

## Commentary

# Pro/con clinical debate: Pulmonary artery catheters increase the morbidity and mortality of intensive care unit patients

Stephen E Lapinsky<sup>1</sup> and Guy A Richards<sup>2</sup>

<sup>1</sup>Associate Director, Intensive Care Unit, Mount Sinai Hospital and Interdisciplinary Division of Critical Care, University of Toronto, Canada

<sup>2</sup>Director of Intensive Care, Johannesburg Hospital and Associate Professor, Department of Medicine, University of the Witwatersrand, Johannesburg, South Africa

Correspondence: *Critical Care Forum* Editorial Office, [editorial@ccforum.com](mailto:editorial@ccforum.com)

Published online: 24 December 2002

*Critical Care* 2002, **7**:101-103 (DOI 10.1186/cc1872)

This article is online at <http://ccforum.com/content/7/2/101>

© 2003 BioMed Central Ltd (Print ISSN 1364-8535; Online ISSN 1466-609X)

### Abstract

One of the highlights of the intensive care unit when I was a resident was the opportunity to place a pulmonary artery catheter and then spend the rest of the day calculating parameters such as oxygen delivery, oxygen consumption, intrapulmonary shunt fraction, and so on. I have noticed in the past few years that the use of these devices in our unit is much less frequent. In our case I am not absolutely certain of the reason for this. Perhaps with time our clinical sense has improved to the point that we do not need the data available, perhaps other tests have replaced the pulmonary artery catheter's role or perhaps we are worried about the possible morbidity/mortality associated with its use. In the present article, we revisit this important debate.

**Keywords** hemodynamics, pulmonary artery catheterization, pulmonary wedge pressure, Swan-Ganz catheterization

### The scenario

A 35-year-old woman is in the intensive care unit (ICU) with abdominal sepsis secondary to a perforated bowel. Complications include acute respiratory distress syndrome and hypotension, requiring mechanical ventilation and inotropes, respectively. The only worrying laboratory values are a doubling of the patient's serum creatinine level (despite good urine

output) and a slightly elevated lactate level. You are comfortable that surgical interventions are adequate and that antibiotic selections are appropriate. However, despite your best supportive care, the patient is not improving. You think a pulmonary artery catheter (PAC) could assist you further but you are worried that it may be harmful to the patient.

### Pro: Yes, PACs increase the morbidity and mortality of ICU patients

Stephen E Lapinsky

Although PACs are widely used in critical care, the precise role for this invasive monitoring intervention remains unclear. One approach to this discussion would be a review of clinical studies demonstrating a lack of efficacy of PACs in improving outcome [1,2] or of studies suggesting a potential harmful effect [3,4]. However, this argument does not seem to have been effective in changing practice. The present discussion will therefore take a logical approach to evaluating the benefits of invasive hemodynamic monitoring in this clinical scenario. Several pertinent questions should be considered.

#### What hemodynamic information do I need in this patient?

This patient has septic shock with acute renal failure. The clinical evaluation (jugular venous pressure, peripheral perfusion) can be very informative and there is usually little risk associated with careful additional volume administration. A trial of the hemodynamic effects of progressive fluid boluses [5] may be more useful than measurement of filling pressures. The evaluation and correction of volume status would be more important if the patients had imminently

reversible prerenal failure. From the clinical scenario, it seems probable that established acute tubular necrosis has occurred, and urine electrolytes would be the investigation of choice to assess this further. Knowledge of this patient's cardiac output is unlikely to be of value; any value from below the normal to one moderately increased would not be unexpected. Although the absolute values recorded may not be immediately helpful, the trend and response to vasopressors can be useful.

### Can the PAC provide this information reliably?

Various factors influence the ability to derive accurate hemodynamic information, and these should always be considered. Intrinsicly, the design of the PAC is unfortunately not ideal for the reliable measurement of pressures. An optimal system would use a short, large-bore catheter with stiff tubing [6]. A number of patient factors may make PAC measurements difficult or inaccurate [7]. A common problem is the spontaneously breathing, tachypneic patient. Pressure measurements and cardiac output estimations rely on timing with the respiratory cycle. The large intrathoracic pressure swings occurring in the patient with respiratory distress can make accurate pressure measurements impossible.

Another patient factor to consider is valvular heart disease. Tricuspid regurgitation makes thermodilution cardiac output difficult to interpret, and mitral regurgitation affects the nature of the wedge pressure waveform. Concomitant interventions, such as mechanical ventilation and positive end-expiratory pressure, can influence pressure measurements in an unpredictable way [8]. Inotropic agents can change ventricular compliance and afterload, altering filling pressures independent of volume changes [7].

