Editorial

Invasive Assessment of Pulmonary Hypertension
Time for a More Fluid Approach?

Barry A. Borlaug, MD

Pulmonary hypertension (PH) is a significant public health problem that may develop from abnormalities in the pulmonary vasculature, with left-sided heart failure (HF), high cardiac output states, or any combination of these. The commonest cause is HF (group 2 PH), although many clinicians continue to associate the term PH with the much smaller cohort of patients with isolated pulmonary vascular disease (group 1 PH). A host of efficacious therapies improve outcome in group 1 PH, and when on appropriate treatment, this subgroup enjoys the highest survival rates. In contrast, group 2 PH is associated with the worst outcomes. Although trials are underway, there is currently no established treatment for group 2 PH, and some pulmonary vasodilators may even worsen outcome in patients with HF. Thus, distinction of these entities is of paramount importance.

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association. From the Division of Cardiovascular Diseases, Department of Medicine, Mayo Clinic, Rochester, MN. Correspondence to Barry A. Borlaug, MD, Mayo Clinic and Foundation, 200 First St SW, Rochester, MN 55905. E-mail borlaug.barry@mayo.edu

© 2014 American Heart Association, Inc.

Circ Heart Fail is available at http://circheartfailure.ahajournals.org
DOI: 10.1161/CIRCHEARTFAILURE.113.000983
have been expected to have PCWP >15 mm Hg after 500-mL saline infusion (dashed lines). In contrast, none of the women (or men; not shown) displayed PCWP ≥18 mm Hg after 0.5-L infusion. Data for this plot have been previously published and were kindly provided by Drs Naoki Fujimoto and Benjamin Levine.

Figure. A. In the normal left ventricle, chamber compliance is high and diastolic pressure–volume relationship (DPVR) is shallow and relatively flat (solid curve), resulting in a normal left ventricular (LV) end-diastolic pressure (LVEDP). Patients may display elevated LVEDP because of loss of diastolic LV compliance (leftward shifted DPVR; dashed line) or a parallel upward shift (dotted line) in the setting of enhanced extrinsic restraint from the pericardium or right heart. Note the similar shape of the normal and restrained DPVR, indicating similar intrinsic LV diastolic properties despite higher LVEDP. B. Line graph shows individual subject increases in pulmonary capillary wedge pressure (PCWP) in 30 healthy women. Over one quarter of women (8 of 30; dark lines/circles) would

increase left heart pressures via parallel effects mediated across the interventricular septum. Enhanced diastolic ventricular interaction is common in patients with left-sided HF and PH, but may also occur with isolated right ventricular pressure overload. Importantly, enhanced pericardial restraint can be observed even among healthy volunteers during saline loading. This was recently demonstrated by Fujimoto et al., where 60% of normal individuals developed a Kussmaul sign (increase or absent fall in RAP during inspiration) after just 1 L of saline infusion. Because RAP approximates pericardial pressure, one can estimate the component of PCWP that is related to LV properties (independent of pericardial restraint) by transmural LV filling pressure, defined as PCWP minus RAP. Although Robbins et al. did not report transmural pressures, the greater increase in PCWP relative to RAP in the OPVH group suggests that, on average, PCWP elevation was driven more by left heart disease. However, it would not be surprising to find that many patients in the OPVH group displayed elevated PCWP largely in relation to right atrial hypertension and pericardial restraint rather than primary left heart disease. This is important because the pathophysiology, natural history, and treatment for this group of patients may be distinct from the others.

In light of these data, it is also important to consider what constitutes a normal PCWP after fluid loading. Fujimoto et al. observed significant increases in PCWP with volume expansion in healthy volunteers, which were greater in women than in men, particularly among older women. Although volumes infused were higher and somewhat more rapid compared with the current study, one can extrapolate what the PCWP would have been after the same 0.5-L infusion used by Robbins et al. As can be seen (Figure, B), 27% of normal women (8 of 30) would have been expected to display PCWP >15 mm Hg after this degree of volume expansion. Men were less likely to show elevated PCWP after 0.5 L (3 of 30; not shown), but given the female predominance in the study of Robbins et al., it is entirely possible that the 22% prevalence of PCWP >15 mm Hg they observed is not all that different from what is seen with saline loading in normal women and men. Furthermore, it would seem that if PCWP ≤15 mm Hg identifies the normal basal filling pressures, one might allow for a higher PCWP cut-off after saline infusion, such as 18 mm Hg (a level achieved by none of the healthy volunteers;
remains unclear what the optimal provocative testing should be in patients presenting with PH and suspected HFpEF. Exercise is the more physiologically relevant stressor, but is less widely available compared with saline infusion.6,7 Future studies comparing these stresses may shed important light on this question.

Robbins et al8 are to be congratulated for a valuable contribution to the literature regarding hemodynamic evaluation of PH. Left heart disease is already the dominant cause of PH, and although the current data suggest that it might be even more dominant than previously appreciated, further study is required to identify the optimal partition values to define left heart disease, the impact of right–left heart interactions and pericardial restraint with fluid loading, the benefits of saline compared with exercise stress, and the ultimate management of the large and growing population of patients with HF and PH.

Disclosures
None.

References

Key Words: Editorials, heart failure, heart failure with preserved ejection fraction, hemodynamics, pulmonary hypertension
Invasive Assessment of Pulmonary Hypertension: Time for a More Fluid Approach?
Barry A. Borlaug

Circ Heart Fail. 2014;7:2-4
doi: 10.1161/CIRCHEARTFAILURE.113.000983
Circulation: Heart Failure is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2014 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-3289. Online ISSN: 1941-3297

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circheartfailure.ahajournals.org/content/7/1/2

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Heart Failure can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Heart Failure is online at:
http://circheartfailure.ahajournals.org//subscriptions/