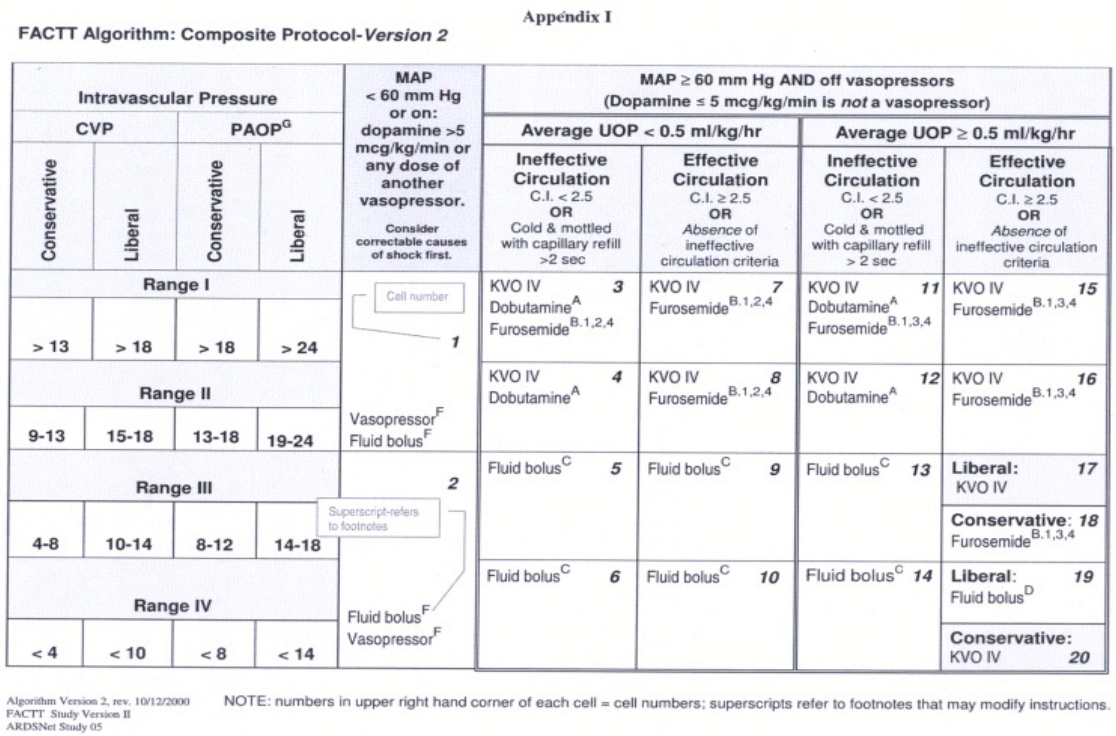
ARDS – What's New?

Since the publication of the Fluid and Catheter Treatment Trial (FACTT) trial in 2006[1,2] there have been further developments that inform our treatment of ARDS with significant outcome benefits for patients. In the FACTT trial you will recall that for patients with acute lung injury or ARDS patient monitoring with a pulmonary artery catheter (PAC) was no better than CVP monitoring and certainly less expensive and perhaps a little safer. Monitoring is used very loosely defined in this analysis, as FACTT simply compared CVP and PCWP targets either conservative (low) CVP <4 or PCWP < 8 vs. liberal (high) CVP > 9 PCWP > 13. (Figure 1)



