PULMONARY ARTERY CATHETERS:
CON DEBATE

Dr. Christopher C. C. Hudson, MD MED MPH FRCPC
Assistant Professor
Department of Anesthesia and Pain Management

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Disclosures

No industry funding or affiliations

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab

COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Marik *Annals of Intensive Care* 2013, **3**:38
http://www.annalsofintensivecare.com/content/3/1/38

Annals of Intensive Care
a SpringerOpen Journal

REVIEW Open Access

Obituary: pulmonary artery catheter 1970 to 2013

Paul E Marik

Abstract

The birth of the intermittent injectate-based conventional pulmonary artery catheter (fondly nicknamed PAC) was proudly announced in the *New England Journal of Medicine* in 1970 by his parents HJ Swan and William Ganz. PAC grew rapidly, reaching manhood in 1986 where, in the US, he was shown to influence the management of over 40% of all ICU patients. His reputation, however, was tarnished in 1996 when Connors and colleagues suggested that he harmed patients. This was followed by randomized controlled trials demonstrating he was of little use. Furthermore, reports surfaced suggesting that he was unreliable and inaccurate. It also became clear that he was poorly understood and misinterpreted. Pretty soon after that, a posse of rivals (bedside echocardiography, pulse contour technology) moved into the neighborhood and claimed they could assess cardiac output more easily, less invasively and no less reliably. To make matter worse, dynamic assessment of fluid responsiveness (pulse pressure variation, stroke volume variation and leg raising) made a mockery of his 'wedge' pressure. While a handful of die-hard followers continued to promote his mission, the last few years of his existence were spent as a castaway until his death in 2013. His cousin (the continuous cardiac output PAC) continues to eke a living mostly in cardiac surgery patients who need central access anyway. This paper reviews the rise and fall of the conventional PAC.

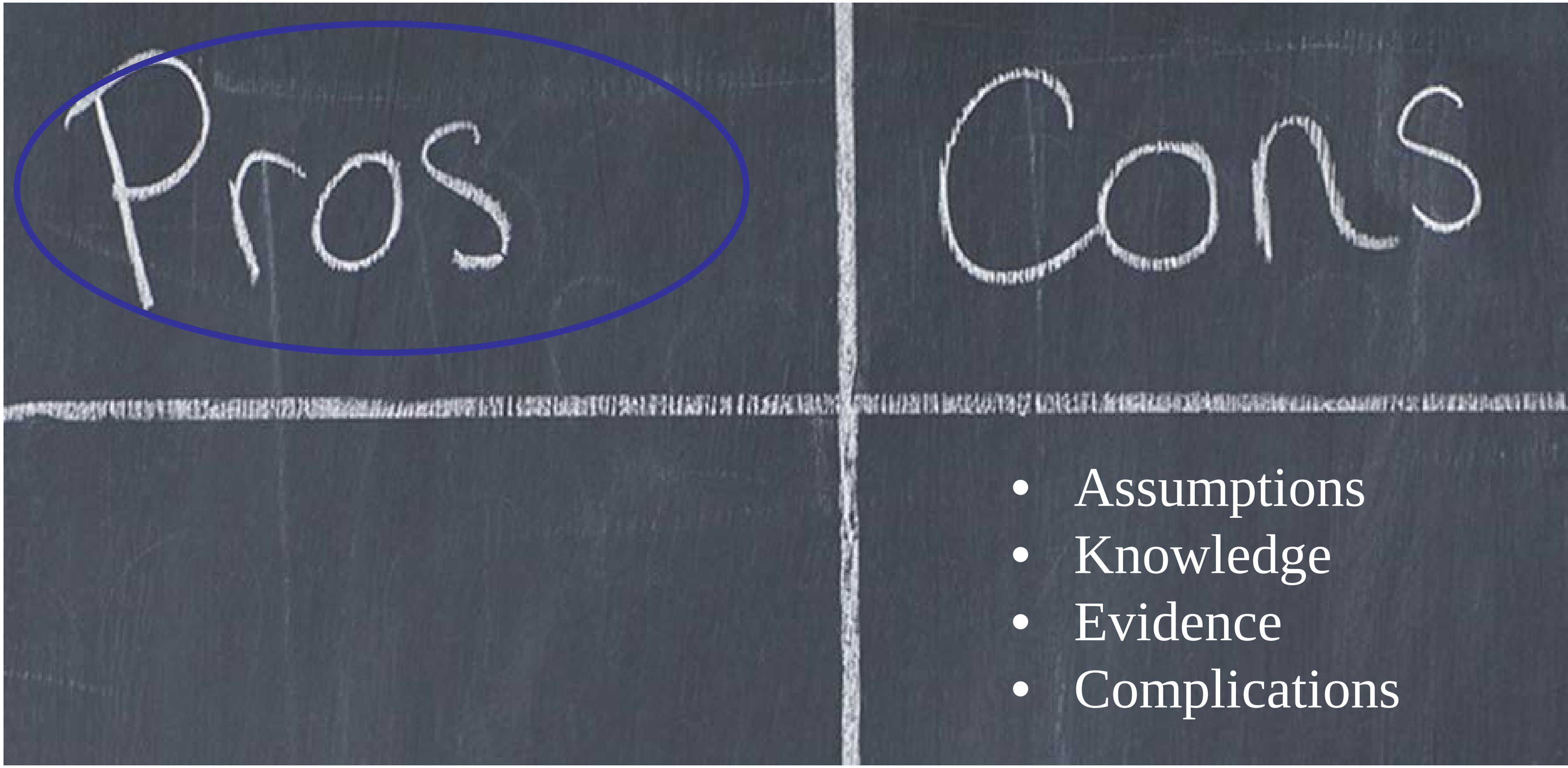
Keywords: Pulmonary artery catheter; Right heart catheterization; ICU; Hemodynamic monitoring; Operating room

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

- Assumptions
- Knowledge
- Evidence
- Complications

http://bahaiteachings.org/god-pro-con#



- Assumptions
- Knowledge
- Evidence
- Complications

http://bahaiteachings.org/god-pro-con#

Disclosures

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Disclosures

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

http://www.joemygod.com/2016/05/03/ted-cruz-meltdown-donald-trump-is-philandering-narcissistic-immoral-pathological-liar-video/

Pro

American Society of Anesthesiologists

View all recommendations from this society

Released October 12, 2013

Don't use pulmonary artery catheters (PACs) routinely for cardiac surgery in patients with a low risk of hemodynamic complications (especially with the concomitant use of alternative diagnostic tools (e.g., TEE).

The increased risk of hemodynamic complications as indicated above is defined as a patient with clinical evidence of significant cardiovascular disease; pulmonary dysfunction, hypoxia, renal insufficiency or other conditions associated with hemodynamic instability (e.g., advanced age, endocrine disorders, sepsis, trauma, burns).

The use of a PAC during cardiac surgery has been associated with increased mortality and a higher risk of severe end-organ complications. There is clear consensus in the literature that the use of a PAC cannot be recommended as a matter of routine, but for a definite role in a very select group of patients undergoing cardiac surgery. According to a survey by practicing anesthesiologists, the use of PAC could be recommended for specific indications in cardiac surgery including coronary artery bypass grafting (CABG) with poor left ventricular (LV) function, LV aneurysmectomy, recent myocardial infarction, pulmonary hypertension, diastolic dysfunction, acute ventricular septal rupture and insertion of left ventricular assist device. The appropriate indications remain debatable. However, although the PAC has no role in routine perioperative care, the existence of a specific subpopulation for which the use of this device may be beneficial cannot be excluded.

