

Presedintele României

Dorind a răsplăti meritele

Domnului profesor universitar

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cu prilejul aniversării a 65 de ani de relații diplomatice între România și Statul Israel, în semn de apreciere pentru contribuția marcantă pe care a avut-o la îmbunătățirea relațiilor bilaterale româno-israeliene, pentru rezultatele de excepție obținute în perfecționarea actului medical.

Conferă

Ordinul "Meritul Sanitar

de "Comandar".

Președintele României

Cancelarul Ording

in grad

Traian Bosen



Pulmonary artery catheter in the operating roomwhen and why ?



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O întrebare pentru colegii români: Câţi dintre Dvs folosesc acest cateter:

În sala de operație? În terapia intensivă? ◆În ultima săptămână? **◆În ultima** lună? **↓În ultimul** trimestru?

## Planul conferinței de azi



QUESTION: why to discuss, once again, things which are supposed to be clear and belong to the clinical judgment ?

Because clinical judgment needs very often special tools for getting a confirmation, and because..... Because in anesthesia the major problem has always been when monitoring or equipment was way below standard and a bad results occur after treatment

# The PAC history in four stages

#### The first one:prehistory!!

- We did not have any precise tool to assess the hemodynamic condition of the patient
- The second one: 1970-the first publication (Swan, Ganz, Forrester, etc) and the enthusiasm: "we will catheterize everybody"!!

The third one, 15 years later (Robin and many others): DENIAL!!( no benefit, more complications, cost)

The current one: the last ten years: we have a good tool in our hands, but caution!!



So, allow me to present you the trip of the 40year PAC life First introduced in clinical practice by Swan, Ganz, Forrester, Marcus, Diamond and Chonnette and published in *NEJM* **1970**;283:447



The main reason behind the use of PAC is the fact that it permits a more accurate determination of the hemodynamic status of the critically ill patient than the clinical assessment alone"

BUT...."PA catheterization can also have important adverse effects, like pneumothorax, infection, arrhythmias, and even fatal pulmonary hemmorrhage"

PAC was used in most ORs, in spite of the criticism in the literature **Society of Cardiovascular Anesthesia-2001 survey ◆25%- placed 1-5 PCAs per** month **◆36%-10-25 PCA/mo** 

# The first alert

**Robin, Ann Int Med 1985;103:445** 

"Sufficient data and indirect evidence now suggest that the frequency of use of PAC is extraordinary high; and except for small groups of patients the measurements derived from its use do not lead to improving outcome for most patients"

#### More than this.....



Reich HS in "Intensive Care Medicine". Eds Irvin and Rippe, 6<sup>th</sup> ed. 2008

1983-2005

41 papers75,089 patients

Lower mortality or morbidity in 11 papers
Improved survival in pts > 60 yrs 1 paper
No difference in morbidity/mortality in 17 papers
Higher or worse morbidity/mortality in 11 papers

In the last two decades we are witnessing a revolution in the domain of monitoring

The main competitors of PAC **Transpulmonary or US indicator** dilution (PICCO, LIDCO, COstatus) ◆ BP trace-derived estimation of cardiac output **ECHO-Doppler** ♦ CO2 rebreathing Bioimpedance and bioreactance

#### So, nothing to surprise us....

#### Trends in the Use of the Pulmonary Artery Catheter in the United JAMA. 2007;298(4):423-429. doi:10.1001/jama.298.4.423



# **PAC** was incriminated for:



- Being used by incompetent, unskilled professionals
- Offering errors in measuring and interpreting data (such as in mechanical ventilation, presence of mitral insufficiency
- Being accompanied by minor and major complications
- Increased mortality, morbidity and length of stay

Somebody felt that we need a professional body which would help us understand the real situation regarding the **PAC** used



Ten years ago (the beginning of a new mileninium) the ASA Task Force reached a conclusion

How did they reach the conclusions?

**First: defining the task** 

Use of PAC only in surgical settings, without comparing its use with any other monitoring method or device



\*4 university –based anesthesiologists

\*4 community-based anesthesiologists

\*1 methodologist

**Review of scientific evidence:** 

\*literature

\*evaluation of individual studies

\*synthesis of results

Experts opinion-confidential voting scheme for 27 cenarios : 1= unnecessary, inappropriate

9= the most appropriate

Public forum, seven experts, members of CV anesthesia society, voting in the same way