Appendix I

FACTT Algorithm: Composite Protocol-*Version 2*

Intravascular Pressure				MAP < 60 mm Hg or on: dopamine >5 mcg/kg/min or any dose of another vasopressor. Consider correctable causes of shock first.	MAP ≥ 60 mm Hg AND off vasopressors (Dopamine ≤ 5 mcg/kg/min is *not* a vasopressor)			
CVP		PAOP[G]			Average UOP < 0.5 ml/kg/hr		Average UOP ≥ 0.5 ml/kg/hr	
Conservative	Liberal	Conservative	Liberal		Ineffective Circulation C.I. < 2.5 OR Cold & mottled with capillary refill >2 sec	Effective Circulation C.I. ≥ 2.5 OR *Absence* of ineffective circulation criteria	Ineffective Circulation C.I. < 2.5 OR Cold & mottled with capillary refill > 2 sec	Effective Circulation C.I. ≥ 2.5 OR *Absence* of ineffective circulation criteria
Range I				Cell number 1	KVO IV 3 Dobutamine[A] Furosemide[B.1,2,4]	KVO IV 7 Furosemide[B.1,2,4]	KVO IV 11 Dobutamine[A] Furosemide[B.1,3,4]	KVO IV 15 Furosemide[B.1,3,4]
> 13	> 18	> 18	> 24					
Range II				Vasopressor[F] Fluid bolus[F]	KVO IV 4 Dobutamine[A]	KVO IV 8 Furosemide[B.1,2,4]	KVO IV 12 Dobutamine[A]	KVO IV 16 Furosemide[B.1,3,4]
9-13	15-18	13-18	19-24					
Range III				2 Superscript-refers to footnotes	Fluid bolus[C] 5	Fluid bolus[C] 9	Fluid bolus[C] 13	**Liberal:** 17 KVO IV
4-8	10-14	8-12	14-18					**Conservative:** 18 Furosemide[B.1,3,4]
Range IV				Fluid bolus[F] Vasopressor[F]	Fluid bolus[C] 6	Fluid bolus[C] 10	Fluid bolus[C] 14	**Liberal:** 19 Fluid bolus[D]
< 4	< 10	< 8	< 14					**Conservative:** KVO IV 20

Algorithm Version 2, rev. 10/12/2000
FACTT Study Version II
ARDSNet Study 05

NOTE: numbers in upper right hand corner of each cell = cell numbers; superscripts refer to footnotes that may modify instructions.

Figure 1.

The major concept of the study was to reach these targets depending on group assignment with either fluids or Furosemide. It is not surprising perhaps that those receiving Lasix were weaned from the ventilator faster than those whose accumulated early resuscitative fluids were allowed

to remain with the patients![3] This trial hastened the decline of the use of pulmonary artery catheter in the ICU and has brought us to the present state of generally poorer understanding of hemodynamic physiology especially among recent trainees. Part 2 of this trial has resulted in significant benefits for our patients and ICU, as hospital utilization and cost in patients that were aggressively diuresed following initial resuscitation utilizing either a CVP target of less than 4 or PCWP target of less than 8 spent two days less on mechanical ventilation in the ICU and ultimately two days less in the hospital. Although there was no mortality benefit achieved, throughput improved along with a significant cost savings. The final analysis of these data suggested that a CVP target of less than 4 be the goal for all patients with ALI/ARDS and that this be achieved with Furosemide dosed approximately every 4 hours. I think you know my feeling about the utility of CVP monitoring and managing the volume prescription for the critically ill and injured (see lectures by Dr. Manecke and myself on this website), but in these patients using either CVP or PCWP as a target to remove fluid, worked. This is not surprising as those patients in the conservative limb were often prescribed Furosemide when this question was asked (is the CVP > 4 or PCWP >8) according to the methodology of the trial. All were receiving positive pressure ventilation with a minimum PEEP value of 5. A more succinct take home message for these patients is that following adequate resuscitation of patients with ALI/ARDS after about 48-72 hours those who are hemodynamically stable (based on clinical assessment) should be actively and aggressively diuresed generally until they are liberated from mechanical ventilation.[3] (Figure 2)