- CABG + poor LV
- LV aneurysm
- Recent MI
- Pulmonary HTN
- Diastolic Dysfunction
- Acute VSD
- LVAD insertion

http://www.choosingwisely.org/clinician-lists/american-society-anesthesiologists-pulmonary-artery-catheters-for-cardiac-surgery/

Pro

Study	Number of Patients	Patient Population	Trial Design	Goal-directed Therapy	Outcomes
TRIALS DEMONSTRATING IMPROVED OUTCOME					
Whittemore et al[15] (1980)	110	Vascular surgical cohort	Prospective retrospective control preop optimization	Yes	Reduced mortality rate PAC group vs. historical control
Rao et al[20] (1983)	1097	Surgical patients cohort	Prospective retrospective control periop PAC	No	Reduced rate of reinfarction PAC group after MI
Hesdorffer et al[16] (1987)	61	Vascular surgical cohort	Prospective retrospective control preop optimization	Yes	Reduced renal dysfunction and mortality rates in PAC group vs. historical control
Shoemaker et al[12] (1988)	88	High-risk surgical	RCT periop PAC	Yes (supranormal)	Reduced morbidity/mortality rates in PAC protocol group vs. PAC control and CVP group
Berlauk et al[17] (1991)	89	Vascular surgical	RCT preop optimization	Yes	Reduced cardiac morbidity and graft thrombosis in PAC group vs. CVP group
Boyd et al[14] (1993)	107	High-risk surgical	RCT preop optimization	Yes (supranormal)	Reduced morbidity/mortality rates in PAC protocol group vs. PAC control group.
Wilson et al[13] (1999)	138	Major elective surgical	RCT preop optimization	Yes (supranormal)	Reduced mortality rate PAC protocol group vs. PAC control group

Evidence-Based Anesthesiology 2009. Fleischer. Section V. P. 286

Pro

Schedule of Benefits

Physician Services Under the Health Insurance Act

(October 30, 2015 (Effective December 21, 2015))

Ministry of Health and Long Term Care

#	Z438	Insertion of Swan-Ganz catheter (not included in anaesthetic, respiratory or critical care benefits)	162.50	6

100 cases/year = $16,250

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

http://www.health.gov.on.ca/en/pro/programs/ohip/sob/physserv/sob_master11062015.pdf

Results

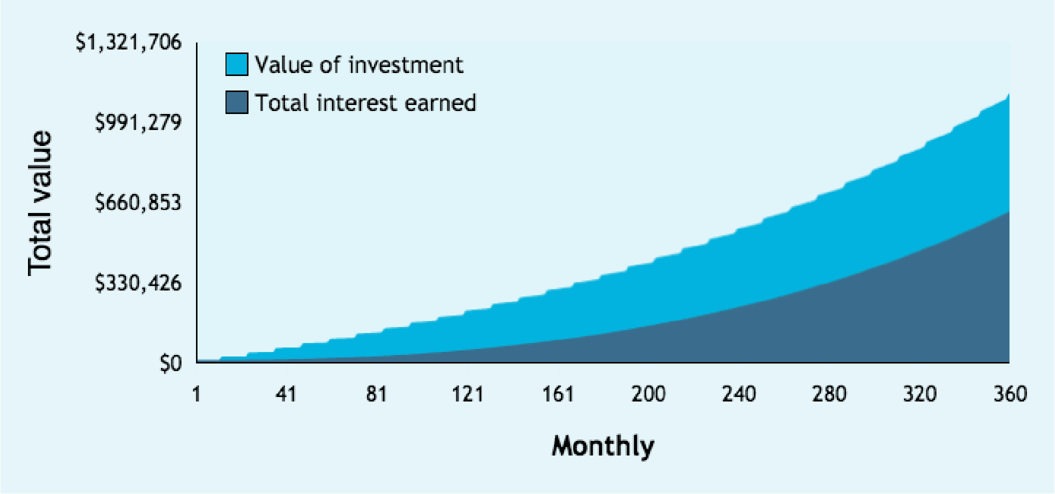
Total value of your investment: **$1,101,422.10**

Total interest earned: **$613,922.10**

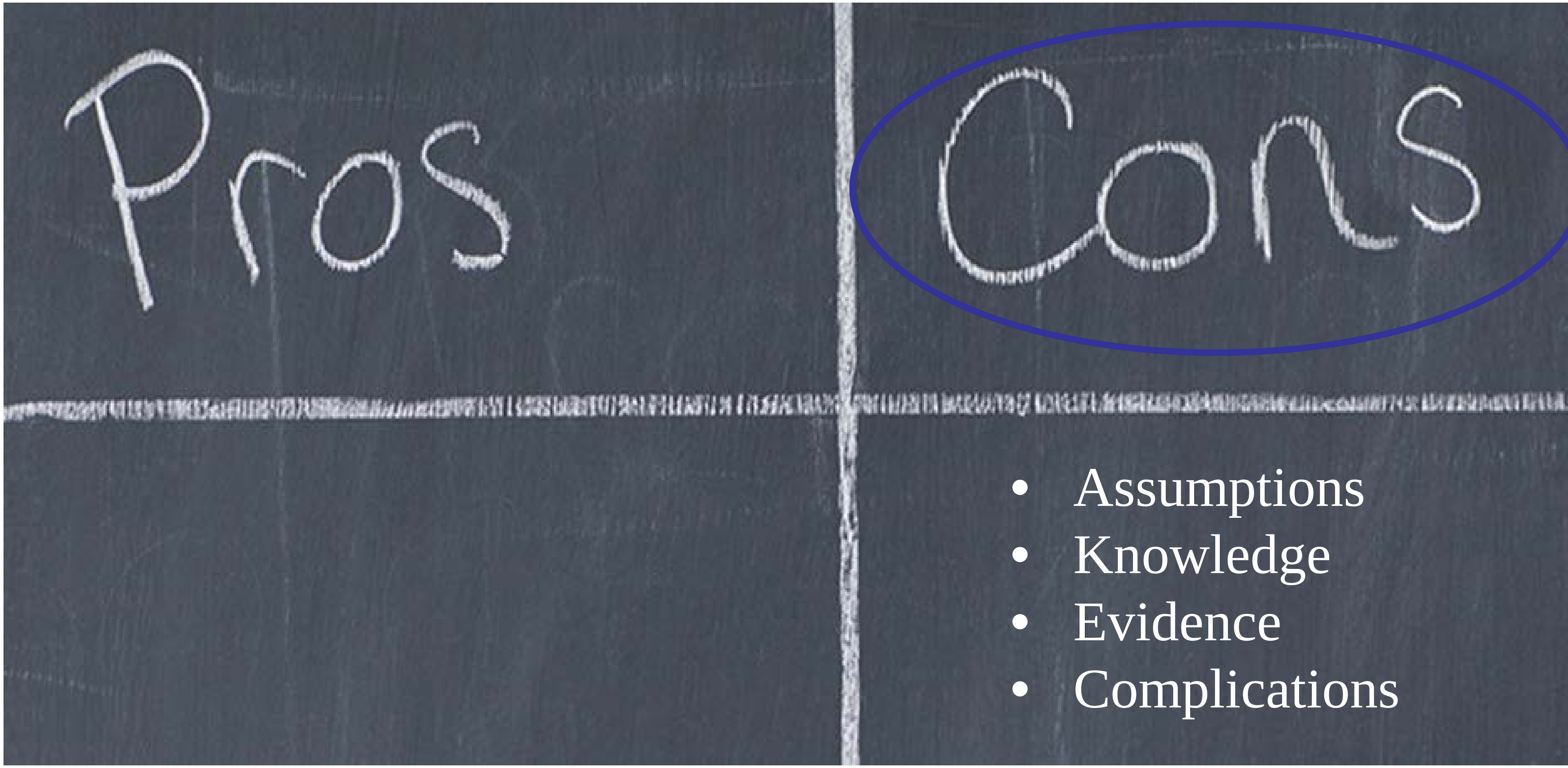
Your initial investment of **$0.00** plus your **yearly** investment of **$16,250.00** at an annualized interest rate of **5%** will be worth **$1,101,422.10** after **30** years when compounded **monthly**.

The longer your time horizon, the more benefit you'll see. Learn more about growing your savings with compound interest.

GRAPH TABLE



https://www.getsmarteraboutmoney.ca/calculators/compound-interest-calculator/



UNIVERSITY OF TORONTO

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab

COURAGE LIVES HERE

http://bahaiteachings.org/god-pro-con#

Assumptions

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

http://kanikasweet-amazing.blogspot.com/2011/09/silly-assumptions-meet-ice-cold-reality.html

Assumptions

Cardiac output

- Fick method:
  - Percentage of error of 56-83%

- Doppler, CO_2-rebreathing, and direct Fick method:

  - "In conclusion, TD overestimated cardiac output compared to the other techniques and the poor agreement has to be taken into consideration especially in measures of low values"

- A change of >25% needed between determinations (3 measurements per determination) to suggest a clinical significance

Marik Annals of Intensive Care 2013; 3:38

Assumptions

Box 40-7 Factors Influencing the Accuracy of Thermodilution Cardiac Output Measurement

- Intracardiac shunts
- Tricuspid or pulmonic valve regurgitation
- Inadequate delivery of thermal indicator
  - Central venous injection site within the catheter introducer sheath
  - Warming of iced injectate
- Thermistor malfunction from fibrin or a clot
- Pulmonary artery blood temperature fluctuations
  - Post–cardiopulmonary bypass status
  - Rapid intravenous fluid administration
- Respiratory cycle influences

Basics of Anesthesia 6e 2011. Miller. Chap 40. P. 1315

Assumptions

Assumptions Upon Which Rests the Validity of Pulmonary Artery Wedge Pressure Measurement

We assume certain things about the physiology of our patients, and the validity of PAWP as a measure of left atrial pressure rests on these assumptions.

Pulmonary artery wedge pressure is the same as left atrial pressure

- Not if the catheter is outside of Wests Zone 3
- Not if there is increased or fluctuating pulmonary artery resistance
- How are you going to predict what that resistance is if Zone 3 is full of pus (i.e. consolidated lung is present), or if there is a huge pneumothorax there, or if there is a chest drain in the pleural cavity applying low wall suction to the system?

