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Response to “Pulmonary arterial compliance and pulmonary vascular resistance as a predictor of survival in acute respiratory distress syndrome: More questions than answers”

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Keywords

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We thank Drs. Jha for their enthusiasm, interest, and comments (1) regarding our work (2). They raise questions concerning the mechanism by which elevated left heart filling pressure is associated with reduced pulmonary arterial compliance (C_{PA}), posit that the transpulmonary gradient (TPG) is a flow independent variable in contrast to PAC, and emphasize that many clinical features of this critically ill patient population also influence pulmonary vascular physiology in ARDS.

Just because the TPG does not include a measure of flow in its calculation (i.e. stroke volume [SV]), this does not mean it is flow “independent”. In fact, TPG is impressively flow dependent – as cardiac output declines toward zero, so does the TPG. In 1971, Harvey et al first witnessed a disproportionate rise in the pulmonary pulse pressure (PPP), and therefore a rise mean pulmonary artery pressure (MPAP) and TPG, as pulmonary artery wedge pressure (PAWP) increased (importantly in the setting of a fixed stroke volume) (3). Analysis from our current FACTT cohort yield similar results to Harvey (Figure): a widening PPP as PAWP rises (note: SV 78-82mL; n=23). Mathematical review of the determinants of the diastolic pressure decay constant (RC time; the product of resistance and compliance), which declines with increasing PAWP (4), also illustrates that these effects are not mediated by SV as SV is included in both terms and cancels out.

The mechanism by which elevated PAWP is associated with a lower PAC for a given PVR is less well established. Because the majority of the compliance of the lung vasculature is

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peripherally located (i.e. small distal arteries and arterioles), one possibility is that pulmonary venous congestion may lower the blood storage capacity of these vessels, thereby decreasing compliance. Alternatively, and considering a scenario of equal PVR, higher MPAP compared with lower MPAP may still result in lower vascular compliance due to the non-linear pressure-diameter relation of the pulmonary arteries. It is also important to remember that both C_{PA} and PVR are estimated using assumptions that assuredly do not reflect all complex features of multifaceted physiologic systems (5); nonetheless, these simplified parameters are associated with outcome across multiple clinical conditions (left heart failure, pulmonary arterial hypertension, and now ARDS), suggesting they are useful to model behavior of complex physiologic systems and suggest hypotheses to be tested in prospective trials.

We agree that a myriad of clinical variables affect pulmonary vascular physiology in the critically ill, among them positive end-expiratory pressure as Drs. Jha suggest, and balancing oxygenation with pulmonary over-distention is a key concept in protecting the right ventricle (6). We demonstrate that different clinical variables are associated with different facets of the pulmonary vasculature- ventilator driving pressure with PVR and fluid balance with C_{PA} . Optimally protecting the RV in ARDS likely requires balancing multiple variables as Drs. Jha note; the vasopressor profile is another such variable that should be further studied. In summary, we agree with Drs. Jha (1) that additional and prospective studies are needed to define which aspects of right ventricular function should be targeted therapeutically.

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Figure.

Regression lines displaying pulmonary artery pressure as a function of pulmonary artery wedge pressure for 23 patients from FACTT with stroke volume 78-82 mL; PA pulse pressure increases with increasing PAWP.