



Examination of the usefulness of non-invasive stroke volume variation monitoring for adjusting fluid supplementation during laparoscopic adrenalectomy in patients with pheochromocytoma

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[Case Report]

**EXAMINATION OF THE USEFULNESS OF NON-INVASIVE STROKE
VOLUME VARIATION MONITORING FOR ADJUSTING FLUID
SUPPLEMENTATION DURING LAPAROSCOPIC
ADRENALECTOMY IN PATIENTS
WITH PHEOCHROMOCYTOMA**

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Abstract :

Purpose of the study

The measurement of stroke volume variation (SVV) using the FloTrac™ system (Edwards Lifescience, USA) is useful to estimate cardiac preload. We evaluated the benefits of SVV monitoring for adjusting fluid supplementation during laparoscopic adrenalectomy under anesthesia in patients with pheochromocytoma.

Subjects and Methods

Among 10 patients who underwent laparoscopic adrenalectomy for pheochromocytoma in our institution from June 2004 to December 2009, SVV was not monitored in 5 patients (group I) and in the other 5 patients (group II), SVV monitoring was performed. Subject age, height and body weight, total volume of fluid supplemented, blood loss, urine output and net fluid in-out balance during the procedure were retrospectively assessed. In those with SVV monitoring, infusion volume was adjusted for SVV less than 13%.

Results

There were significant differences in the patient age and body weight between the two groups (group I : 64.2 years old and 55.1 kg ; group II : 43.6 years old and 71.7 kg). Both total infusion volume and urine output were significantly higher in group I compared with group II (5,610 vs. 2,400 ml and 1,125 vs. 750 ml, respectively). Total blood loss was similar between the two groups. Values of the net fluid balance divided by the body weight and total anesthesia period (hr) were significantly lower in group II compared with group I (I ; +13.2 in group I and +6.2 in group II, ml/kg/hr).

Conclusions

These data suggest that SVV monitoring is helpful to estimate the optimal volume for fluid supplementation and could prevent excessive fluid infusion during surgical procedures.

Key words : APCO, SVV, Infusion volume

INTRODUCTION

A monitoring system for arterial pressure-based

cardiac output (APCO), FloTrac™ (Edwards Lifescience, USA) was introduced to the market for clinical use in Japan in August 2005. The system

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measures stroke volume variations (SVV), which might be more sensitive as an index for cardiac preload than central venous pressure (CVP)^{1,2)}. Circulatory management during laparoscopic adrenalectomy for pheochromocytoma is extremely difficult, due to the loading infusion volume. During surgery, tumor resection may cause catecholamine release and thus increase vascular tension. If a hypovascular status persists, it can lead to hypotension and low output syndrome after resection of tumors. On the other hand, the risk of developing pulmonary edema is increased if excessive fluid infusion is performed. Thus, modest infusion fluid management is preferable. It is suggested that monitoring of SVV will adequately determine the amount of circulating blood volume.

Herein, we retrospectively evaluated the efficacy of SVV monitoring in estimating the necessary volume of fluid supplementation during laparoscopic adrenalectomy for pheochromocytoma.

SUBJECTS AND METHODS

We selected patients who underwent laparoscopic adrenalectomy under general anesthesia for pheochromocytoma between June 2004 and December 2009 in our institution [$N=10$, 5 each with (group II) or without (group I) SVV monitoring]. Data were retrospectively analyzed for the following variables: age, height, body weight, mean and duration of anesthesia, total volume of fluid supplemented, blood loss and urine output, and net fluid balance. The volume of fluid infusion was determined by the anesthesiologist in charge in group I, and was controlled by SVV to be lower than 13% in group II. Each anesthesiologist decided on the use of colloid solution and the starting time of the blood transfusion. The study protocol was evaluated and

approved by the Ethics Committee for Clinical Research at Fukushima Medical University. Data were analyzed using the Mann-Whitney test and P -values <0.05 were considered statistically significant.

RESULTS

The demographic backgrounds of the subjects are shown in Table 1. There were significant differences in the patient age and body weight between the two groups (group I: 64.2 years old and 55.1 kg; group II: 43.6 years old and 71.7 kg). General anesthesia and supplemented epidural anesthesia were provided in 4 cases in group I and in 2 cases in group II, and by general anesthesia alone in 1 case in group I and in 3 cases in group II. The general anesthetics used were sevoflurane and fentanyl in 3 cases in group I, sevoflurane and remifentanyl in 1 case in group I and in 5 cases in group II, and propofol and remifentanyl in 1 case in group I. There was no significant difference in the total duration of anesthesia between the two groups (301 vs. 304 min). We also calculated the values of net fluid balance divided by body weight and duration of anesthesia, to correct for the significant difference in body weights between the two groups. The corrected balances were positive in both groups and significantly lower in group II compared with group I (13.2 vs. 6.2 ml/kg/hr, Table 2).

After tumor resection, all cases in group I required catecholamine administration, compared with only two cases in group II.

