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Influence of the central venous site on the transpulmonary thermodilution parameters in critically ill burn patients

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ABSTRACT

The aim of this study was to verify the measurement concordance of cardiac index (CI), extra-vascular lung water index (EVLWI) and global end diastolic volume index (GEDVI) with transpulmonary thermodilution (TPTD) between the jugular and femoral access with catheters inserted ipsilaterally in critically ill burn patients. Correlations were excellent and the concordance was good for the CI, EVLW and GEDVI (mean bias −0.11 L/min/m^2, −0.3 mL/kg and −20 mL/m^2 for CI, EVLW and GEDVI, respectively). We conclude that ipsilateral arterial and venous femoral and jugular measurement of TPTD parameters can be used interchangeably if catheters with different lengths on the femoral site are used.

1. Background

Transpulmonary thermodilution (TPTD) can be used to guide fluid management in critically ill patients by the measurement of cardiac index (CI), extra-vascular lung water index (EVLWI) and global end diastolic volume index (GEDVI) [1,2]. Although thermodilution cold saline bolus through a superior vena cava access is the reference method for the TPTD [3,4], caring physicians may face limited vascular access sites. In this line, ipsilateral insertion of venous and arterial femoral catheters for TPTD has been suggested to induce errors measurements due to "the cross talk phenomenon" between the venous and arterial sites (i.e. a cold saline bolus injected through the femoral central venous catheter (CVC) induces significant temperature changes in the close femoral artery by contiguity) [5–7].

The aim of this study was to verify the concordance of CI, EVLWI and the GEDVI measurements with TPTD between the jugular and femoral access – with CVC inserted ipsilateral to the arterial line (AL) – using venous and arterial catheters with 10 cm length difference in severe burn patients.

2. Methods

Prospective observational study from December 2013 to March 2014 in the Burn unit of the Saint Louis Hospital, Paris, France. The study was approved by the ethic committee of the "*Société de Réanimation de Langue Française*" (CE SRLF 11-356). Patient's consent was waived because procedures did not differ from our standard of care. Critically ill burned patients with both an internal jugular CVC and a femoral CVC homolateral to the AL at the same time, during a catheter changing procedure, were included. The measurements were performed in patients with stabilized hemodynamic condition (no need of fluid loading for 2 h and no need to change vasopressor infusion rate) and the same respiratory conditions and position on both sites. Non-inclusion criteria was the presence of an intracardiac shunt identified by contrast echocardiography.

2.1. *Study protocol*

All catheters were inserted with ultra-sound guidance. CVCs of 16–20 cm in the internal jugular vena and 30 cm in the femoral territory were used (Arrow International, Inc, USA). After insertion of the jugular CVC, the correct tip position was verified by thoracic X-rays. A 20 cm thermistor tipped arterial line was placed homolateraly to the femoral CVC and connected to a PiCCO monitor (PiCCO-2 Pulsion Medical Systems AG, Munich, Germany). The TPTD was achieved with an injection of 15 mL of 0.9% cold saline (0–6°) through the distal lumen of the CVC for the CI, the EVLWI and the GEDVI measurements. One measurement procedure consisted of three consecutive thermodilutions via each central venous

Abbreviations: TPTD, transpulmonary thermodilution; CI, cardiac index; EVLWI, extra-vascular lung water index; GEDVI, global end diastolic volume index; CVC, central venous catheter; AL, arterial line; SD, standard deviation; LOA, limits of agreement.

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access (starting with the jugular access then the femoral) within a maximum of 10 min. Results were calculated as the mean of three consecutive thermodilution measurements on each central venous site. Hemodynamic parameters obtained with superior vena cava injections were compared to those determined from inferior vena cava injections. Extra-vascular lung water was indexed for ideal body weight and global end-diastolic volume was indexed to body surface area.

2.2. *Statistical analysis*

The data are presented as mean ± standard deviation (SD) or number and percentage as appropriate. The correlation between the TPTD parameters (CI, EVLWI, GEDVI) was evaluated by linear regression analysis and the Pearson test. Bias and limits of agreement (LOA) were calculated according to the method described by Bland and Altman and correction for repeated measurements was applied [8]. All analyses were performed using R 2.10.1 statistical software (The R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. *Patients' characteristics*

A total of 19 measurements were performed in 13 patients with age 61 ± 17 years, weight 82 ± 9 kg, height 165 ± 6 cm, body surface area 1.9 ± 0.2 m^2, Simplified Acute Physiology Score II 36 ± 14, Sequential Organ Failure Assessment Score 6 ± 3, total body surface area burn 38 ± 18%. 52% (10/19) of the measurements were performed in patients receiving vasopressors and 89% (17/19) in patients under mechanical ventilation. Hemodynamics parameters showed mean arterial pressure 84 ± 12 mmHg, central venous pressure 8 ± 3 mmHg, CI 4.5 ± 1.54 L/min/m^2, heart rate 103 ± 18 bpm and central venous oxygen saturation 72.7 ± 12.4%. Measurements were performed in 15/19 (79%) of cases in sinus rhythm. Body central temperature was 37.5 ± 0.9 °C.

