# Does the Central Venous Pressure Predict Fluid Responsiveness? An Updated Meta-Analysis and a Plea for Some Common Sense

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## Background

- IV fluid is the cornerstone of treating hypotension, hypoperfusion, and shock.
- Early aggressive resuscitation may improve outcome
- BP=CO x SVR
- CO=SV x HR
- SV=EDV – ESV
- CVP was used as surrogate for preload

## Background

- In 2008, a meta-analysis evaluating the ability of the CVP to guide fluid therapy.
- *CVP should not be used to make clinical decisions regarding fluid management.*
- CVP still recommended to guide fluid resuscitation.
- Various techniques to assess fluid responsiveness

## Background

- Critical Care and Anesthesia literature
- Update meta-analysis to include the most recent studies
- Setting: operating room vs ICU
- Patient population: cardiac surgery vs non-cardiac surgery
- Find role of the CVP in guiding fluid resuscitation.

## Method

- Fluid responsiveness: increase in CO or SV following a preload challenge

## Method

- **Identification of Trials**
  - Database:
    - National Library of Medicine's MEDLINE database
    - EMBASE
    - Cochrane Database of Systematic Reviews
  - Time:1966 to June 2012
  - Keyword:
    - CVP (explode)
    - Fluid therapy
    - Fluid responsiveness
  - Restriction: human adult

## Method

- **Study Selection and Data Extraction**
  - Correlation coefficient or ROC of AUC(area under the receiver operating characteristic curve)
  - Inclusion technique
    - Fluid challenge
    - PLR maneuver/postural change
    - Positive end-expiratory pressure challenge

## Method

- **Data abstracted**
  - Study design
  - Study size
  - Study setting
  - Patient population
  - Criteria used to define fluid responsiveness
  - Type of fluid challenge
  - The primary technology being assessed
  - The correlation coefficients and AUC (including 95% CIs) for the CVP and fluid responsiveness
  - The percentage of patients responding to a fluid challenge
  - Baseline CVP in the fluid responders and nonresponders

## Method

- **Data Analysis**
  - Location subgroup
    - ICU
    - Operating room
  - Patient population subgroup
    - Cardiac surgery
    - Noncardiac surgery
    - Normal
  - Summary data
    - means (± standard deviations) and percentages

## Method

- Random effects models: Comprehensive Meta-analysis 2.0
- Heterogeneity: Cochran Q statistic, $p < 0.10$
- $I2$ with suggested thresholds
  - Low (25%–49%),
  - Moderate (50%–74%)
  - High (> 75%)

## Method

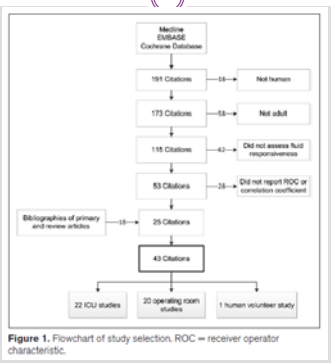



**Figure 1.** Flowchart of study selection. ROC = receiver operator characteristic.

## Results

- 2,105 fluid responsiveness maneuvers
- 1,802 patients
- 22 ICU(4 cardiac surgery)
- 20 operation room(13 cardiac surgery)
- 1 healthy volunteers
- Fluid responsiveness :stroke volume index (SVI) or cardiac index (CI) 15% increased following a 500 cc fluid challenge

