TO THE EDITOR: We have read with interest the article “Decay time of the total vascular compliance during aging is different for different arterial beds” by MacKenzie Ross et al. (6). Using fluid-filled catheters, the authors have documented that the pulmonary arterial compliance is decreased in patients with proximal chronic thromboembolic pulmonary hypertension (CTEPH) compared with idiopathic pulmonary arterial hypertension. The empirical relationship between mean pulmonary artery pressure (mPAP) and systolic pressure (sPAP) (2, 3, 9) was also found to be altered by the presence of proximal thromboembolic obstructions (6). As a result, the equations to predict mPAP from sPAP used in clinical practice when sPAP is estimated from the maximum velocity of tricuspid regurgitant jet at echocardiography have to be adapted in proximal CTEPH with a lower mPAP recalculated from any sPAP estimate (6).

The empirical equation first proposed by our group was as follows: mPAP = 0.61 sPAP + 2 mmHg (2). The strong linear relationship between sPAP and mPAP has been confirmed by Syyed et al. (9). Our empirical equation has been further confirmed in a total of 166 individuals studied with micromanometer-tipped catheter, of whom 57% had pulmonary hypertension (PH) caused by many different conditions (3). A recent fluid-filled catheter pressure study performed in 307 patients, mainly with left heart diseases, has documented an empirical equation strictly identical to ours, namely mPAP = 0.61 sPAP + 1.95 mmHg (8). Very recently, a retrospective fluid-filled catheter pressure study of 463 congestive heart failure patients, with reduced ejection fraction and no PH, venous PH, or mixed venous and superimposed arterial PH has also reported an empirical equation remarkably similar to ours, namely mPAP = 0.615 sPAP + 3 mmHg (7). The authors of the current study (6) indicate that their results in idiopathic pulmonary arterial hypertension are in keeping with previous empirical equations including ours as they “generated a remarkably similar relationship between mean and systolic pressures as those observed using high-fidelity catheters, suggesting that this has little impact on our measurements.” Conversely, their results in CTEPH (6) clearly challenge previous empirical equations (2, 3, 7–9).

Our esteemed colleagues are experts in the field of pulmonary circulation. However, before accepting their conclusion, we have checked whether or not their new modified equation works in the subgroup of CTEPH patients whose individual pressure values have been previously published by two independent research groups using micromanometer-tipped catheters (2, 9). If one applies the author’s equation to predict mPAP in our seven CTEPH (proximal) (2), this leads to a −7 ± 4 mmHg mPAP bias (mean ± SD). In the seven CTEPH patients studied by Syyed et al. (9), the new equation leads to a −8 ± 4 and −6 ± 3 mmHg mPAP bias, assuming proximal or distal obstruction, respectively. It must be acknowledged that these negative results were derived from a relatively small number of CTEPH patients (n = 14), but the fact that the authors (6) have studied a much larger number of patients in no way guarantees the accuracy of their measurement. Given such marked discrepancies, favoring the results obtained with fluid-filled catheters (6) over those obtained with micromanometer-tipped catheter (2, 9) is counterintuitive.

One may wonder why standard catheters reliably picture the empirical relationship existing between mPAP and sPAP in numerous forms of PH (2, 3, 6–9) but not in CTEPH. Our hypothesis is that wave reflection phenomena are tremendously increased in CTEPH (1, 4), as acknowledged by the authors themselves (6), and that this is responsible for pulsatile pressure characteristics that cannot be reliably captured by standard catheters given their frequency response (4, 5). It is admitted that this may affect systolic pressure to a greater extent than the time-averaged mean pressure (4, 5). The resulting inaccuracies in the estimation of sPAP may have biased the mPAP versus sPAP relationship in CTEPH patients studied with fluid-filled catheters. This could explain the discrepancies with micromanometer-tipped catheter results discussed above. Consistently, if one compares the various empirical equations (2, 6), such discrepancies appear more marked in the patients with the highest sPAP values, i.e., in the patients who are likely to experience the most enhanced wave reflection phenomena. Thus, while fluid-filled catheters furnish invaluable information for current clinical care studies in CTEPH, one must be cautious to draw any firm conclusion on pulsatile pressure pathophysiology, even when strict technical requirements are met (5). As previously stressed, however, we fully agree that care is needed when applying our empirical equation to some subsets of patients, especially in cases where there is a ventricularization of the PAP curve due to proximal obstacle (e.g., pulmonary embolism) (2, 3). Thus we cannot exclude the possibility that a slightly different empirical equation relating mPAP and sPAP may apply in CTEPH, especially proximal CTEPH.

In conclusion, when applied to a database of 14 CTEPH patients whose individual pressure values have been previously documented by two independent research groups using high-fidelity recordings (2, 9), the new modified empirical equation proposed in CTEPH (6) does not work (i.e., mPAP is markedly underestimated). Here we respectfully...
suggest the possibility of a technical limitation of fluid-filled catheters given marked pressure wave reflections in CTEPH. The ability of the modified equation to accurately quantify the physiological link between the mean and pulsatile components of pulmonary artery load in CTEPH thus remains questionable. Before further studies are performed in a large CTEPH population to precisely document the mPAP-sPAP relationship with micromanometer-tipped catheter, caution is needed and the use of the modified equation (6) cannot be recommended in routine.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

D.C., V.C., and P.H. drafted manuscript; D.C., V.C., and P.H. edited and revised manuscript; D.C., V.C., and P.H. approved final version of manuscript.

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