3.2. *Comparison of the TPTD measurements on the two sites*

All thermodilution curves on the femoral site had a monophasic shape. Measurements on the two sites showed good to excellent correlation ($r = 0.97$, $p < 0.0001$; $r = 0.88$, $p < 0.0005$; $r = 0.85$, $p < 0.0001$ for CI, EVLWI and GEDVI, respectively). The analysis of the agreements showed excellent concordance for the CI and EVLW with clinically acceptable bias (CI mean bias −0.11 L/min/m^2 [LOA: −0.85, +0.62], EVLWI mean bias −0.3 mL/kg [LOA: −2.5,+1.89]). The GEDVI mean bias was low −20 mL/m^2, but LOA were rather large [LOA: −202, +162] (Fig. 1). 9/18 (50%) patients received vasopressors at 0.22 ± 0.14 γ/kg/min. Excluding patients off vasopressors or patient not in sinus rhythm ($n = 4$) did not affect CI measurement (mean bias of CI 0.11 L/min/m^2 [LOA: −0.72, +0.50] and −0.14 L/min/m^2 [LOA: −0.99, +0.70], respectively).

4. Discussion

The results of this study showed clinically acceptable agreement between jugular and ipsilateral femoral measurements for CI and EVLWI when femoral catheters with a 10 cm difference length were used. Larger limits of agreement for GEDVI might be related to the increased dilution volume of the cold boluses [3,4]. Although different catheter lengths had already been recommended when ipsilateral femoral placements were used [5–7], this assumption has not been formally validated. To our knowledge, only two studies refered to the use of nonstandard vascular access sites for transpulmonary thermodilution measurements and specifically correlated femoral and jugular injection sites [3,4]. In the study of Schmidt et al. the authors have not reported if their femoral

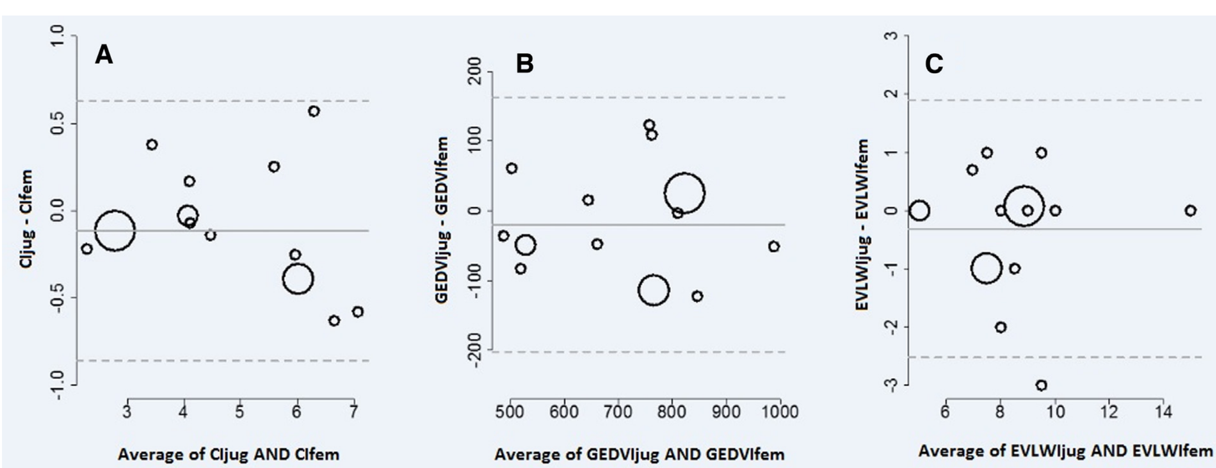

Fig. 1 – Bland–Altman analysis of the TPTD variables derived from the femoral and jugular sites: ICfem and ICjug (A), GEDVIfem and GEDVIjug (B) and EVLWIfem and EVLWIjug (C). CIjug = jugular cardiac index (L/min/m^2); CIfem = femoral cardiac index (L/min/m^2); EVLWIjug = jugular extravascular lung water index (mL/kg); EVLWIfem = femoral extravascular lung water index (mL/kg); GEDVIjug = jugular global end-diastolic volume index (mL/m^2); GEDVIfem = femoral global end-diastolic volume index (mL/m^2). The unbroken line indicates the mean difference (bias), and broken lines indicate 95% limits of agreement. Note that some of the data points are superimposed.