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Original Contribution

Disagreement between fourth generation FloTrac and LiDCOrapid measurements of cardiac output and stroke volume variation during laparoscopic colectomy☆

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Abstract

Study objective: To determine the agreement between cardiac output (CO) and stroke volume variation (SVV) measured simultaneously by the fourth generation FloTrac/Vigileo system and LiDCOrapid system during pneumoperitoneum in patients undergoing laparoscopic colectomy.

Design: Retrospective observational study.

Settings: Operating room in a general hospital.

Patients: Ten patients (American Society of Anesthesiologist 1 or 2) without preoperative anemia.

Interventions: A 22-gauge catheter was inserted in the radial artery after induction of anesthesia. The arterial line was split to monitor CO and SVV simultaneously with the LiDCOrapid and fourth generation FloTrac/Vigileo systems. All data were downloaded from each system after surgery and simultaneous paired $CO_{FloTrac}$, CO_{LiDCO} and $SVV_{FloTrac}$, SVV_{LiDCO} values estimated every 1 minute during the pneumoperitoneum were analyzed.

Measurements: To assess the agreement after carbon dioxide insufflation, a scatter 4-quadrant plot was generated using paired ΔCO values (changes in $CO_{FloTrac}$ and CO_{LiDCO} just before pneumoperitoneum and 3

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minutes after the induction of pneumoperitoneum). For data in which $SVV_{FloTrac}$ was >9% but <16% and cardiac index measured by FloTrac/Vigileo was <2.5 L/min per m^2 during stable pneumoperitoneum (the period from 5 minutes after Trendelenburg position until discontinuation of pneumoperitoneum), simultaneously measured paired $SVV_{FloTrac}$ and SVV_{LiDCO} were plotted every 1 minute using the Bland-Altman method.

Main results: A concordance ratio for changes in CO after the induction of pneumoperitoneum was 83% in 4-quadrant plot. During stable pneumoperitoneum, 702 paired $SVV_{FloTrac}$ and SVV_{LiDCO} matched the criteria. These data sets were plotted by the Bland-Altman method and the bias and 95% limit of agreement of SVV were 2.01 and −2.63% to 6.65%, respectively, with 38% percentage error. The regression equation was $SVV_{LiDCO} = 0.98 \times SVV_{FloTrac} - 1.73$ with Pearson correlation coefficient of 0.55.

Conclusions: Our study showed disagreement between the 2 methods and the hemodynamic parameters measured by one of the two devices should be interpreted with caution before therapeutic interventions.

1. Introduction

The use of laparoscopy in colonic and rectal surgery has increased exponentially in recent years. In spite of the postoperative benefits, intraoperative management has turned out to be more complex than conventional laparotomy. For example, the initial carbon dioxide (CO_2) insufflation into the abdominal cavity induces circulatory instability [1,2]. For precise tracking of the circulatory changes, cardiac output (CO) should be monitored with the least invasive device compared with pulmonary artery catheterization. Even under stable pneumoperitoneum condition (SPC), the circulatory status is modified by Trendelenburg position [3,4] as well as by a rise in intrathoracic pressure induced by CO_2 insufflation. The usefulness of dynamic predictive parameters, such as stroke volume variation (SVV) in laparoscopic surgery has been reported [3,4], and individualized fluid optimization based on SVV, which is considered more useful than pulse pressure variation [5], is better than conventional fluid management based on blood pressure, heart rate, and static parameters such as the central venous pressure [6], and significantly improves postoperative outcome under certain surgical settings [7-10].

The uncalibrated arterial waveform analysis is useful for tracking rapid circulatory changes and helping in hemodynamics stabilization [11]. The minimally invasive FloTrac/Vigileo system (Edwards Lifesciences, Irvine, CA) was introduced in 2005 [12]. The device can accurately detect hemodynamic instability associated with changes in systemic vascular resistance [13,14], especially with the latest fourth generation software [15]. Another minimally invasive device is the LiDCOrapid system (LiDCO, Cambridge, UK), which was introduced in Japan in 2012 and is based on the PulseCO system [16]. The availability of these devices at each clinical facility depends on various issues such as hospital system orientation, costs, and clinical need for measurement of hemodynamic parameters. Usually, the values of hemodynamic parameters are reported without specifying the device used for the measurement. But, are the rapid changes in CO measured by the FloTrac/Vigileo and LiDCOrapid after CO_2 insufflation similar? Interestingly, the reported predictive and cutoff values of fluid responsiveness for SVV measured by the FloTrac/Vigileo and LiDCOrapid systems varied from 9% to 13% [7-10,17-19]. Individualized fluid optimization is initiated in patients monitored with the FloTrac/Vigileo system. However, in patients monitored with the LiDCOrapid system, it is not clear if individualized fluid optimization therapy is delayed or withheld even when the same values of SVV are used as predictive values. The FloTrac/Vigileo version 1.07 and 1.10 had already been compared with the LiDCOplus and LiDCOrapid [18,20]. To the best of our knowledge, no such comparison has been published for the latest version of FloTrac/Vigileo (version 4.00) and LiDCOrapid.

The aim of the present study was to elucidate the agreement between the values of rapid changes in CO after CO_2 insufflation and SVV under stable pneumoperitoneum measured by the FloTrac/Vigileo and LiDCOrapid systems in patients undergoing laparoscopic colectomy.

2. Materials and methods

After the approval of the Human Ethics Committee of Kansai Electric Power Hospital (registration #26-56) and obtaining written informed consent from the patients, we conducted retrospective observational study of consecutive patients (American Society of Anesthesiologists 1 or 2) who underwent laparoscopic colectomy between July 2014 and November 2014. We excluded patients with preoperative anemia (hemoglobin < 10 g/dL) and also patients in whom the intraoperative procedure deviated from the standardized protocol followed at our hospital. The standardized protocol followed at our hospital included the following: after placement of epidural catheter into the T10 to 12 intervertebral space, general anesthesia was induced with propofol (1.5-2 mg/kg), sevoflurane (2%-3%), and remifentanil (0.3-0.5 μg/kg per min). This was followed by tracheal intubation after injection of rocuronium (0.6-1 mg/kg). Anesthesia was maintained with sevoflurane (1.5%-2.5%), remifentanil (0.2-0.3 μg/kg per min), epidural ropivacaine (7.5-12.5 mg/h), and rocuronium. Acetate Ringer's solution was infused at 3 to 5 mL/kg body weight per hour. When