

*Is Utilization of the Pulmonary Artery
Catheter Still Relevant in Patients
Undergoing CABG and/or Single
Valve Replacement?*

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Disclosures

- None

Goals of this lecture

- Review the development of the flow-directed pulmonary artery catheter
- Review the physiology assessed by the catheter
- Critically assess current status of risk/benefits in cardiac surgery from the literature
- Make recommendations for when the use of a pulmonary artery catheter might be indicated.

Development of the Pulmonary Artery Catheter

- Werner Forssman 1929 – right atrial catheterisation (on himself)
- Cournand and Richards 1945 – Cardiac output measurement by direct Fick method
- All three won the Nobel Prize in 1956
- Swan 1970 – PAC monitoring of right heart pressures
- Forrester 1972 – thermistor added to PAC allowing CO measurement by thermodilution
- 1975 – Stephen Streat assists with first PAC used in New Zealand
- 1970s and 1980s – PAC use becomes widespread due to ‘obvious’ utility of the hemodynamic parameters provided

Catheterization of the Heart in Man with Use of a Flow-Directed Balloon-Tipped Catheter

H. J. C. Swan, M.B., Ph.D., F.R.C.P., William Ganz, M.D., C.Sc., James Forrester, M.D., Harold Marcus, M.D., George Diamond, M.D., and David Chonette

August 27, 1970

N Engl J Med 1970; 283:447-451

- Pressures in the right side of the heart and pulmonary capillary wedge can be obtained by cardiac catheterization without the aid of fluoroscopy. A No. 5 Fr double-lumen catheter with a balloon just proximal to the tip is inserted into the right atrium under pressure monitoring. The balloon is then inflated with 0.8 ml of air. The balloon is carried by blood flow through the right side of the heart into the smaller radicles of the pulmonary artery. In this position when the balloon is inflated wedge pressure is obtained. The average time for passage of the catheter from the right atrium to the pulmonary artery was 35 seconds in the first 100 passages. The frequency of premature beats was minimal, and no other arrhythmias occurred.

Thermodilution cardiac output determination with a single flow-directed catheter.

Forrester JS, Ganz W, Diamond G, McHugh T, Chonette DW, Swan HJ.
Am Heart J.
1972 Mar;83(3):306-11.

First demonstration of using the catheter for cardiac output determination.

Rapid Adoption of the PA Catheter

- Seemed rooted in solid physiology
- Provided information previously unavailable
 - Cardiac output
 - An indirect measure of left atrial pressure
 - A wave provided evidence of LV compliance
 - V wave an indicator of mitral regurgitation
 - Avoidance of high wedge pressure associated with pulmonary edema
- Also provided a new chargeable procedure

The Effectiveness of Right Heart Catheterization in the Initial Care of Critically III Patients

Alfred F. Connors Jr, MD; Theodore Speroff, PhD; Neal V. Dawson, MD; et al
JAMA. 1996;276(11):889-897.

- Methods
 - 5 teaching hospitals, 1989-1994
 - 5,735 patients
 - Measured survival, cost of care, intensity of care and LOS
 - Clinical record and National Death Index
 - Propensity scoring
- Results
 - Increased 30 d mortality (OR 10.3-1049)
 - Increased cost ~\$10K
 - Increased ICU LOS ~1.5 d

The Effectiveness of Right Heart Catheterization in the Initial Care of Critically Ill Patients

Alfred F. Connors Jr, MD; Theodore Speroff, PhD; Neal V. Dawson, MD; et al
JAMA. 1996;276(11):889-897.

“In this observational study of critically ill patients, after adjustment for treatment selection bias, RHC was associated with increased mortality and increased utilization of resources. The cause of this apparent lack of benefit is unclear.”

Is It Time to Pull the Pulmonary Artery Catheter?

