventricular function, and body surface area. No correlation between transvalvular pressure drop and any single factor appears to be stable under variation of other factors. For example, in one of the papers by Izzat and others,⁸ there was a correlation between transvalvular pressure drop and cardiac output and transvalvular pressure drop and body surface area for one prosthesis type but not for another; unpublished results of our own, for 19 mm valves but not for larger sizes, exhibit correlations of transvalvular pressure drop with body surface area both at rest and after exercise and correlation with cardiac output only after exercise. On the other hand, quite an uncontroversial correlation exists between body surface area and aortic root size, which is what determines the size of prosthesis that can be implanted without a root enlargement procedure.

In view of the foregoing, we believe it is unnecessary to reply explicitly to their fourth criticism.

We incidentally point out what must surely be an error in two of Izzat's papers,^{7,8} both of which report a cardiac output of only 2.8 L/min in their group of 10 patients with 21 mm CarboMedics valves (of the value of 4.1 L/min they report for their 19 mm group). We also take this opportunity to point out another unconvincing feature of the data reported in one of the papers by Izzat and others⁷: the finding that whereas the effective area of 19 mm CarboMedics valves was 1.37 ± 0.53 cm², that of 21 mm valves of the same type was only 1.20 ± 0.62 cm². The problem there is not so much that the order of the mean values is the reverse of what it should logically be, but that this inversion is presumably the result of standard deviations that are much larger than those usually reported (0.1 to 0.2 cm² for 19 mm valves¹⁻⁶). One wonders whether these large standard deviations really reflect mainly inter-patient variation, especially inasmuch as no data on evaluator variability are given.

To close, we reiterate our reservations as to the routine use of 19 mm prostheses and bioprostheses. The exercise results to which Izzat and Yim look forward, and whose recent submission for publication was mentioned earlier, show that the increase in transvalvular pressure drops across small valves during effort is, to say the least, alarming.

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