| Author | Year | Patients | No. of Patients | Method |
|---|---|---|---|---|
| ICU | | | | |
| Calvin et al (23) | 1981 | Various | 28 | PAC |
| Reuse et al (24) | 1990 | Various | 41 | PAC |
| Wagner and Leatherman (25) | 1998 | Various | 25 | PAC |
| Michard et al (26) | 2000 | Sepsis | 40 | PAC |
| Reuter et al (27) | 2002 | CABG | 20 | PICCO |
| Barbier et al (28) | 2004 | Sepsis | 30 | TEE |
| Kramer et al (29) | 2004 | CABG | 21 | PAC |
| Marx et al (30) | 2004 | Sepsis | 10 | PAC, PICCO |
| Perel et al (31) | 2005 | Vascular surgery | 14 | TEE |
| De Backer et al (32) | 2005 | Various | 60 | PAC |
| Osman et al (33) | 2007 | Septic | 96 | PAC |
| Magder and Bafaqeeh (34) | 2007 | CABG | 66 | PAC |
| Wyffels et al (35) | 2007 | CABG | 30 | PAC |
| Auler et al (36) | 2008 | CABG | 59 | PAC |
| Muller et al (37) | 2008 | Various | 35 | PICCO |
| Huang et al (38) | 2008 | ARDS | 22 | PAC, PICCO |
| Garcia et al (39) | 2009 | Various | 38 | Flotrac (Edwards Life-Sciences, Irvine, CA) |
| Thiel et al (40) | 2009 | Various | 89 | Doppler |
| Garcia et al (41) | 2009 | Various | 30 | Flotrac |
| Morelli and Pizzi (42) | 2010 | SAH | 29 | PICCO |
| Muller et al (43) | 2011 | Various | 39 | TTE |
| Lakhal et al (44) | 2011 | ARDS | 65 | PAC/PICCO |

| Author | Inclusion Criteria | Mechanical Ventilation | Other Comparator | Challenge | r-ΔSV | Area Under the Receiver Operator Characteristic Curve |
|---|---|---|---|---|---|---|
| ICU | | | | | | |
| Calvin et al (23) | SV | N | – | 250 cc Colloid | 0.16 | – |
| Reuse et al (24) | CI | Y | RVEDVI | 300 cc Colloid | 0.21 | – |
| Wagner and Leatherman (25) | SV > 10% | Y | RVEDVI | 500 cc Colloid | 0.44 | – |
| Michard et al (26) | CI > 15% | Y | PPV | 500 cc Colloid | – | 0.51 |
| Reuter et al (27) | SVI > 15% | Y | SVV | 500 cc Colloid | – | 0.42 |
| Barbier et al (28) | CI > 15% | Y | IVC-collapse | 7 mL/kg Colloid | 0.17 | 0.57 |
| Kramer et al (29) | CI > 12% | Y | PPV | 500 cc Colloid | 0.13 | 0.49 |
| Marx et al (30) | CI | Y | SVV, ITBVI | 500 cc Colloid | 0.41 | – |
| Perel et al (31) | CI > 15% | Y | SVV | 7 mL/kg colloid | 0.27 | – |
| De Backer et al (32) | CI > 15% | Y | SVV | 500 cc Colloid | – | 0.54 |
| Osman et al (33) | CI > 15% | Y | – | 500 cc Colloid | – | 0.58 |
| Magder and Bafaqeeh (34) | CI > 0.3% | Y | – | 350 cc Colloid | 0.36 | – |
| Wyffels et al (35) | CI > 15% | Y | PPV | 500 cc Colloid | 0.16 | 0.6 |
| Auler et al (36) | CI > 15% | Y | PPV | 20 mL/kg LR | – | 0.58 |
| Muller et al (37) | SVI > 15% | Y | ITBVI | 500 cc Colloid | – | 0.68 |
| Huang et al (38) | CI > 15% | Y | SVV, PPV | 500 cc Colloid | – | 0.42 |
| Garcia et al (39) | SVI > 15% | Y | Brachial artery velocity | 500 cc Colloid | – | 0.64 |
| Thiel et al (40) | SV > 15% | Y | PLR | PLR | – | 0.52 |
| Garcia et al (41) | SVI > 15% | N | Valsalva | 500 cc Colloid | – | 0.51 |
| Morelli and Pizzi (42) | CI > 15% | Y | SVV, IVC-collapse | 7 mL/kg Colloid | – | 0.66 |
| Muller et al (43) | VTI > 15% | Y | PPV/VTI | 500 cc Colloid | – | 0.61 |
| Lakhal et al (44) | CO > 10% | Y | PPV | 500 cc Colloid | – | 0.63 |