DISCUSSION

FloTrac™ is a non-invasive monitoring device for cardiac output (CO) and is an APCO that continu-

Table 1. Patient Demographics

	Group I	Group II
Age (years)	64.2 69(40~77)	43.6 34(19~78)*
Gender (M/F)	4/1	2/3
Height (cm)	162.1 162(156.2~167.9)	161.1 161.6(144.7~177.9)
Body weight (kg)	55.1 51.3(40~70.8)	71.7 70(66.5~78.5)*

Data shown as mean and median (Minimum~Maximum)

* $P<0.05$

Table 2. Methods of anesthesia and measurements during adrenalectomy

	Group I	Group II
Anesthesia (N of patients)		
General + epidural	4	2
General anesthesia only	1	3
Periods of anesthesia (min)	301(174~407)	304(190~338)
Infusion volume (ml)	5,610(3,100~6,650)	2,400(1,900~4,450) *
Urine output (ml)	1,125(470~2,890)	750(300~860)*
Blood loss (ml)	400(10~1,180)	250(10~1,400)
Corrected fluid balance [#] (ml/kg/hr)	13.2(7.8~19.3)	6.2(2.1~8.2)*

Data shown as median (Minimum~Maximum) * $P<0.05$

Net fluid balance (ml)=Infusion volume (ml)–Blood loss (ml)–Urine output (ml)

[#]Corrected fluid balance (ml/kg/hr)=Net fluid balance (ml)÷Body weight (kg)÷Anesthesia time (hr)

ously measures CO via an arterial pressure line that is commonly applied during any major surgical procedure. The APCO consists of the FloTracTM sensor and VigileoTM monitor, and measures CO using an index computed with the patient's quantitative characteristics (i.e., height, body weight and age) and measurements of arterial pressure waves, without the need to calibrate prior to application^{3,4}. The CO is estimated by stroke volume (SV), which is calculated by multiplying this index (χ) with the standard deviation(σ_{AP}) of the arterial pressure measurements.

Thus, the equation for APCO can be written as follows⁵ :

$$APCO = HR \times \sigma_{AP} \times \chi$$

(σ_{AP} : the standard deviation of arterial pressure)

(χ : a scaling multivariate model proportional to the effects of vascular tone on pulse pressure)

where HR is the heart rate or pulse rate and SV is a product of σ_{AP} and χ .

SVV, which reflects respiratory fluctuation of the stroke volume, is also continuously monitored in this system³. For accurate measurements of SVV, ventilation has to be under total mechanical control as respiratory rate and tidal volume would not be constant in the presence of spontaneous respiratory effort. Arrhythmia is another important factor that might affect SVV readings. Therefore, it is essential that SVV be applied to patients undergoing controlled mechanical ventilation and without arrhythmia.

As previously reported in studies observing SVV changes in patients receiving intravenous fluid infusion under transesophageal echocardiographic monitoring, SVV is highly sensitive in estimating cardiac preload compared with CVP measurements^{1,2}. The threshold for optimal responsiveness in stroke volume after fluid supplementation has been reported as approximately 13%⁶, and therefore we routinely utilize these criteria for our practice, in addition to being the targeted measurement in the present study.

There have been several reports utilizing the FloTracTM sensor to monitor APCO in patients with deteriorating cardiac function and in the management of patients under anesthesia and/or critical care^{7,8}. Biais *et al.*⁸) also found that, in 40 patients who underwent liver transplantation, patients whose CO, as measured by transesophageal echocardiography, was increased by 15% or more in response to fluid supplementation (responders) demonstrated significantly higher pre-fluid-challenge SVV values, compared with the non-responders, whose increase of CO was less than 15%. Increments of SVV after fluid supplementation were also greater in the responders compared with the non-responders. Another report from Kobayashi *et al.*⁹) retrospectively assessed the possible benefits of FloTracTM sensor and VigileoTM monitoring in order to adjust fluid supplementation during and after surgery in 18 esophageal cancer patients. In their study, 11 out of 18 patients became hypotensive and required fluid infusion within 10 hours after surgery. The maximum pre-infusion SVV values in all 11 patients exceeded 15%, whereas, maximum SVV

values were less than 15% in the remaining 7 cases that did not become hypotensive after surgery.

To our knowledge, the present study is the first to compare the infusion volume administered during surgical procedures in the presence or absence of SVV monitoring. However, due its retrospective design and smaller sample size, there were statistically significant demographical differences in age and body weight between the two groups. To adjust for these differences, we also compared the values of net fluid balance divided both by body weight and duration of anesthesia, and found that these values were also significantly lower in group II in which SVV was monitored, compared with group I without SVV monitoring.

Lower infusion volume might also cause renal function to deteriorate by possibly decreasing urine output. However, in the present study, even patients in group II that showed lower urine volumes maintained a median urine output of 750 ml, which is in the range that would not typically affect renal functions.

After tumor resection, all cases in group I required catecholamine administration, compare with only two cases in group II.

Although we did not take the effects of various inotropic agents likely to be administered during surgery into account, the present data suggest that SVV monitoring is useful to prevent excessive fluid supplementation during surgical procedures.

Further evaluation of the efficacy of SVV monitoring in estimating circulation volume and optimal amount of fluid supplementation, not only during surgery, but also in broader perioperative assessment, is warranted.

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