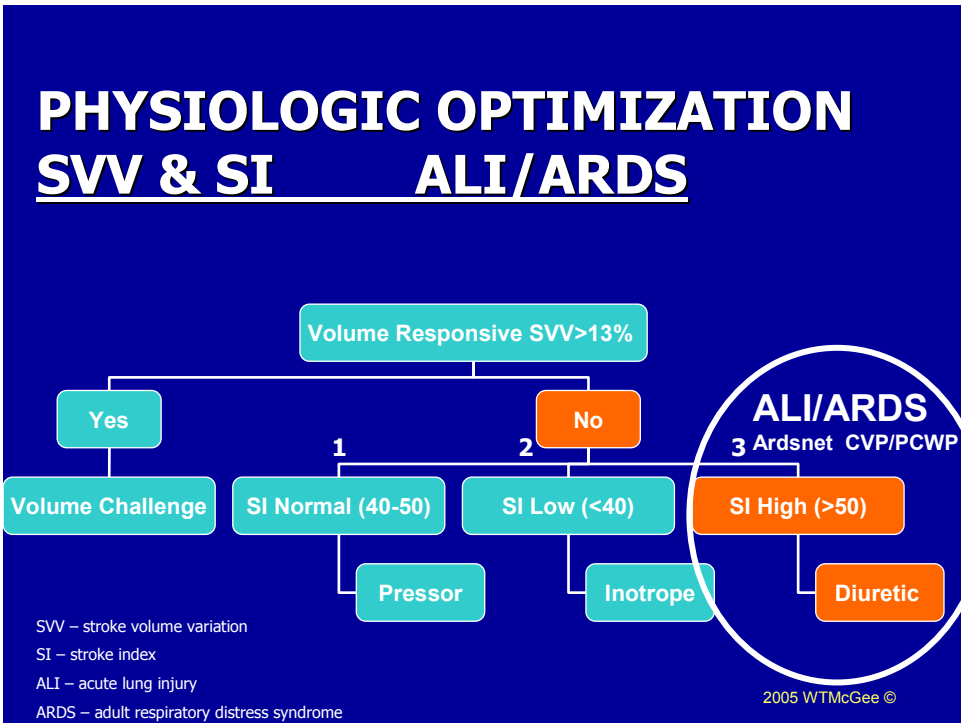


Figure 2.

Pathway 1 may represent a vasodilated patient; resuscitated septic shock is a common example. Pathway 2 may represent a patient with congestive heart failure; determination of ejection fraction is very helpful in selecting appropriate therapy for this situation. Pathway 3 often represents the aftermath of successful resuscitation. For patients with acute lung injury or acute respiratory distress syndrome, diuretics are appropriate. For patients with clear lungs, this remains an open question but, at a minimum, further volume therapy should be withheld.

SV = stroke volume. SVV = stroke volume variation.

The goal being accumulated fluid balance close to 0! (Figure 3)