| Author | Year | Type of Patients | No. of Patients | Method |
|---|---|---|---|---|
| Operating room | | | | |
| Berkenstadt et al (45) | 2001 | Neurosurg | 15 | PICCO |
| Rex et al (46) | 2004 | CABG | 14 | PICCO/TEE |
| Preisman et al (47) | 2005 | CABG | 18 | TEE, PICCO |
| Hofer et al (48) | 2005 | CABG | 40 | PAC, PICCO |
| Wiesenack et al (49) | 2005 | CABG | 20 | PICCO |
| Solus-Biguenet et al (50) | 2006 | Hepatic | 8 | PAC, TEE |
| Cannesson et al (51) | 2006 | CABG | 18 | TEE |
| Lee et al (52) | 2007 | Neurosurg | 20 | TEE, Doppler |
| Cannesson et al (53) | 2007 | CABG | 25 | PAC |
| Belloni et al (54) | 2008 | CABG | 19 | PAC, TEE |
| Biais et al (55) | 2008 | OTLTx | 35 | PAC, TEE |
| Hofer et al (56) | 2008 | CABG | 40 | PAC, Flotrac |
| de Waal et al (57) | 2009 | CABG | 18 | PICCO |
| Cannesson et al (58) | 2009 | CABG | 25 | PAC |
| Zimmerman et al (59) | 2010 | Abr-surg | 20 | Flotrac |
| Desebbe et al (60) | 2010 | CABG | 21 | PAC |
| Desgranges et al (61) | 2011 | CABG | 28 | PAC |
| Shin et al (62) | 2011 | OTLTx | 33 | PAC, Flotrac |
| Broch et al (63) | 2011 | CABG | 81 | PICCO |
| Cannesson et al (64) | 2011 | Various | 413 | PAC/PICCO |

| Author | Inclusion Criteria | Mechanical Ventilation | Other Comparator | Challenge | r-ΔSV | Area Under the Receiver Operator Characteristic Curve |
|---|---|---|---|---|---|---|
| Operating room | | | | | | |
| Berkenstadt et al (45) | SV > 5% | Y | SVV | 100 cc Colloid | 0.05 | 0.493 |
| Rex et al (46) | SVI > 5% | Y | PPV, ITBVI | Head up-down | 0.3 | – |
| Preisman et al (47) | SV > 15% | Y | SVV | 250 cc Colloid | – | 0.61 |
| Hofer et al (48) | SVI > 25% | Y | SVV, GEDV | 10 mL/kg Colloid | 0.02 | 0.54 |
| Wiesenack et al (49) | SVI > 20% | Y | PPV | 7 mL/kg Colloid | 0.34 | – |
| Solus-Biguenet et al (50) | SVI > 10% | Y | PPV, LVEDA | 250 cc Colloid | – | 0.63 |
| Cannesson et al (51) | CO > 15% | Y | LVSA | PLR | 0.23 | 0.27 |
| Lee et al (52) | SVI > 10% | Y | PPV, Doppler | 7 mL/kg Colloid | – | 0.54 |
| Cannesson et al (53) | CI > 15% | Y | PVI, PPV | 500 cc Colloid | 0.26 | 0.57 |
| Belloni et al (54) | CI > 15% | Y | PPV | 7 mL/kg Colloid | 0.08 | – |
| Biais et al (55) | SV > 25% | Y | SVV, PPV | Head up-down | – | 0.29 |
| Hofer et al (56) | SVI > 12% | Y | PPV, SVV | 10 mL/kg Colloid | – | 0.57 |
| de Waal et al (57) | CI > 15% | Y | SVV | 500 cc Colloid | – | 0.53 |
| Cannesson et al (58) | SVI > 15% | Y | SVV/PVI | 7 mL/kg Colloid | 0.18 | 0.55 |
| Zimmerman et al (59) | CI < 15% | Y | PVI | 10 cm PEEP | – | 0.25 |
| Desebbe et al (60) | CI > 15% | Y | PVI | 500 cc Colloid | – | 0.48 |
| Desgranges et al (61) | CI > 15% | Y | SVV | 10 mL/kg Colloid | 0.11 | 0.57 |
| Shin et al (62) | SVI > 15% | Y | PVI, PPV | PLR | 0.12 | 0.6 |
| Broch et al (63) | CO > 15% | Y | PPV | 500 cc Colloid | – | 0.57 |