Left atrial pressure is the same as left ventricular end-diastolic pressure

- Not if the atrium is scarred and non-compliant
- Not if the mitral valve is incompetent

Left ventricular end-diastolic pressure is a good reflection of LV end-diastolic volume

- Not if the ventricle is scarred and non-compliant
- Not if the mitral valve is incompetent

Assumptions

PCWP

Table 40-5 Underestimation of Left Ventricular End-Diastolic Pressure

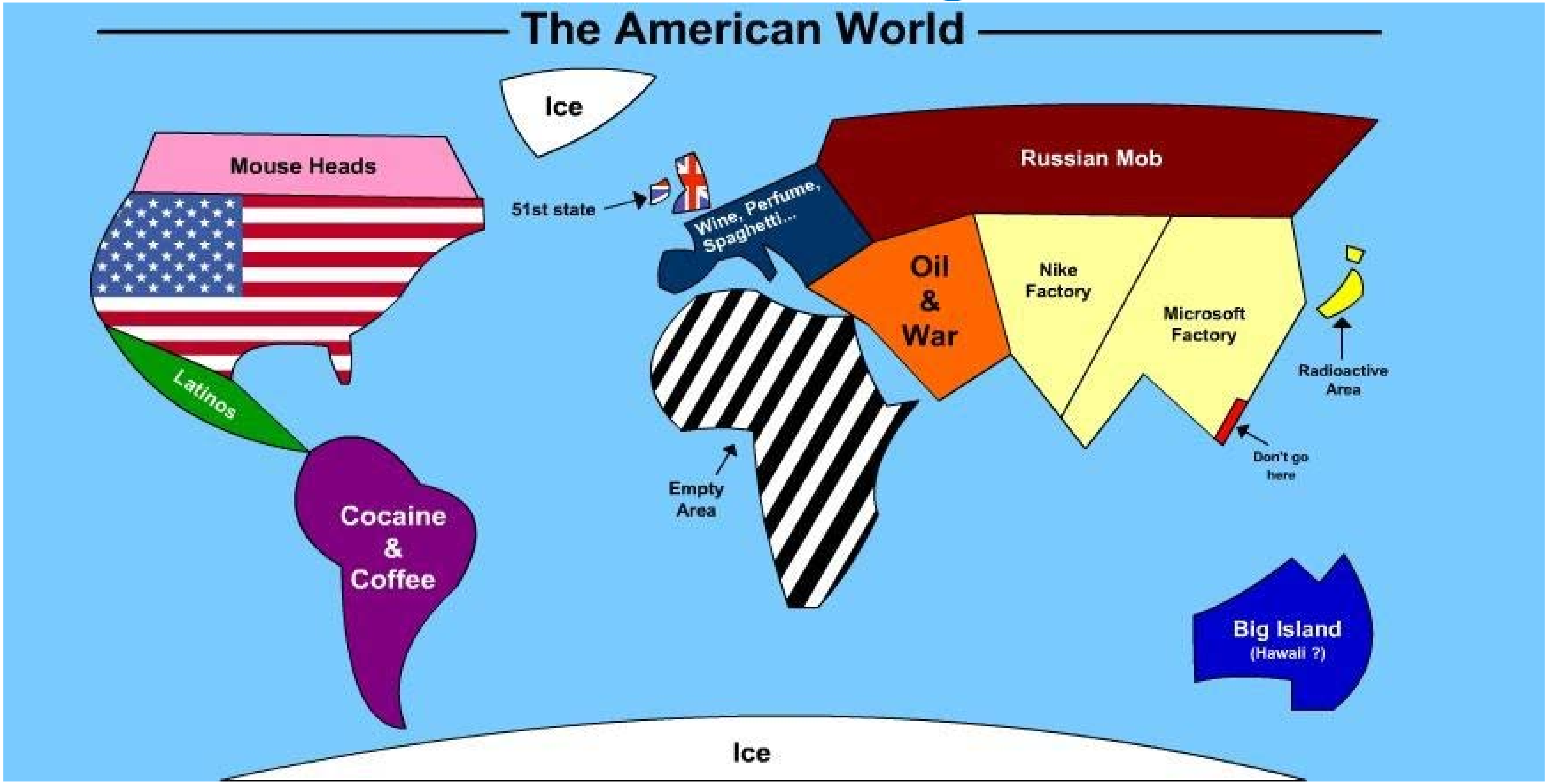
Condition	Site of Discrepancy	Cause of Discrepancy
Diastolic dysfunction	Mean LAP < LVEDP	Increased end-diastolic a wave
Aortic regurgitation	LAP a wave < LVEDP	Mitral valve closure before end diastole
Pulmonic regurgitation	PADP < LVEDP	Bidirectional runoff for pulmonary artery flow
Right bundle branch block	PADP < LVEDP	Delayed pulmonic valve opening
After pneumonectomy	PAWP < LAP or LVEDP	Obstruction of pulmonary blood flow

Table 40-6 Overestimation of Left Ventricular End Diastolic Pressure

Condition	Site of Discrepancy	Cause of Discrepancy
Positive end-expiratory pressure	Mean PAWP > mean LAP	Creation of lung zone 1 or 2 or pericardial pressure changes
Pulmonary arterial hypertension	PADP > mean PAWP	Increased pulmonary vascular resistance
Pulmonary veno-occlusive disease	Mean PAWP > mean LAP	Obstruction to flow in large pulmonary veins
Mitral stenosis	Mean LAP > LVEDP	Obstruction to flow across the mitral valve
Mitral regurgitation	Mean LAP > LVEDP	Retrograde systolic v wave raises mean atrial pressure
Ventricular septal defect	Mean LAP > LVEDP	Antegrade systolic v wave raises mean atrial pressure
Tachycardia	PADP > mean LAP > LVEDP	Short diastole creates pulmonary vascular and mitral valve gradients

Basics of Anesthesia 6e 2011. Miller. Chap 40. P. 1311

Knowledge



http://humorsection.blogspot.com/2006/10/funny-picture-american-geography.html

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

Knowledge

Table 1.—Modified Response Options for Pulmonary Artery Catheter (PAC) Study Questionnaire

Response options for three questions were altered between the pilot version and the final version of the questionnaire. These questions are presented below as they appeared on the pilot questionnaire. The modified response options that were incorporated into the final version of the questionnaire are given in the footnotes.

1. Which of the following attempts at pulmonary artery catheter placement should be discontinued:
   a. Blood aspirated from the PA catheter introducer in the left internal jugular puncture reveals a pH 7.29, Po_2 60, saturation 90%
   b. Five-beat ventricular tachycardia occurs while passing through the right ventricle
   c. While attempting catheterization, the nurse points out that the patient had an LBBB on the admission EKG
   d. Patient complains of pain at the insertion site
   e. None of the above*
2. All of the following may raise the Po_2 of blood drawn from the distal port of a pulmonary artery catheter in a patient with no cardiorespiratory pathology **except**
   a. Early sepsis
   b. Increased cardiac output
   c. Arteriovenous fistula
   d. Hyperthermia†
   e. Inotropic agents
3. An 18-year-old male is injured in a head-on collision in which he was the driver of the vehicle. At surgery, he had repair of a liver laceration and resection of his pancreas and spleen. On admission to the ICU his B/P is 60/40 mm HG, HR 120, and he is mechanically ventilated. He is given 500 cc of fluid without response and a pulmonary artery catheter is inserted revealing CI 2.0 L/min/m, CVP 2, PCW 1, and PAP 15/5. The **most likely** diagnosis is
   a. Cardiac contusion
   b. Hypovolemia
   c. Overventilation
   d. Fluid overload‡
   e. Pulmonary contusion§