Peer review- three experts and six professional organizations

Low risk	Low-risk surgery	Low-risk settings
<u>patient</u>	*no fluid changes	*good catheter skills
ASA 1 and 2	*small chance of	*technical support
	hemodynamic problems	*good training , nurses
	*low morbidity, mortaltity	and MDs
		*good facilities for
		treating complications
<b>Moderate risk</b>	<b>Moderate-risk surgery</b>	<b>Moderate-risk settings</b>
<u>patient</u>	*moderate chance for	*moderate skills,
ASA 3	fluids change or	training and facilities
	hemodynamic disturbances	for treating
	*moderate chance for	complications
	infection, morbidity,	
	mortality	
<u>High-risk</u>	<u>High –risk surgery</u>	High risk settings
<u>patient</u>	*large chance for	*poor catheter skills,
	hemodynamic changes	rare use, no training,
ASA 4 and 5	*high morbidity/mortality	no specialists or
		equipment to treat
		complications

First, the TASK FORCE discussed the effectiveness of using PAC in surgical settings



- 1. Effect on treatment decisions
- 2. **Preoperative catheterization** 
  - 3. Perioperative monitoring
    - 4. Goal-directed therapy
- 5. Hemodynamic monitoring
  - a. Cardiac surgery
  - b. Vascular surgery
    - c. Trauma
  - d. Obstetrics-Gynecology

#### **1.Effect on treatment decision**

 In approximately 50% of cases PAC data provide new information and seem to change therapy

#### BUT

There is no evidence of association with mortality among patients whose therapy was altered based on PAC data



#### 2. Preoperative catheterization

- **Uncontrolled data on rate of** cancellation or modification of surgical decision because of PAC measurements Some data showed a lower morbidity and mortality in patients monitored preoperatively by PAC insertion- poor quality *methodology*
- Graft viability is better
   when PAC data are used in
   peripheral vascular surgery vulnerable results



## **3.Perioperative monitoring**

The "classical" data Rao et al. Anesthesiology 1983;59:499 \*733 patients \*lower perioperative infarction during "PAC era" The data "after" Shoemaker, Chest 1988;94:1176

\*146 patients \*no difference in mortality, length of stay in hospital, ICU stay, use of ventilators WHEN COMPARED TO CVP !!!



#### **4.Goal-directed therapy**

♦ When DO2 was chosen as a goal (Boyd, JAMA) 1933), a significantly lower 28-day mortality Two later studies, from the same center (1993) and 1995) infirmed the previous results: -no reduction in organ dysfunction -same length of stay **IN SPITE OF THE FACT THAT THE DO2 WAS KEPT HIGHER IN THE TREATED GROUP !!** ♦ Rivers 2001;345:1368 **28-day mortality significantly lower in septic** shock patients when a MIXED VENOUS **OXYGEN SENSING CVP CATHETER !!!!** 



"All those in favour of moving the decimal point one place to the right?"

# 5.Hemodynamic monitoring



**Parameters to be** calculated or measured by PAC •Presssures •**CO** •PVR •SVR •SVO2 •DO2

#### a. Cardiac anesthesia

*Tuman, Anesthesiology* 1989;70:199

\*1094 patents, prospective study

No difference (mortality, ischemia) in CABG

\*PAC patients had a longer ICU stay and needed more vasopressors Stewart, Ann Thor Surg 1998;66:1306

\*194 patients

PAC patients had increased complications :

-increased infusion volumes

-higher 24-hour weight gain

-longer ICU stay

#### More data in cardiac anesthesia (Ramsey SD et al J Cardiothorac Vasc Anesth 2000;14:113)

Parameter	No PAC	PAC	р
Mean critical care days	2.03	3.14	<0.001
Length of stay in hospital	7.44	8.45	<0.001
Died in hospital	85	225	<0.001
<b>Discharged at home %</b>	76%	79%	<0.001
	4443	6412	
Total hospital cost (in \$ 1000)	18.4	20.5	<0.001



## b. Vascular surgery- peripheral

One single major paper : Berlauk, Ann Surg 1991;214:289 A randomized controlled study on patients for peripheral vascular surgery

-less tachycardia,
hypotension, arrhythmias
during surgery and
anesthesia
IF
The PAC was inserted
preoperatively

Same paper found a lower rate of incidence of postoperative complications, explained by :

Higher CO

thrombosis

# b. Vascular surgery- Abdominal aortic reconstruction

#### **Three different papers :**

Hessdorfer, Clin Nephrol 1987;28:272

\*Less complications (renal failure, hypotension ) in the PAC group Sandison, Eur J Vasc Endovasc Surg 1998;16:356

\*comparison between two hospitals with a significantly different mortality rate

\*nonelective aortic repair, PAC was more used in that hospital with a higher mortality Isaacson, J Vasc Surg 1990;4:633

\*PAC vs CVP

Found no difference in outcomes



#### c. Trauma (Arch Surg 1992;127:1125)

**Prospective trial of supranormal values as goals of resuscitation in severe trauma** 

A. Fleming et ql Department of Surgery, Charles R. Drew University of Medicine & Science, Martin Luther King Jr/Drew Medical Center, Los Angeles, CA 90059.