### Will this information change my management?

No matter how much information the PAC provides, it is difficult to imagine that this invasive intervention can positively affect outcome if it does not result in changes to management. A useful exercise is to consider the various management options available (e.g. fluid administration, diuresis, vasopressors) and whether any specific hemodynamic finding would, in fact, change treatment.

### Summary

Invasive hemodynamic monitoring may have a role in the management of a select group of ICU patients, if done by properly trained physicians [9]. The potential risks are significant, however, and in many situations PACs contribute only to unnecessary morbidity and mortality [10].

---

## Con: No, PACs do not increase morbidity and mortality of ICU patients

Guy A Richards

It should be remembered that hemodynamic monitoring is not itself diagnostic of an underlying disease process unless the patient is merely hypovolemic. The following discussion does not therefore consider what further might be wrong with this patient, but this obviously warrants further attention. It is, however, necessary to support the patient until the primary disease responds and invasive monitoring would be useful to guide the use of vasoactive agents and fluid replacement. Clinical parameters alone are relatively inaccurate with regard to hemodynamic status in critically ill patients [11].

Parameters that are of particular value are cardiac output, pulmonary artery occlusion pressure, mixed venous oxygen saturation, right ventricular end diastolic volume, and systemic vascular resistance. Whereas some parameters may be obtainable with less invasive techniques, such as Doppler esophageal monitoring, only the PAC can easily and continuously or repetitively monitor them all. Despite these benefits, no agreement has been reached with regard to its potential to cause harm [12]. There have even been calls for a moratorium on its use until the issue is settled [13,14].

Most recent studies, although not showing benefit, have not shown an increase in mortality or morbidity [15,16]; although some have found an increase in length of stay and costs. Those studies that do suggest an increased mortality have serious methodologic flaws such as small numbers of

heterogeneous patient populations, inappropriate use of the PAC, insufficient evaluation of intensivist expertise and nonprotocol-driven therapeutic strategies in response to PAC data [17,18].

The most important shortcoming of the PAC appears to be that the derived data is incorrectly measured, interpreted and utilized [19]. In a recent study by Squara and colleagues, at least 35% of doctors attending three critical care congresses suggested at least one potentially harmful intervention when assessing clinical data in a case study provided. Subsequent to insertion of a PAC, the range of treatments and the number of harmful interventions were reduced and there was improved agreement between participants and designated experts as to correct management [20]. Nevertheless, the harmful interventions remained greater than 15% even without the participants themselves having to measure and record the PAC data. Ten percent of physicians still suggested harmful therapeutic strategies even after three PAC recordings were given, effectively increasing PAC-associated mortality by 30%. This study concurs that the PAC is more accurate than clinical assessment of hemodynamic status and that, when correctly utilized, diagnosis and management is improved. However, the persistent misutilization of data by a relatively small percentage of participants, and by extension a small percentage of study populations, will result in the

misconception that the PAC has no effect on or actually increases mortality. Studies that examine homogeneous populations with protocol-driven responses are the only ones likely to show benefit.

In conclusion, in the present scenario a PAC inserted by an intensivist trained in its use and utilizing protocol-directed responses would not increase mortality and morbidity, and probably would improve outcome.

## Pro's response

Stephen E Lapinsky

As Guy Richards points out, both clinical assessment and PAC measurement are associated with errors in evaluation and management. Clinical assessment is sometimes inaccurate in the evaluation of hemodynamic status but, similarly, PAC data is often incorrectly interpreted and utilized. The current standard of practice is to insert a PAC in cases of hemodynamic uncertainty. As there is no data

supporting a beneficial effect of the PAC in patients with hemodynamic compromise, the default state should be to rely on the clinical assessment. The PAC should be reserved for the minority of cases where, despite attempts to optimize therapy, further hemodynamic information is required and where these data can be interpreted and utilized correctly.

## Con's response

Guy A Richards

Stephen Lapinsky has not provided any evidence that the PAC would increase mortality. He states only that hemodynamic data would be unnecessary and that measurements may be unreliable. In terms of the former, clinical data must have been insufficient as "despite best supportive care" the patient did not improve. In terms of the latter, the circumstances in which the PAC is unreliable do

not apply to this patient; the fact that she was ventilated and was on inotropes without improvement mandates hemodynamic monitoring to exclude adverse effects of these interventions. It is true that the PAC is of value in certain selected patients. The present scenario describes just such a patient.