JAMA 1990; 264:2928-2928

Knowledge

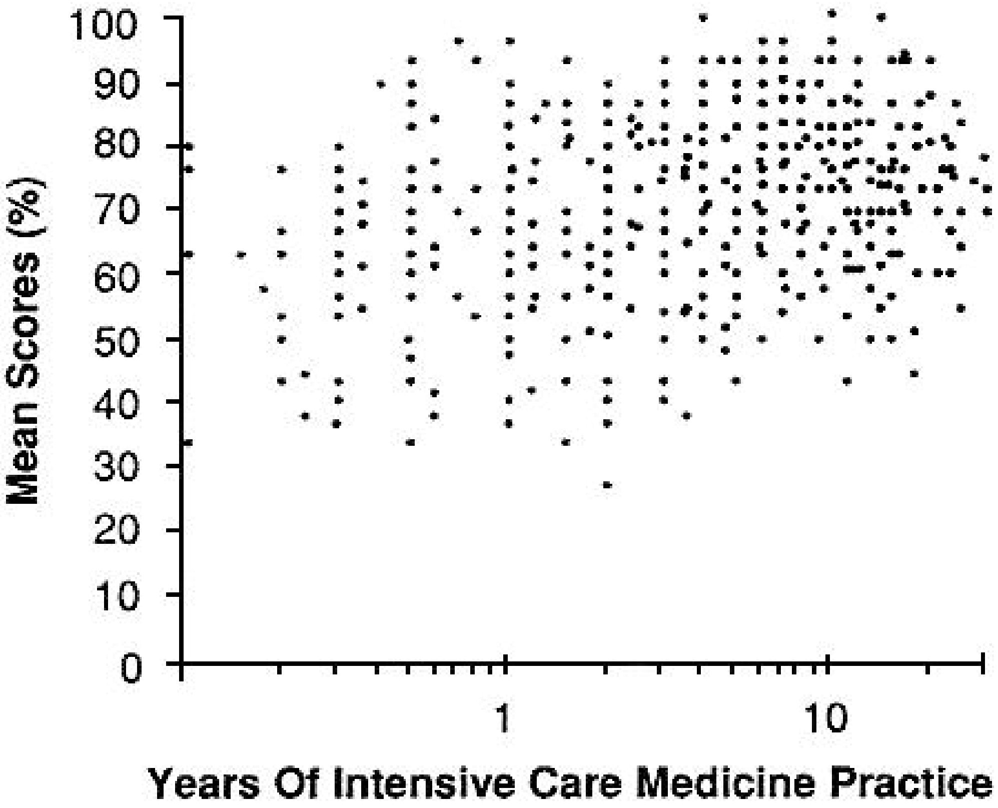
Table 3.—Comparison of Scores on Pilot Test and Final Test Administration

		Pilot Test (N=121)		Final Test (N=375)	
	No. of Questions	Mean Score	SD	Mean Score	SD
Complete test	**31**	21.0	4.4	20.6	5.6
Subtests					
Insertion & complications	6	4.0	1.2	3.8	1.5
Cardiac physiology	3	2.0	0.8	2.1	0.9
Interpretation*	14	9.3	2.4	9.0	2.7
Application of data	8	5.6	1.5	5.7	1.8

*Covers interpretation of waveforms, pulmonary artery catheter data, and pressure-volume relationships.

JAMA 1990; 264:2928-2928

Knowledge



Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Crit Care Med 1997; 25(2):213-220

Knowledge

TABLE 1g

Score by ICU experience

ICU experience in years	Number	Score (%)	SD (±)
0-2	21	35.3	7.9
3-4	34	39.4	12.5
5-7	25	47.3	13.7
8-10	19	52.1	15.4
10+	40	43.8	14.8

TABLE 2

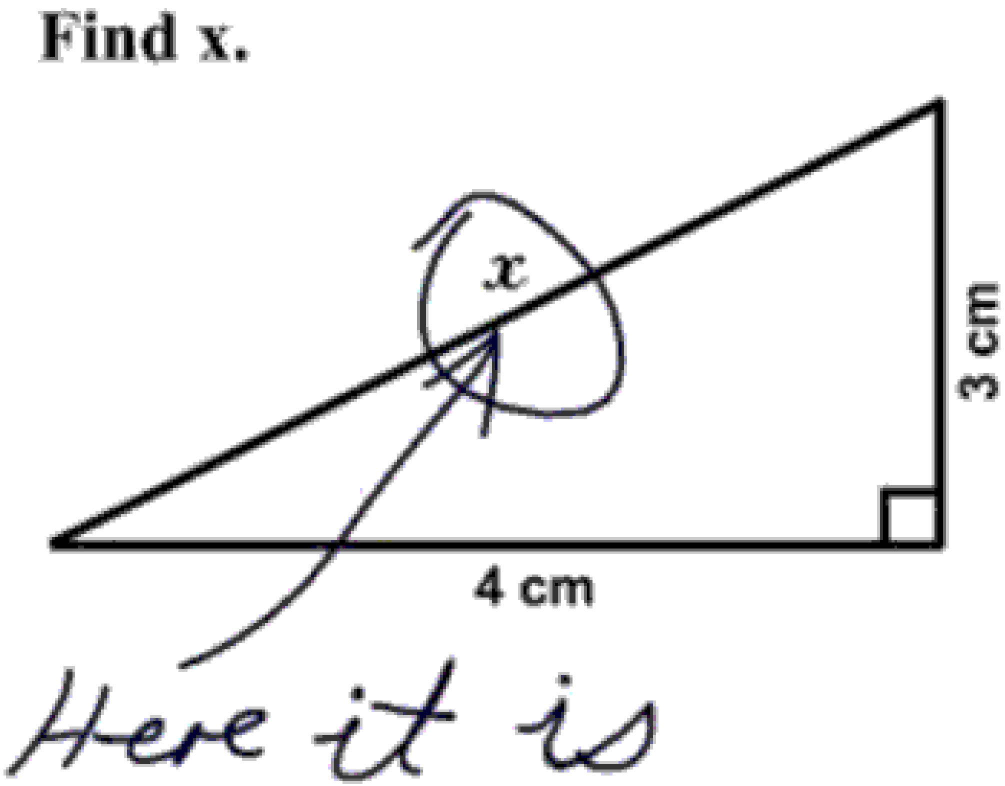
Scores by subset analysis

Category	Number of questions	Mean score ±SD	Percentage correct
Waveform analysis	5	2.8±1.1	55.3%
Management/interpretation	6	2.9±1.2	48.9%
General usage	4	1.9±0.7	46.6%
Physiology	6	2.3±1.2	39.1%
Complications	4	1.5±0.9	38.6%
Calculations	6	1.8±1.3	30.2%

UHN
Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Anaesth Intensive Care 2004; 32:564-568

Evidence



Rob Chen Grade 5 Algebra test

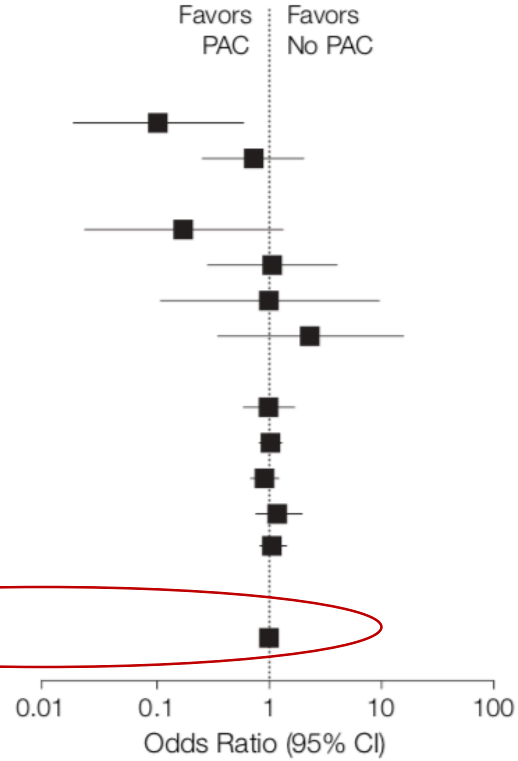
UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

https://occupymath.wordpress.com/2016/09/02/a-variety-of-math-jokes/

Critical Care - 2005

Figure 2. Odds Ratio (PAC vs No PAC) for Mortality of RCTs Evaluating the Safety and Efficacy of the PAC

Source	No. of Deaths/Total No. of Patients: PAC	No. of Deaths/Total No. of Patients: No PAC	Odds Ratio (95% CI)
Schultz et al,[15] 1985	1/35	10/35	0.11 (0.02-0.63)
Shoemaker et al,[16] 1988	11/58	7/30	0.76 (0.27-2.15)
Isaacson et al,[17] 1990	1/49	0/53	NA
Berlauk et al,[18] 1991	1/66	2/21	0.18 (0.02-1.42)
Guyatt,[19] 1991	10/16	9/17	1.10 (0.29-4.22)
Bender et al,[20] 1997	1/51	1/53	1.04 (0.11-9.95)
Valentine et al,[21] 1998	3/60	1/60	2.38 (0.35-16.29)
Bonazzi et al,[22] 2002	0/50	0/50	NA
Rhodes et al,[23] 2002	46/95	50/106	1.01 (0.58-1.76)
Sandham et al,[24] 2003	163/997	155/997	1.06 (0.83-1.35)
Richard et al,[25] 2003	199/338	208/343	0.93 (0.68-1.26)
ESCAPE,[10] 2005	45/215	38/218	1.25 (0.78-2.02)
Harvey et al,[14] 2005 (PAC-Man)	346/506	333/507	1.13 (0.87-1.47)
Combined			**1.04 (0.90-1.20)**



UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

JAMA 2005; 29(4): 1664-1670

Critical Care – 2013

Pulmonary artery catheter for adult patients in intensive care

Patient or population: Adult patients in intensive care
Settings: Intensive care unit
Intervention: Pulmonary artery catheter