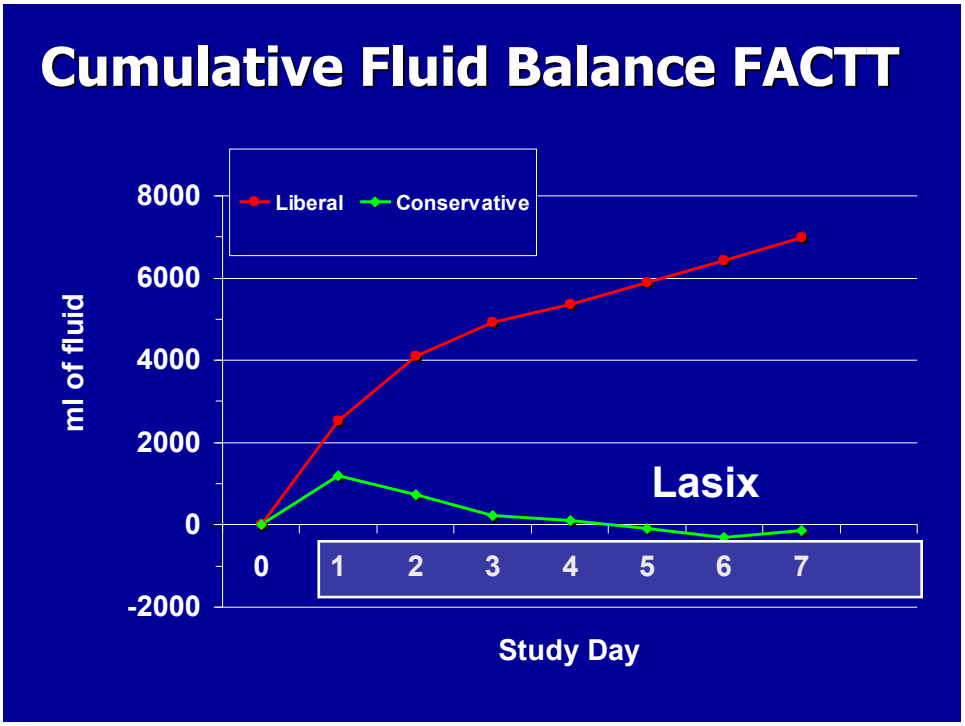


Figure 3.

I believe that utilizing each patient's unique Frank-Starling curve is a more efficient and physiologic approach to volume removal and this can now be easily accomplished with the widely available arterial pressure based cardiac output devices. My approach is to simply and aggressively remove fluids with continuous cardiac output and stroke volume monitoring until these values change significantly and meaningfully. Physiologic deresuscitation is simply moving to the left in Figure 4.. A significant change is determined clinically and will vary depending on all the clinical issues relevant to you and your patient at a particular point in time, A, B or somewhere in between on Figure 4.. Intellectually and physiologically this is a more satisfying approach and provides assurance that perfusion is maintained.

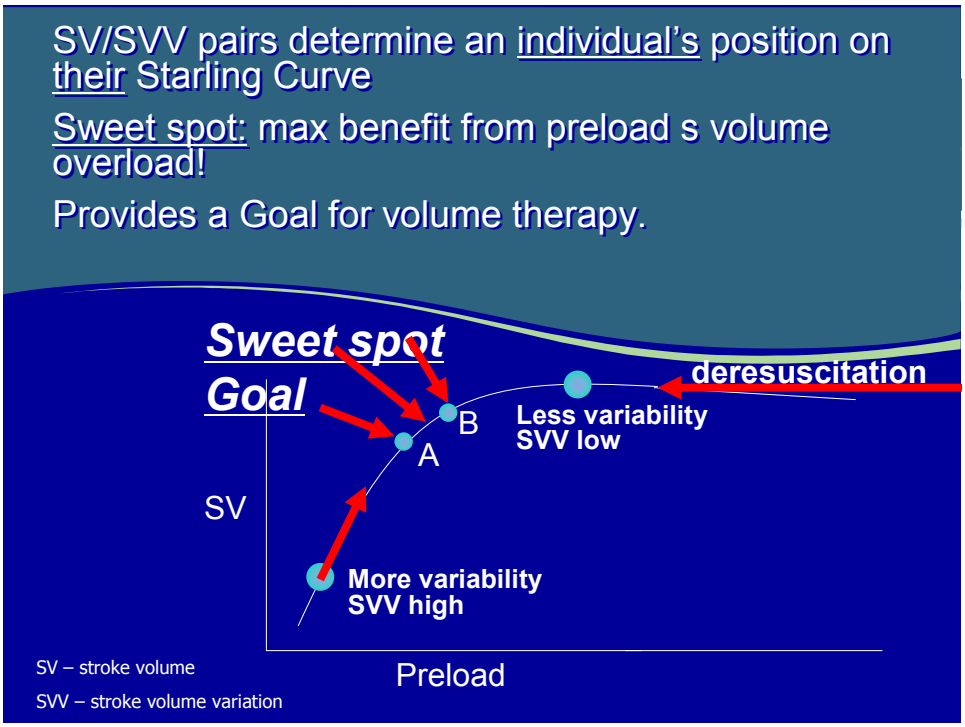


Figure 4.