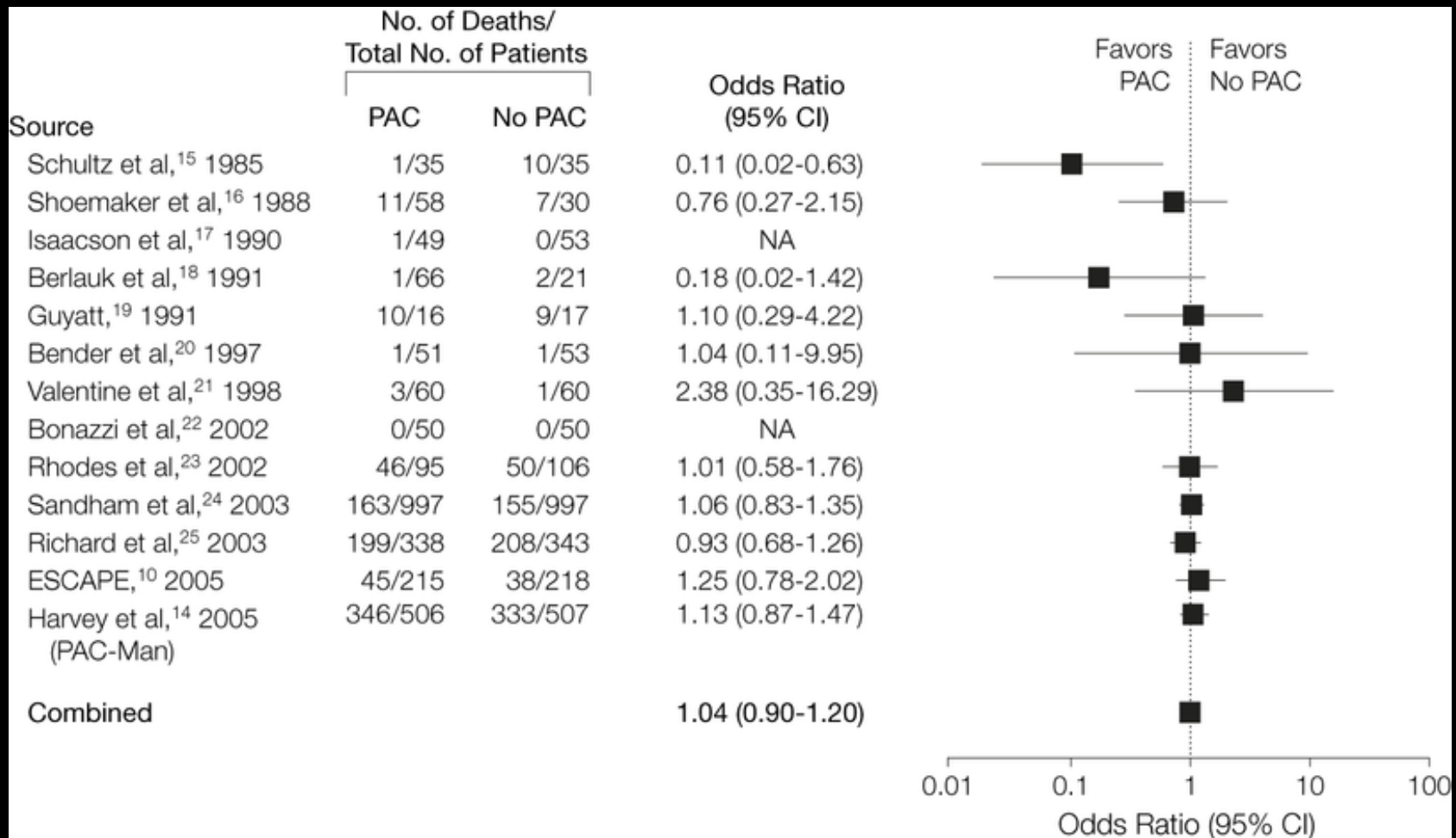
James E. Dalen, MD, MPH; Roger C. Bone, MD

JAMA. 1996;276(11):916-918.

“Despite the widespread use of this procedure and its attendant costs, there is no evidence that it benefits patients. Its use has not been shown to decrease patient morbidity or mortality. To the contrary, there is evidence that it may increase morbidity and mortality.”

Impact of the Pulmonary Artery Catheter in Critically Ill Patients Meta-analysis of Randomized Clinical Trials

Monica R. Shah, MD, MHS, MSJ; Vic Hasselblad, PhD; Lynne W. Stevenson, MD; et al
JAMA. 2005;294(13):1664-1670.



Searching for Evidence to Support Pulmonary Artery Catheter Use in Critically Ill Patients

J Hall

JAMA. 2005;294(13):1693-1694
(editorial)

“...it is likely that the available data will indicate that it is time to remove the catheter from widespread use, or at the very least relegate this former common monitoring tool to salvage therapy of an extremely small and select number of patients.”