We prospectively tested the **effect of the early postinjury** attainment of supranormal values of cardiac index (> or = 4.52 L/min per square meter), oxygen delivery (> or = 670 mL/min per square meter), and oxygen consumption (> or = 166 mL/min per square meter) on outcome in traumatized patients with an estimated blood loss of 2000 mL or more. The goals in control patients were to attain normal values for all hemodynamic measurements. During the 6-month period, 33 protocol patients and 34 control patients with similar vital signs, estimated blood losses, and severity of injuries were enrolled in the study. Eight (24%) protocol patients died, while 15 (44%) control patients died. The protocol patients had fewer mean (+/-SEM) organ failures per patient (0.76 +/- 1.21 vs 1.59 +/- 1.60), shorter stays in the intensive care unit (5 + - 3 vs 12 + - 12), and fewer mean days requiring ventilation (4 +/- 3 vs 11 +/- 10) than did the control patients (P < .05 for each). We conclude that attaining supranormal circulatory values improves survival and decreases morbidity in the severely traumatized patient.

#### Durham et al J Trauma, 1996;41:32

**Design:** Fifty-eight critically ill patients were randomized to two groups. *In group 1 (27 patients) attempts were made to maintain VO2 I greater than or equal to 150 or DO2 I greater than or equal to 600 mL/min/m2. If DO2 I was > 600, no attempt was made to increase VO sub 2 I even if it was <150. Group 2 (31 patients) was resuscitated based on conventional parameters.* 

**Main Results:** Three patients in group 1 and two patients in group 2 died of organ failure (OF). One additional patient in group 2 died of refractory shock within 24 hours. Two of the patients in group 1 who died failed to meet VO2 I/DO2 I goals within 24 hours despite maximal resuscitation. Mortality was not different between the groups even with exclusion of the group 1 patients who failed to meet VO2 I/DO2 I goals (p = 0.66). After exclusion of the patient in group 2 who died of refractory shock, OF occurred in 18 of 27 (67%) in group 1 and in 22 of 30 (73%) in group 2 (p = 0.58). Length of ventilator support, intensive care unit stay, and hospital stay were not different between groups. When all patients were assessed, no difference was found in the incidence of OF between patients who attained the VO2 I goal and those who did not. OF occurred in 20 of 34 (59%) patients who maintained a mean DO2 I greater than or equal to 600 during the first 24 hours of the study and in 21 of 24 (88%) of those who did not (p < 0.02).

Conclusions: No difference was found in the incidence of death in patients resuscitated based on oxygen transport parameters compared to conventional parameters. These data suggest that given adequate volume resuscitation, oxygen-based parameters are more useful as predictors of outcome than as endpoints for resuscitation

## d. Obstetrics and Gynecology

- Very scarce data, on few patients
- PAC used as a tool and not as a study target
  - A consensus , based on no objective data, would include the indication of PAC insertion in preeclampsia
- Seems to have no place in preventing myocardial infarction for surgery during pregnancy



# But after all, there is a clear evidence that PAC insertion and use is accompanied by complications

Complications	Percentage in literature
<u>Central venous access</u>	
-pneumothorax	3.6 0.3-1.9
-air embolism	0.5
<b>Catheterization</b>	
-minor arrhythmias	20
-major arrhythmias	0.3-3.8
-increase in tricuspid regurgitation	17
-complete heart block	0-8.5
<b>Catheter residence (minor complications)</b>	
<u>-positive tip culture</u>	20
-catheter relates sepsis	0.7-3
/ thrombophlebitis	65



# **Major complications**

Catheter related sepsis 0.7-3% Endocarditis 2.2-7.1% Pulmonary artery rupture

0.03-7%

Pulmonary infarction

0.1-2.6%

DEATH

0.02-1.5%

And finally, after the literature search results, what the ASA Task Force experts said, ten years ago, about PCA ?