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Pulmonary artery Catheter				
ICU length of stay (general intensive care patients) Follow-up: mean 10-12 days		The mean ICU length of stay (general intensive care patients) in the intervention groups was **0.5 higher** (0.44 to 0.55 higher)		2723 (4 studies)	⊕⊕⊕⊕ **high**	
Combined mortality of all studies Follow-up: mean 28-60 days	**Study population**		**RR 1.01** (0.95-1.08)	5686 (13 studies)	⊕⊕⊕⊕ **high**	
	297 per 1000	**301 per 1000** (273 to 333)				
	Moderate					
	95 per 1000	**97 per 1000** (85 to 110)				

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Cochrane Database 2013; Issue 2.
Art. No.: CD003408

Critical Care – 2017

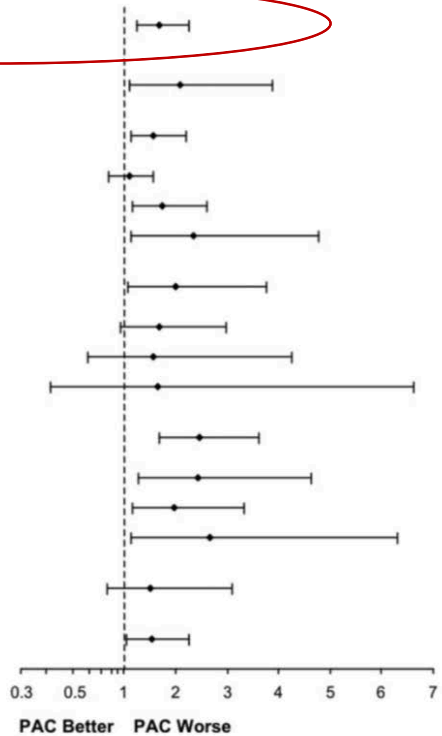
Table 1. Summary of clinical studies of PAC use in the general medical ICU

Reference	Number of cases	Study design	Clinical setting	Significant results
Connors et al.[7]	5735	Prospective cohort	Critically ill ICU patients	The use of PAC is associated with an increased 30-day mortality (OR, 1.24; 95% CI, 1.03-1.49) in this patient population
Richard et al.[8]	676	Multicentre RCT	ICU patients with shock or ARDS	No significant differences in mortality with or without PAC at day 14
Yu et al.[9]	1010	Prospective cohort	ICU patients in severe sepsis	No change in mortality, length of stay, or resource utilization
Chittock et al.[10]	7310	Observational cohort	Critically ill ICU patients	The use of PAC might decrease mortality rate in the most severely ill whereas it might increase it in a population with a lower severity of illness
Sakr et al.[11]	3147	Multicentre prospective observational	ICU patients with sepsis	No significant difference in 60-day mortality with or without PAC placement
Binanay et al.[12] (ESCAPE)	433	Multicentre RCT	Severely symptomatic patients with CHF	No difference in mortality, however, more adverse events were recorded in the PAC group
Harvey et al.[13] (PAC-Man)	1041	Multicentre RCT	All adult ICU patients	Neither benefit nor harm related to PAC use was found
Wheeler et al.[14]	1000	RCT	ICU patients with acute lung injury	No improvement in survival or organ function but was associated with more complications

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

Can J Cardio 2017; 33:135-141

Cardiac Surgery – 2011



Outcome	Incidence — no. (%) PAC (n = 1273)	No PAC (n = 1273)	*P* Value
Composite outcome	271 (21.3)	196 (15.4)	<0.001
Death from any cause	44 (3.5)	22 (1.7)	0.02
Cardiac events	202 (15.9)	153 (12.0)	0.007
Myocardial infarction	102 (8.0)	102 (8.0)	0.60
Congestive heart failure	118 (9.3)	70 (5.5)	0.008
Death from cardiac causes	38 (3.0)	17 (1.3)	0.02
Cerebral events	49 (3.9)	27 (2.1)	0.03
Stroke	26 (2.0)	16 (1.3)	0.08
Encephalopathy	24 (1.9)	10 (0.8)	0.37
Death from cerebral causes	5 (0.4)	3 (0.2)	0.48
Renal events	75 (5.9)	35 (2.8)	<0.001
Dysfunction	43 (3.4)	20 (1.6)	0.007
Failure	45 (3.5)	24 (1.9)	0.01
Death from renal failure	27 (2.1)	10 (0.8)	0.02
Pulmonary events	17 (1.3)	12 (0.9)	0.25
Prolonged ICU stay	185 (14.5)	129 (10.1)	0.02

Figure 2. Outcomes of 1273 propensity score matched pairs with pulmonary artery catheter (PAC) and no PAC. Death, congestive heart failure, and cerebral and renal events are major contributors to the adverse outcomes of PAC patients. Note that intensive care unit stay is also significantly more often prolonged in patients with PAC monitoring. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) and associated *P* values were calculated from the generalized estimating equations (GENMOD procedure).

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab

COURAGE LIVES HERE

Anesth Analg 2011; 113:994-1002

Cardiac Surgery – 2011

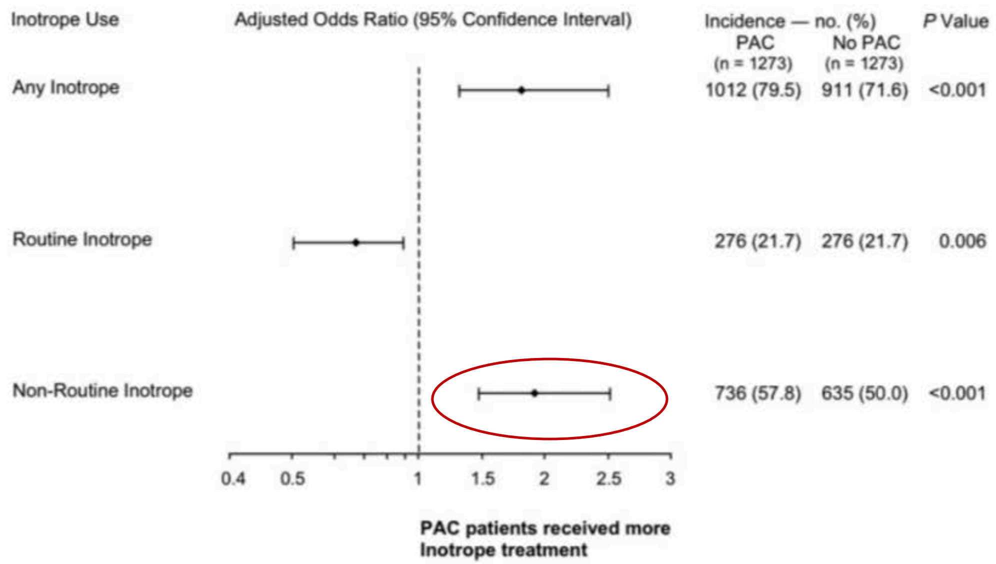


Figure 3. Inotrope use in matched pairs of patients with pulmonary artery catheter (PAC) and no PAC. Patients with PAC received nonroutine inotropes more often than patients monitored without PAC. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) and associated *P* values were calculated from the generalized estimating equations (GENMOD procedure).

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Anesth Analg 2011; 113:994-1002

Cardiac Surgery – 2015a

Table 2. Intraoperative Vasoactive Drugs and Postoperative Outcomes.

Variable	Entire cohort		Adjusted OR	95% CI	P Value	Propensity-matched cohort		P Value
	PAC N = 453	Non-PAC N = 908				PAC N = 424	Non-PAC N = 424	
Nitroglycerin	183(40.40)	326(35.90)	0.732	0.274–1.518	0.451	164(38.60)	148(35.09)	0.255
Dopamine	321(70.86)	413(45.48)	2.923	2.267–3.770	<0.001	309(72.88)	192(45.28)	<0.001
Epinephrine	35(7.73)	24(2.64)	2.796	1.623–3.816	<0.001	33(7.78)	13(3.07)	0.002
In-hospital death	6(1.32)	10(1.10)	0.636	0.170–2.384	0.502	6(1.42)	5(1.18)	0.762
Myocardial infarction	3(0.66)	4(0.44)	1.464	0.337–6.350	0.611	3(0.71)	2(0.47)	0.654
Atrial fibrillation	41(9.05)	78(7.95)	2.156	0.755–6.153	0.151	38(8.96)	33(7.78)	0.535
Cerebrovascular accident	3(0.66)	4(0.44)	0.432	0.074–2.518	0.351	3(0.71)	3(0.71)	NA
Acute renal failure	10(2.21)	18(1.83)	1.894	0.625–5.741	0.259	9(2.12)	7(1.65)	0.614
Reoperation for bleeding	7(1.54)	11(1.12)	0.892	0.288–2.758	0.843	7(1.65)	6(1.42)	0.780
Infective complications	4(0.88)	7(0.77)	0.968	0.924–1.105	0.184	4(0.94)	3(0.71)	0.704

PLOS ONE|DOI:10.1371/journal.pone.0117610

Cardiac Surgery – 2015a

Table 3. Long-term Outcomes.