Impact of the Pulmonary Artery Catheter in Critically Ill Patients

Meta-analysis of Randomized Clinical Trials

Monica R. Shah, MD, MHS, MSJ; Vic Hasselblad, PhD; Lynne W. Stevenson, MD; et al
JAMA. 2005;294(13):1664-1670.

- Conclusions
 - No benefit conferred
 - No increase in mortality or length of stay
 - No clear strategy for use of PAC
 - May be due to absence of effective evidence-based treatments

Lack of Effectiveness of the Pulmonary Artery Catheter in Cardiac Surgery

Schwann, Nanette M. MD^{*,†}; Hillel, Zak PhD, MD[‡]; Hoefft, Andreas MD[§]; et al

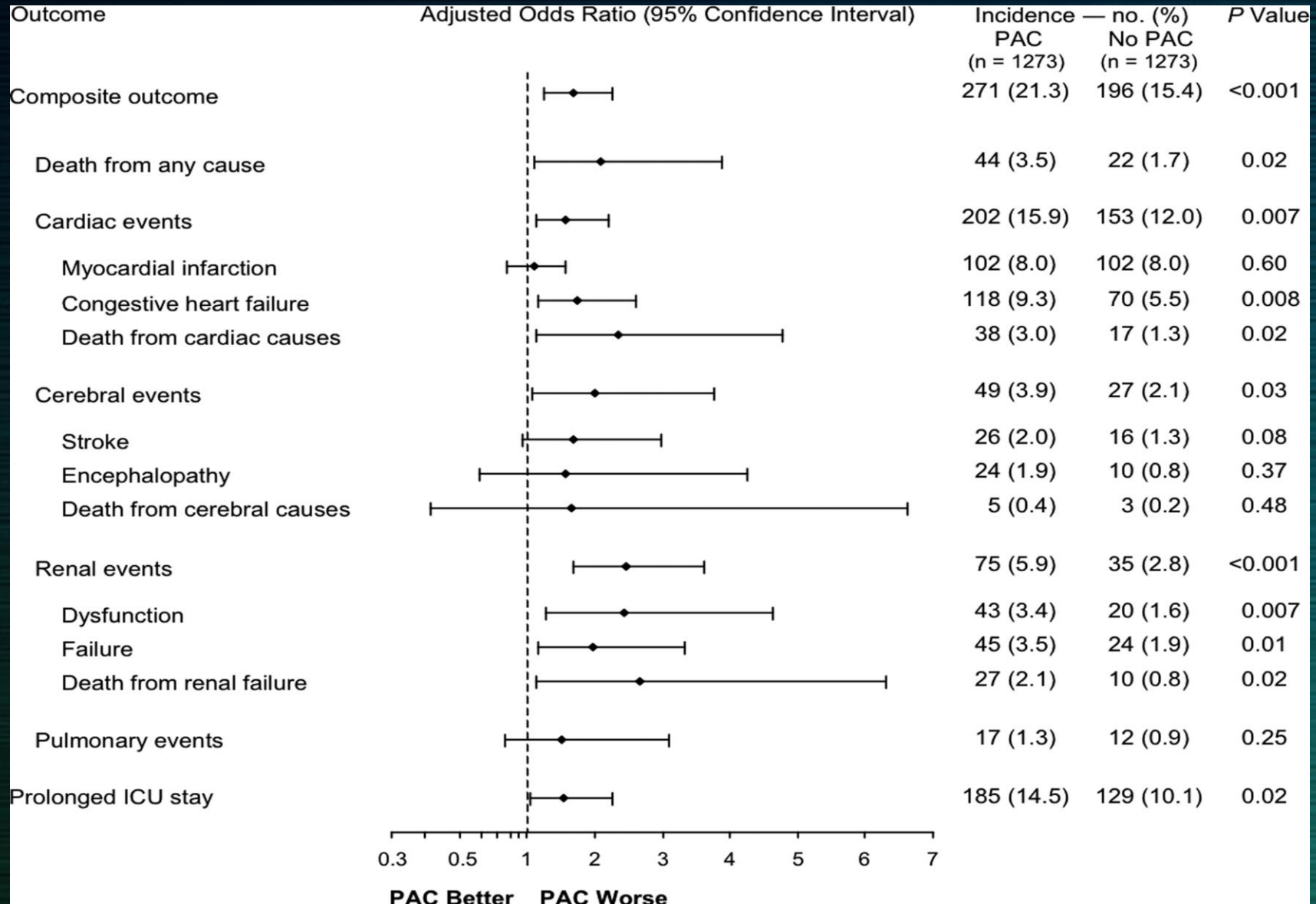
Anesthesia & Analgesia:

November 2011 – 113(5): 994–1002

- **Methods**
 - Multicenter (70) study
 - Prospective observational study 1996-2000
 - 5065 patients yielding 1273 propensity-matched pairs
 - Composite endpoint- death, MI, CHF, stroke, encephalopathy, renal dysfunction, pulmonary dysfunction
 - Secondary endpoints- inotropes, fluids, intubation duration, ICU LOS
 - Excluded patients with TEE as well, contrasted PAC only vs. neither PAC/TEE

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- Conclusions
 - Increased mortality
 - Higher incidence of end-organ dysfunction
 - Randomized trial with defined hemodynamic goals needed

PAC Cost

- Introduce kit ~\$54
- PAC- \$52-52
- Multilumen CVP- \$121

Cost of equipment alone is mildly favorable to PAC

Why Hasn't the PA Catheter Proven Helpful?

- The information it provides is of no value
 - ?
- Utility has been diluted by using in too many patients who will not benefit
 - Either too many good or too many bad outcomes in the population
- Inability of user to interpret
 - Does not seek appropriate information at appropriate times
 - When was the last time you got a wedge pressure?
 - Is the data obtained before an intervention is decided upon
 - Does not recognize relevant information
- Inappropriate treatment algorithms
 - Likely need some degree of individualization, but need a coherent approach

Conclusions

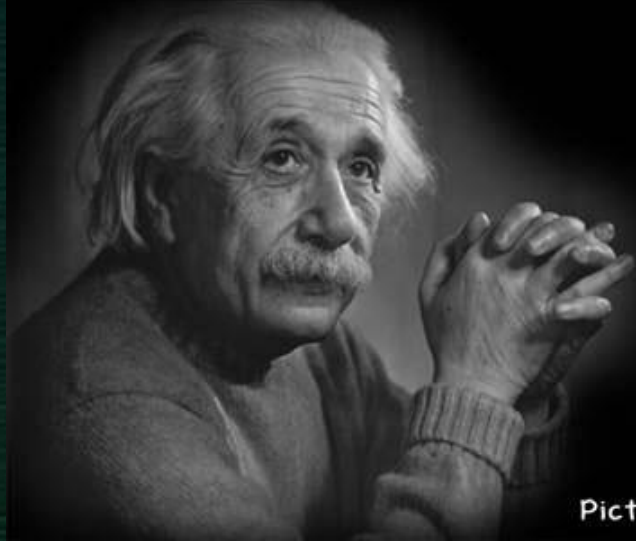
- There are good physiologic arguments why pulmonary catheters might be helpful
- Nevertheless, there is very little data to support the use of pulmonary catheters (in any patient population)
 - All studies have serious flaws
 - Higher proportion of interventions (inotropes, fluid) in PAC groups
 - There is a great deal of variability among users to correctly identify data
 - There are essentially no proven guidelines about how to use the data
 - Using a monitor in a trial designed to test results of undefined therapy is questionable
- There appears to be no or little added risk although probably added cost due to additional therapies utilized
- *If they were half as helpful as we thought they were, it shouldn't be so damned hard to prove.*

Other monitors we use

- CVP-
- A-line-
- Pulse oximetry
 - Only randomized trial was negative
- EKG
- Processed EEG (BIS, etc.)
- Cerebral oximetry
- Etc.

None have been demonstrated in randomized trials or even propensity matched trials

**Insanity: doing the
same thing over and
over again and
expecting different
results.**



Albert Einstein

?Recommendations for Possible Use of Pulmonary Catheters in Cardiac Surgery

- Disclaimer- this is only my opinions based on literature and experience
- Complex cases
- High risk of organ dysfunction (renal, intestinal, cardiac)
- Low EF or substantial change in LVEDP pre- to post-catheterization
- No MD coverage at night
- Surgeon demands it
- Poor surgeon
- Only when appropriately skilled and knowledgeable users are available 24/7
- Useful therapies need to be better identified