## References

- Guyatt G: **A randomized control trial of right-heart catheterization in critically ill patients. Ontario Intensive Care Study Group.** *J Intensive Care Med* 1991, **6**:91-95.
- Gattinoni L, Brazzi L, Pelosi P, Latini R, Tognono G, Pesenti A, Fumagalli R: **A trial of goal-oriented hemodynamic therapy in critically ill patients. SvO<sub>2</sub> Collaborative Group.** *N Engl J Med* 1995, **333**:1025-1032.
- Hayes MA, Timmins AC, Yau EH, Palazzo M, Hinds CJ, Watson D: **Elevation of systemic oxygen delivery in the treatment of critically ill patients.** *N Engl J Med* 1994, **330**:1717-1722.
- Connors AF, Speroff T, Dawson NV, Thomas C, Harrell FE, Wagner D, Desbiens N, Goldman L, Wu AW, Califf RM, Fulkerson WJ, Vidaillet H, Broste S, Bellamy P, Lynn J, Knaus WA: **The effectiveness of right heart catheterization in the initial care of critically ill patients. SUPPORT Investigators.** *JAMA* 1996, **276**:889-897.
- Webb AR: **Recognizing hypovolaemia.** *Minerva Anestesiol* 2001, **67**:185-189.
- Gardner RM: **Direct blood pressure measurements – dynamic response requirements.** *Anesthesiology* 1981, **54**:227-236.
- Raper R, Sibbald WJ: **Misled by the wedge? The Swan-Ganz catheter and left ventricular preload.** *Chest* 1986, **89**:427-434.
- Rajacich N, Burchard KW, Hasan FM, Singh AK: **Central venous pressure and pulmonary capillary wedge pressure as estimates of left atrial pressure: effects of positive end-expiratory pressure and catheter tip malposition.** *Crit Care Med* 1989, **17**:7-11.
- Iberti TJ, Fischer EP, Leibowitz AB, Panacek EA, Silverstein JH, Albertson TE: **A multicenter study of physicians' knowledge of the pulmonary artery catheter. Pulmonary Artery Catheter Study Group.** *JAMA* 1990, **264**:2928-2932.
- Dalen JE, Bone RC: **Is it time to pull the pulmonary artery catheter?** *JAMA* 1996, **276**:916-918.
- Abou-Khalil B, Scalea TM, Trooskin SZ, Hitchcock R: **Hemodynamic responses to shock in young trauma patients: need for invasive monitoring.** *Crit Care Med* 1994, **22**:633-639.
- Trotter SJ, Taylor RW: **Physicians attitudes toward and knowledge of the pulmonary artery catheter. Society of Critical Care Medicine membership survey.** *New Horiz* 1997, **5**:201-206.
- Bernard GR, Sopko G, Cerra F, Demling R, Edmunds H, Kaplan S, Kessler L, Masur H, Parsons P, Shure D, Webb C, Weidemann H, Weinmann G, Williams D: **Pulmonary artery catheterization and clinical outcomes. National Heart, Lung and Blood Institute and Food and Drug Administration workshop report. Consensus Statement.** *JAMA* 2000, **283**:2568-2570.
- Pulmonary Artery Catheter Consensus Conference: **Consensus statement.** *Crit Care Med* 1997, **25**:910-925.
- Rhodes A, Cusack RJ, Newman PJ: **A randomized controlled trial of pulmonary artery catheter in critically ill patients.** *Intensive Care Med* 2002, **28**:256-264.
- Williams G, Grounds M, Rhodes A: **Pulmonary artery catheter.** *Curr Opin Crit Care* 2002, **8**:251-256.
- Ivanov R, Allen J, Sandham J, Calvin JE: **Pulmonary artery catheterization: a narrative and systematic critique of randomized trials and recommendations for the future.** *New Horiz* 1997, **5**:268-276.
- Sibbald N, Keenan S: **Show me the evidence: a critical appraisal of the Pulmonary Artery Consensus Conference and other musings on how critical care practitioners need to improve the way to conduct business.** *Crit Care Med* 1997, **25**:2060-2063.
- Gnaegi A, Feihl F, Perret C: **Intensive care physicians insufficient knowledge of right heart catheterization at the bedside: time to act?** *Crit Care Med* 1997, **25**:213-220.
- Squara P, Bennet D, Perret C: **Pulmonary artery catheter: does the problem lie with the users.** *Chest* 2002, **121**:2009-2015.