Variable	Entire cohort		Adjusted HR	95% CI	P Value	Propensity-matched cohort		P Value
	PAC N = 453	Non-PAC N = 908				PAC N = 424	Non-PAC N = 424	
Death	8(1.77)	14(1.54)	1.135	0.371–2.470	0.824	8(1.89)	6(1.41)	0.590
MI	10(2.21)	18(1.98)	0.643	0.275–1.504	0.309	9(2.12)	12(2.83)	0.507
CVA	15(3.31)	34(3.74)	0.597	0.191–1.873	0.377	14(3.30)	18(4.24)	0.471
Death/MI/CVA	29(6.40)	61(6.72)	0.636	0.354–1.144	0.131	27(6.37)	33(7.78)	0.422
Renal failure	19(4.19)	35(3.85)	1.076	0.419–2.763	0.880	18(4.24)	21(4.95)	0.623

MI, myocardial infarction; CVA, cerebrovascular accident; HR, hazard ratios; CI, confidence interval.

PLOS ONE|DOI:10.1371/journal.pone.0117610

Cardiac Surgery – 2015b

Table 4. Propensity Matched Subgroup Analysis of Mortality Rates According to Use of Pulmonary Artery Catheters

Patient Factor	Overall (%)	No PAC (%)	PAC (%)	p Value	Adjusted OR (95% CI)	p Value
Low-risk patients	1.3	1.2	1.3	0.546	1.12 (0.75-1.68)	0.571
High-risk patients	10.9	9.6	12.2	<0.001	1.30 (1.14-1.48)	<0.001
Patients aged > 80 years	7.7	7.0	8.5	0.016	1.24 (1.03-1.50)	0.024
Pulmonary hypertension	9.3	9.2	9.4	0.830	1.00 (0.80-1.23)	0.961
Multiple valve	12.2	12.1	12.3	0.871	0.98 (0.73-1.32)	0.888

Abbreviations: CI, confidence interval; OR, odds ratio; PAC, pulmonary artery catheterization.

J Cardio Vasc Anesth 2015; 29(1):76-81

Cardiac Surgery – 2017

Table 3. Summary of clinical studies of PAC use in cardiac surgery

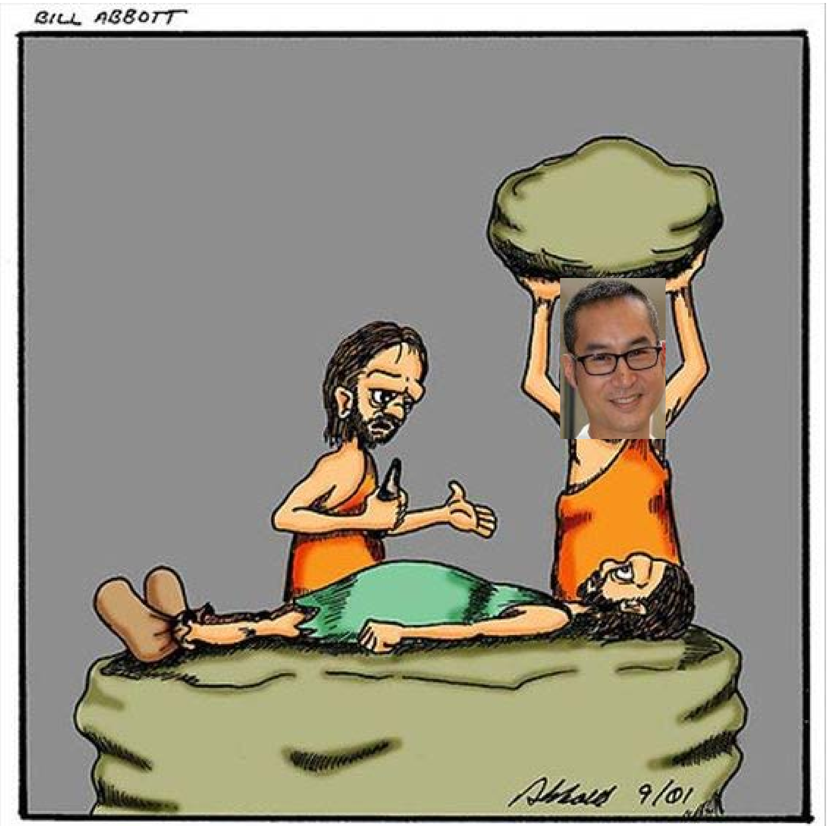
Reference	Number of cases	Study design	Clinical setting	Significant results
Ramsey et al.[18]	13,907	Retrospective cohort	Elective CABG	Increased in-hospital mortality, longer lengths of stay, and greater total costs
Schwann et al.[19]	2685	Retrospective analysis	Elective CABG	No difference in surgical outcomes
Resano et al.[20]	2414	Retrospective chart review	Off-pump CABG	No difference in operative mortality, on-pump conversion rate, development of postoperative low CO, and prolonged inotropic use
Djaiani et al.[21]	200	Observational	Elective CABG	Placement of a PAC can be safely delayed until the clinical need arises either intraoperatively or in the ICU
Schwann et al.[22]	5065	Prospective observational	Elective CABG	Use of a PAC was associated with increased mortality and a higher risk of severe end-organ complications
Chiang et al.[23]	2,063,337	Retrospective database analysis	Cardiac surgery	No reductions in operative mortality or morbidity and PAC use was associated with increases in duration of ventilation and length of stay in the ICU

CABG, coronary artery bypass grafting; CO, cardiac output; ICU, intensive care unit; PAC, pulmonary artery catheter.

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

Can J Cardio 2017; 33:135-141

Complications



"...and this **Rob** your anesthesiologist."

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

https://www.pinterest.ca/pin/278097345717728449/?lp=true

Outline

- The ASA Task Force
  - 0.1-0.5% serious complications

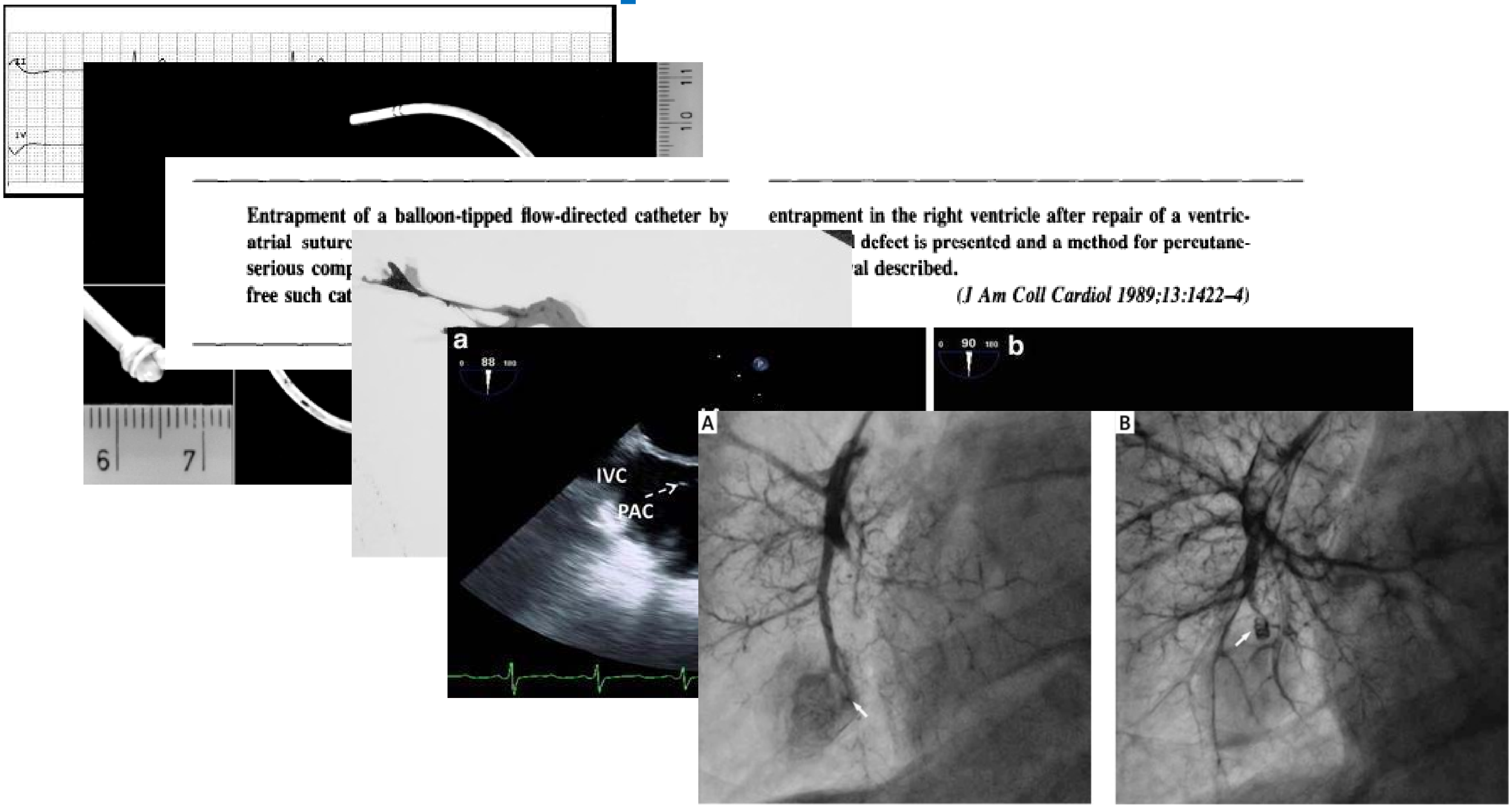
- Grouped in three categories:
  - Insertion
  - Use and maintenance
  - Misinterpretation