Regardless of how it is accomplished volume removal should be pursued in all hemodynamically stable patients with ALI/ARDS after the initial resuscitation is accomplished. Utilizing stroke volume and cardiac output data to manage patient's IV fluids early has great potential to minimize and likely prevent some cases of "ALI/ARDS". Figure 5. is data from FACTT that shows 30% of patients diagnosed with ALI/ARDS in FACTT had hydrostatic pulmonary edema with the overwhelming majority having a cardiac index $\geq$ normal. Would ARDS be less common if volume was managed better? These data suggest this is possible if not likely! Using the Frank-Starling mechanism it becomes very clear when volume is no longer beneficial and can then simply be discontinued.[4]

There is a huge opportunity to limit volume therapy in these patients once cardiac output and stroke volume have normalized. This is best accomplished during resuscitation where

knowledge of cardiac performance evaluated by the flow parameters, stroke volume, and cardiac output can limit unnecessary fluid loading. Once blood flow has have either normalized or stopped improving, the patient is typically at or beyond the inflection point in the Frank Starling curve and additional volume is not only necessary but likely harmful. (Figure 4). The precise point on the Frank-Starling Curve the patient needs to be is a clinical decision that can now be fairly easily determined.

The FACT Trial tells us excess volume loading is harmful as many of these patients are simply fluid overloaded and perhaps mischaracterized as ALI/ARDS. Precise management of fluids is clearly beneficial especially in the population with ALI/ARDS.

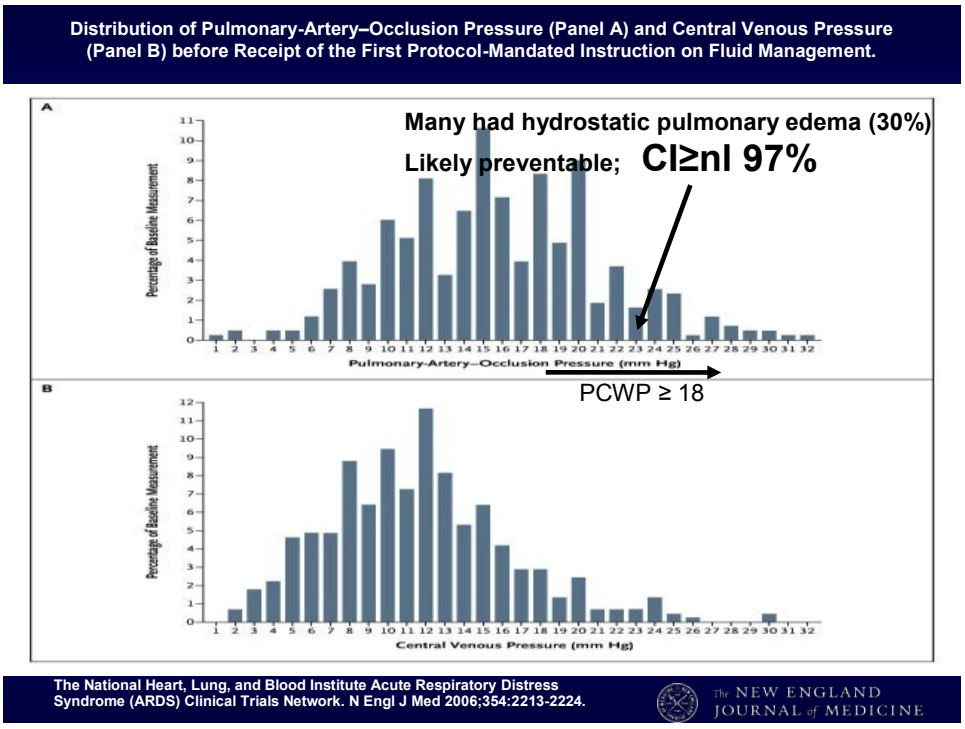


Figure 5.

Additionally, from this trial we now know many were not appropriately diuresed and based on their hemodynamic physiology may have actually been given fluids even when the circulation was adequate or better as blood pressure and not flow (CO/SV) was often the deciding factor!