# The experts opinion –ten years ago

- Routine use of PAC in low risk patients does not reduce mortality, length of stay or any other markers for severity of illness
- In some settings, the risk of the procedure may outweigh its benefits
- But, on the contrary, in selected surgical cases, PAC can reduce incidence of postop complications BY PROVIDING IMMEDIATE ACCESS TO CRITICAL HEMODYNAMIC DATA



# What does it mean ?

#### It means that :

•For selected indications and settings

•When accurate interpretation is available

•And appropriate treatment would be tailored to the hemodynamic findings

The use of PAC can reduce perioperative mortality and morbidity by reducing cardiac complications (ischemia, congestive heart failure, arrhythmias), renal failure, brain injury or pulmonary complications

#### But, in the same time....

 By delaying treatment, once complications showed up, in order to insert PAC,
 MAY ENDANGER THE PATIENT AND INCREASE THE RISK OF COMPLICATIONS OF THE INSERTION

#### BESIDE

Emergency insertion of PAC under hastily prepared conditions, MAY INCREASE THE RISK OF VASCULAR INJURY AND SEPSIS

# So, who would really need and deserve a pulmonary artery catheter insertion, IN SPITE OF THE RISK ?

"The risk of PAC is both appropriate and necessary in selected surgical patients undergoing procedures associated with complications from hemodynamic changes OR entering surgery with pre-existing risk factors for hemodynamic disturbances"



The last sentence, 10 years ago

The evidence reviewed to date does not support the routine use of PAC when there is a low risk of hemodynamic complications

## The 27 scenarios

Categories	Low-risk settings	Moderate risk settings	High-risk settings
P-low S-low			
P-low S-moderate			
P-low S-high			
P-moderate S-low			
P-moderate S-moderate			
P-moderate S-high			
P-high S-low			
P-high S-moderate			
P-high S-high			

Categories	Low-risk settings	Moderate risk	High-risk settings
P=patient		settings	
S=surgery			
P-low S-low	1	1	1
P-low S-moderate	1	1	1
P-low S-high	5	3	1
P-moderate S-low	1	1	1
P-moderate S-moderate	6	3	1
P-moderate S-high	8	6	2
P-high S-low	5	3	2
P-high S-moderate	8	7	3
P-high S-high	0	8	

# Interesting to see some data.....

What about at
 Soroka Medical
 Center, Beer
 Sheva Israel?

An interesting question ! Soroka Medical Center: 1,100 beds

 All kind of surgery , except lung, heart and liver transplant

- A 12-bed General ICU
- Trauma, big surgery, severe sespsis

#### Percentage of patients with a pulmonary artery catheter-Soroka





## So, what is the real place of the PAC in the current daily practice?



#### Could we summarize the indications of using PAC? (Evans DC Scand J Surg 2009; 98:199)

- Assessment of ventricular, Rt and Lt function, pulmonary hypertension as well
- Assessment of hemodynamic response to therapy
- Diagnostic confirmation of intracardiac shunts, pulmonary embolism
- Differentiation between low-pressure and highpressure edema
- Differentiation of different kinds of shock
- Hemodynamic monitoring of:

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\*

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- \*multiple organ failure \*burns \*acute MI
- Therapeutic aspiration of intracardiac air emboli

#### The well known paper of Pinsky and Vincent

*Crit Care Med 2005;33:1119* 

"Let us use PAC correctly and only when we need it" The risks are mainly due to usertion of a central catheter and not because PAG Continuous measurement of hemodynamic parameters is a unique PAC feature Additional cost is not significant Errors in interpretation are due to lack of education Nonitoring device , no matter how simple or sophisticated, will improve the outcome UNLESS coupled with a treatment, which itself improves outcome

# Two main ideas, trying to solve the problem as per today

Evans et al Scand J Surg 2009;98:199

PAC provides clinicians with wealth of potentially useful hemodynamic information. IF this information is used correctly, IT MAY be very helpful in patient management Rajaram SS et al Cochrane Database Syst Rev 2013;Febr 28

PAC is a diagnostic an hemodynamic monitoring tool BUT not a therapeutic intervention....The use of PAC DID NOT ALTER the mortality, general ICU or hospital length of stay, or cost for adult patients

#### In other words.....

The last years brought us back: • We do not catheterize every hemodynamically instable patient • We weight carefully the risk and benefit for every catheterization ♦ We try to combine, more than anytime, the clinical picture with the data offered by PAC **And the most important thing: we try** not to be the slaves of our tools!!!!

# Finally, a wise saying, from a very well known intensivist:



The pulmonary artery catheter is like a politician: it seems to perform well, but you are never sure that you could trust what it is telling you!!!!

#### What's coming next ?!



"Don't worry about him. They'll keep re-inventing that thing till the end of time!"