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Anesthesiology 2003; 99:988-1014

Complications

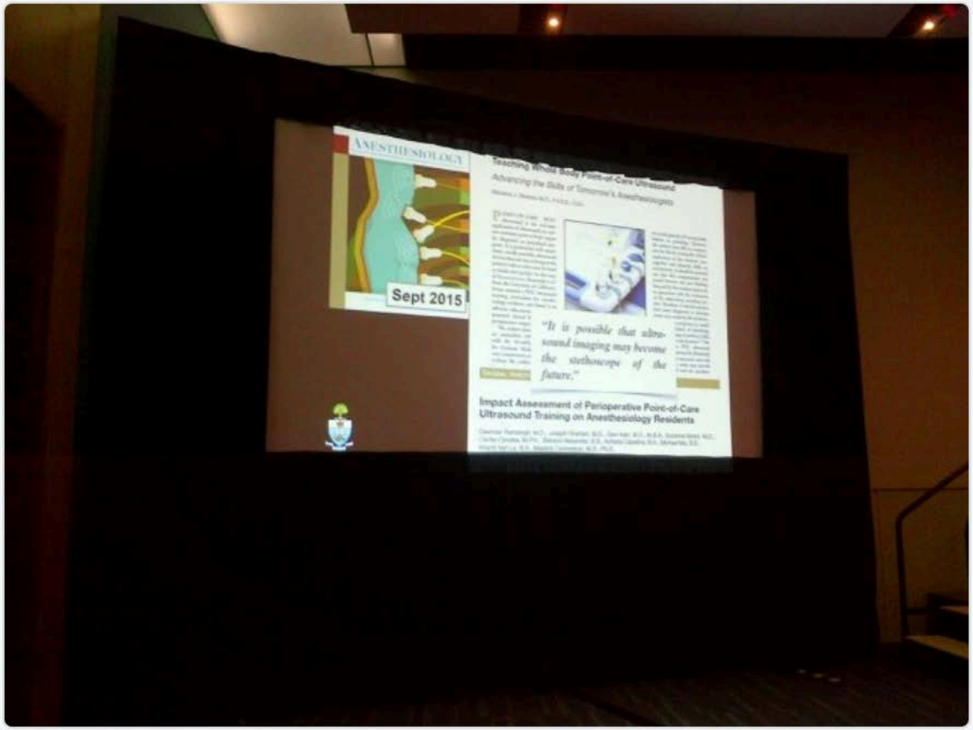


Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Alternatives

Robert Chen @ottawaheartrob · 27 Jun 2016

#POCUS is stethoscope of future?!? IT IS THE stethoscope (other thing is stethophone)



9 8

UHN
Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

https://twitter.com/ottawaheartrob/media?lang=en

Alternatives

Table 1

Haemodynamic data availability and reliability with PAC and TEE

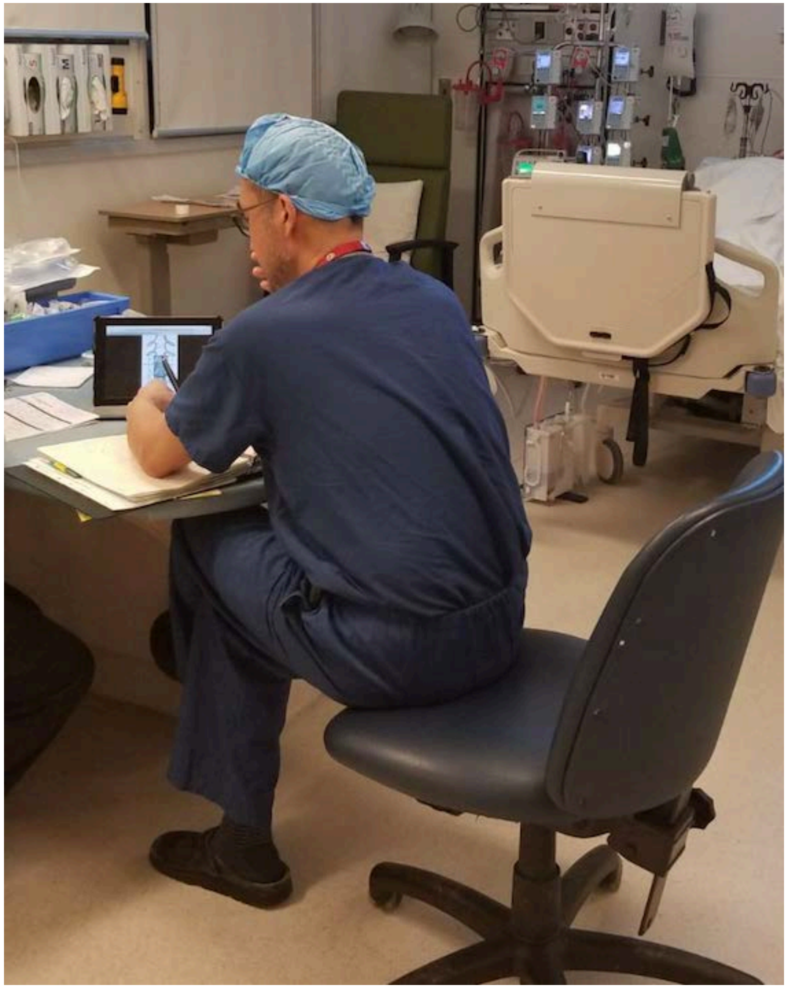
	PAC		TEE	
Parameter	Feasibility	Reliability	Feasibility	Reliability
Svo_2	Yes	+++	No	
CVP	Yes	+++	No	
PAP	Yes	+++	Possible if TR	++
LAP (wp)	Yes	++	Possible if MR	+
CO	Yes	+++	Yes	+
SV	Yes	+++	Yes	+
Systemic resistance	Yes	+++	Yes	+
Pulmonary resistance	Yes	+++	Yes	+
RVEDV	Yes	+	Yes	+
Right ventricular EF	Yes	+	Yes	+
LVEDV	No		Yes	++
Left ventricular EF	No		Yes	++
Left ventricular FAC	No		Yes	+++
Left ventricular SF	No		Yes	+++
Delta SV	No		Yes	+++
Delta peak pressure	Yes (pulmonary)	+++	No	
Peak velocity changes	No		Yes	+++
Valve function	No		Yes	+++
Fluid responsiveness	Yes	+	Yes	+++
Diastolic function	No		Yes	+++

Critical Care 2006; 10 (Suppl 3):S6

Final Curtain Call (Closing Argument)

https://frontandcentrestage.com/red-curtainscurtains-superb-beautiful-stage-red-curtain-desktop-wallpaper-hd-tpnbttxr/

A Bootie For A Scrub Hat?



Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

Thank You!

Questions?

Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

christopher.hudson@uhn.ca

Pulmonary Artery Catheters:
Con Debate – Rebuttal

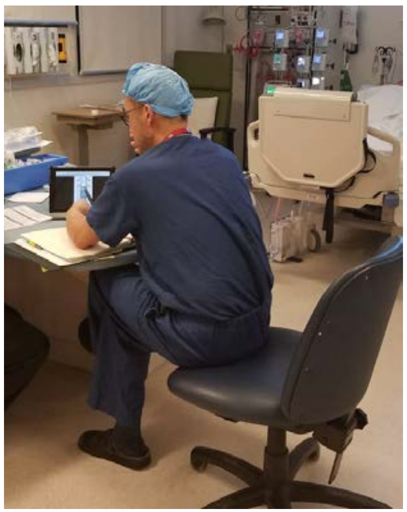
Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Fake News

https://www.express.co.uk/

Fake News



Cardiovascular and Thoracic **520DE**	**Getting the Most Out of an Echo Report** Echocardiograms are commonly ordered pre-operatively, yet the literature does not support their efficacy in improving outcome. Is this because we are falsely reassured by the written conclusion "normal EF"? Recent anaesthesia interest in diastolic dysfunction and in "heart failure with preserved ejection fraction" (HFPEF) means that practitioners must understand echocardiography reports at the highest level. This session will review echocardiography reports and in particular the significance of the numeric values. *Robert Chen, Ottawa, ON*
08:00-17:00	**ADVANCED: Perioperative, Hands-on Point of Care Ultrasound Course (POCUS)**
Pre-Conference Workshop	This one day hands-on course will focus on advanced applications of POCUS in perioperative medicine. These will include advanced application of cardiac, and lung US, FAST, Trans-cranial Doppler, Optic nerve sheath diameter and Deep Venous thrombosis assessment. All instructors are experts in the field from across the country. The course is entirely hands-on and will require completion of online learning pre-course and post-course tests. Scans will be performed using a wide variety of equipment on healthy volunteers and simulators. Image interpretation will be practiced on real US images.

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

“everything but the Kitchen Sink

UHN
Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

https://f1-history.deviantart.com/

“everything but the Kitchen Sink

- **Major Components**
  - **Cost Per Unit**
- ***Engine Unit***
  - ***$8.0 Million***
- ***Carbon fibre monocoque***
  - ***$675,000 per chassis***
- ***Front wing & nose cone***
  - ***$170,000***
- ***Rear wing & DRS overtaking aid***
  - ***$82,000***

- ***Steering wheel***
  - ***$50,000***
- ***Fuel tank plus assembly***
  - ***$110,000***
- ***Hydraulics***
  - ***$165,000***
- ***Gearbox***
  - ***$490,000***
- ***Cooling system***
  - ***$160,000***

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
COURAGE LIVES HERE

What if need one later?

Clinical Outcomes in Patients Undergoing Elective Coronary Artery Bypass Graft Surgery With and Without Utilization of Pulmonary Artery Catheter–Generated Data

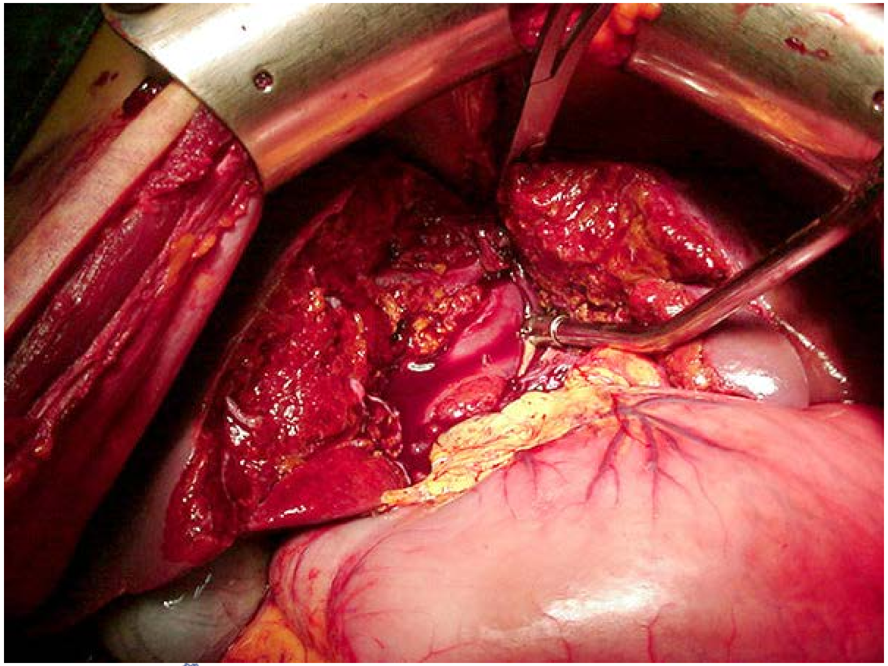
George Djaiani, MD, FRCA, Jacek Karski, MD, FRCPC, Mark Yudin, MD, Maria Hynninen, MD, Ludwik Fedorko, MD, PhD, FRCPC, Jo Carroll, RN, Humara Poonawala, MD, and Davy Cheng, MD, FRCPC

Conclusions: This study confirmed the contention that insertion of a PAC can be safely delayed until the clinical need arises either in the operating room or in the ICU after elective CABG surgery.

JCVA 2009; 3:307-310

Case Description

- You are called urgently to the ICU. A 56-year-old male underwent emergency CABG x 3 five hours ago. The patient's blood pressure has been sluggish 75/50, HR 99, CVP 15, PAWP 32/20, and CI 2.0. Epi has been increased from 0.05 to 0.2 mcg/k/m. DDX?



Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

http://www.trauma.org/index.php/main/image/154/

Answer ??

1. Hypovolemic Shock

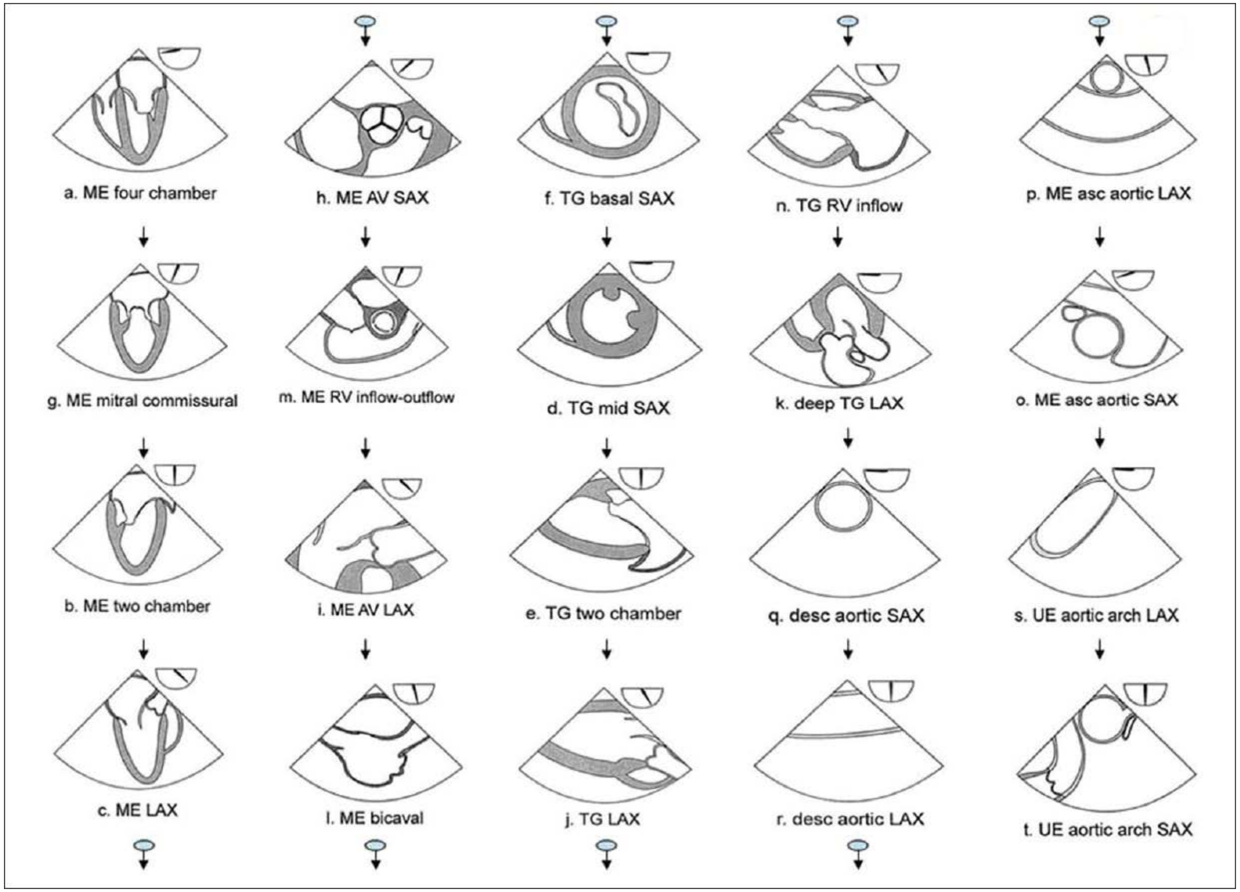
2. Distributive Shock

3. Cardiogenic Shock

4. Obstructive Shock

https://www.uptodate.com/contents/intraoperative-rescue-transesophageal-echocardiography-tee

3 TEE Views



Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

UNIVERSITY OF TORONTO

Ann Card Ann 2013; 16(4): 268-278