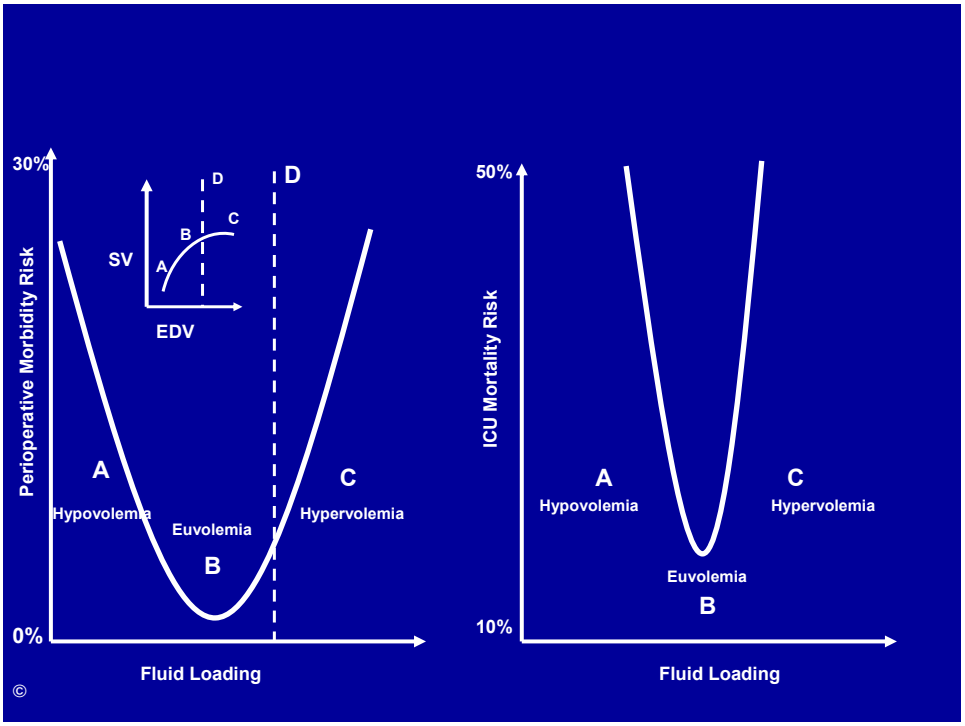


Figure 6.

Left side panel shows the Frank-Starling model underlying Stroke Volume Optimization Programs. Unrecognized hypovolemia (A) when corrected by goal directed therapy programs (B) will result in lower perioperative morbidity. Patients will be moved from left to right along the curve. However, equally important is the prevention of unnecessary volume excess (C). During goal directed therapy, this is done by stopping the use of volume loading when patients are not volume responsive hence staying to the left of line D.

Right side panel: In the ICU, risk of morbidity and mortality is higher as shown by the difference in the y-axis scale. Margin for error is narrower as the curve shifts from being U-shaped to V-shaped. Precision with regard to volume therapy becomes even more important as physiologic reserve declines. Line D is missing as common volume

management practice often proceeds without physiologic guidance. The end result is that outcomes are worse when sicker patients receive volume therapy without physiologic flow-based algorithms.

Figure 6 emphasizes the importance of getting the volume prescription right especially for vulnerable populations in the ICU.

I continue to be impressed by the opportunities to improve care by simply getting the volume prescription right and how simple this is to do applying the Frank-Starling relationship to volume management utilizing arterial pressure cardiac output monitoring. Certainly in the population with ALI/ARDS, an arterial waveform is available for this analysis in the majority!

I include this final figure (Figure 6) as a way to consider the importance of accurate fluid management for the patients we treat.[5]

References:

1. The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network: Comparison of two fluid-management strategies in acute lung injury. *N Engl J Med* 2006;354:2564-2575.
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3. Murphy CV, Schramm GE, Doherty JA et al: The importance of fluid management in acute lung injury secondary to septic shock. CHEST 2009;136(1):102-109.
4. Raghunathan K, McGee WT**,** Higgins TL: Importance of intravenous fluid dose and composition in surgical ICU patients. Current Opinions in Critical Care Medicine, Aug 2012; 18(4):350-7.
5. McGee WT Raghunathan K: Physiologic Goal-Directed Therapy in the Perioperative Period: The volume prescription for high risk patients. J Cardiovasc Thor Anes. 2013 In Press.