| Author | Year | Type of Patients | No. of Patients | Method |
|---|---|---|---|---|
| Volunteers | | | | |
| Kumar et al (65) | 2007 | Healthy volunteer | 12 | Echocardiography |

| Inclusion Criteria | Mechanical Ventilation | Other Comparator | Challenge | r-ΔSV | Area Under the Receiver Operator Characteristic Curve |
|---|---|---|---|---|---|
| | N | Various | 3,000 Crystalloid | 0.32 | – |

## Results

- AUC 33 studies
- Correlation data 20 studies
- Fluid responders
  - Overall: 57% ± 13%
  - ICU: 52% ± 11%
  - Operating room: 63% ± 15%
  - mean baseline CVP: 8.2 ± 2.3 mmHg(nonresponders 9.5 ± 2.2 mmHg)

## Results

- Summary AUC: 0.56 (95% CI, 0.54–0.58, Q statistic $p = 0.9$, $I2 = 0\%$)
  - ICU: 0.56 (95% CI, 0.52–0.60)
  - Operating room: 0.56 (95% CI, 0.54–0.58)
  - Cardiac surgery: 0.56(95% CI, 0.51–0.61)
  - Noncardiac surgery: 0.56(95% CI, 0.54–0.58)
- Correlation coefficient: baseline CVP and delta SVI/CI: 0.18 (95% CI, 0.1–0.25)
  - ICU: 0.28(95% CI, 0.16–0.40)
  - Operating room: 0.11 (95% CI, 0.02–0.21)

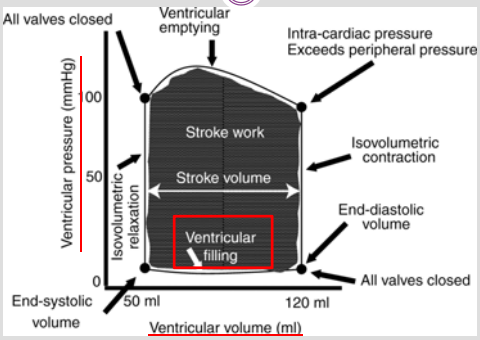
## Discussion

- CVP is unable to predict fluid responsiveness among a broad range of patients in various clinical settings.

## Discussion

- CVP (or pulmonary artery occlusion pressure) is a measure of preload responsiveness
- Indicator of right ventricular end-diastolic volume index (RVEDVI)
- Ventricular pressure-volume curve

## Discussion




## Discussion

- Furthermore, clinical studies have clearly demonstrated that ventricular volumes (RVEDVI, left ventricular end-diastolic area, global end diastolic volumes) are unable to predict fluid responsiveness.

## Discussion

- The origin of CVP monitoring
- Hughes and Magovern in 1954
- blood volume (using radioactive serum albumin) and hourly urine output, blood pressure, respiratory rate, and pulse rate in 25 postthoracotomy patients
- Without providing any summary data or statistical testing

## Discussion

- Wilson and Grow
- CVP monitoring became routine in patients undergoing thoracic surgery.

## Conclusion

- There are no data to support the widespread practice of using CVP to guide fluid therapy.
- This approach to fluid resuscitation is without a scientific basis and should be abandoned.