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ผลของการงดน้ำงดอาหารต่อค่า Stroke Volume Index เมื่อวัดโดย Whole Body Impedance Cardiography

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The Effect of Overnight Fasting on Stroke Volume Index Measured by Whole Body Impedance Cardiography

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หลักการและวัตถุประสงค์: ผู้ป่วยที่เข้ารับการระงับความรู้สึกและผ่าตัดควรงดน้ำงดอาหารในระยะเวลาที่เหมาะสมเพื่อป้องกันการเกิดภาวะปอดอักเสบจากการสำลัก การงดน้ำงดอาหารก่อให้เกิดภาวะพร่องสารน้ำในร่างกาย การให้สารน้ำทดแทนทางหลอดเลือดดำเพื่อแก้ไขภาวะพร่องสารน้ำสามารถป้องกันภาวะความดันโลหิตต่ำระหว่างการระงับความรู้สึก แต่การให้สารน้ำมากเกินความจำเป็นก่อให้เกินผลเสีย ปัจจุบันยังไม่สามารถสรุปชัดเจนเกี่ยวกับผลของการงดน้ำงดอาหารต่อสภาวะของสารน้ำในร่างกายที่เปลี่ยนแปลงไป ที่ผ่านมายังไม่มีการศึกษาวัดสภาวะของสารน้ำในหลอดเลือดหลังการงดน้ำงดอาหารโดยใช้ whole body bioimpedance cardiography ซึ่งเป็นอุปกรณ์ที่ไม่รุกราน ใช้ง่าย และค่าที่วัดได้ไม่ขึ้นกับผู้วัด ความน่าเชื่อถือของค่าที่วัดได้จาก whole body bioimpedance cardiography เทียบเท่า pulmonary artery thermodilution ซึ่งเป็นวิธีมาตรฐาน ในการศึกษานี้ใช้ whole body bioimpedance cardiography วัดค่าปริมาตรเลือดที่ถูกสูบฉีดออกจากหัวใจในการบีบตัวหนึ่งครั้งต่อพื้นที่ผิวกาย (stroke volume index, SVI) ก่อนและหลังงดน้ำงดอาหารเป็นเวลา 8 ถึง 10 ชั่วโมง

วิธีการศึกษา: ศึกษาในอาสาสมัครอายุ 18-65 ปี American society of anesthesiologists (ASA) physical status 1-2 ใช้อุปกรณ์ whole body bioimpedance วัดค่า SVI และ hemodynamic parameters อื่นๆก่อนและหลังงดน้ำงดอาหาร โดยเปรียบเทียบความแตกต่างค่า hemodynamic parameters ก่อนและหลังงดน้ำงดอาหารหากมากกว่าร้อยละ 10 ถือว่ามีนัยสำคัญทางคลินิก ค่า p-value < 0.05 ถือว่ามีนัยสำคัญทางสถิติ

Background and Objecitve: Preoperative fasting is recommended to prevent pulmonary aspiration. Fasting induces hypovolemia. Intravenous fluid infusion is commonly given during anesthesia to minimize the risk of hypotension. However, intravenous fluid overload has been shown to deteriorate patient outcome. From previous literatures, the effect of preoperative fasting on intravascular volume is still inconclusive. There is no previous study that assesses intravascular volume status before and after fasting using the whole body impedance cardiography which is a non-invasive, practical and operator-independent. The reliability of whole body impedance cardiography is comparable to pulmonary artery thermodilution which is gold standard. In this study, we assessed stroke volume index (SVI) before and after fasting for 8 to 10 hours using whole body impedance cardiography.

Methods: This is prospective observational study. We included volunteers with American society of anesthesiologists (ASA) physical status classification I–II with age between 18-65 years old. SVI and other hemodynamic parameters were measured before and after fasting using whole body impedance cardiography. The absolute change of hemodynamic parameters before and after fasting more than 10% indicated clinical significance. P value < 0.05 indicates statistical significance.

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ผลการศึกษา: อาสาสมัครเข้าร่วมวิจัยจนสิ้นสุดจำนวน 62 ราย SVI ก่อนและหลังงดน้ำงดอาหารมีค่า 40.0±8.7 มล.ต่อตร.ม. และ 37.7±8.2 มล.ต่อตร.ม. ตามลำดับ โดยมีค่าลดลงร้อยละ 5.5 ค่าร้อยละของการเปลี่ยนแปลง SVI ในผู้เข้าร่วมวิจัยแต่ละรายมีค่าอยู่ในช่วงตั้งแต่ เพิ่มขึ้นร้อยละ3.1 ถึง ลดลงร้อยละ17.0 มีผู้เข้าร่วมวิจัยจำนวน 12 ราย (ร้อยละ 19.4) มีค่า SVI ลดลงมากกว่าร้อยละ 10 ค่า stroke volume (SV), cardiac output (CO) and cardiac index (CI) มีค่าลดลงร้อยละ 5.6, 6.6 และ 6.4 ตามลำดับ ค่า hemodynamic parameters ทุกตัวยกเว้นอัตราการเต้นของหัวใจมีค่าลดลงแบบมีนัยสำคัญทางสถิติ แต่ลดลงน้อยกว่าร้อยละ 10

สรุป: การงดน้ำงดอาหารไม่มีผลเปลี่ยนแปลงค่า SVI ทางคลินิกเมื่อวัดโดย whole body impedance cardiography ในประชากรที่มีสุขภาพแข็งแรง ผู้เข้าร่วมวิจัยบางรายมีค่า SVI ลดลงอย่างมีนัยสำคัญหลังการงดน้ำงดอาหาร และการให้สารน้ำทางหลอดเลือดดำในปริมาณที่เหมาะสมน่าจะช่วยเพิ่มอัตราการไหลของเลือดออกจากหัวใจ (cardiac output)

Keywords: ปริมาตรเลือดที่ถูกสูบฉีดออกจากหัวใจในการบีบตัวหนึ่งครั้งต่อพื้นที่ผิวกาย; การงดน้ำงดอาหาร; ภาวะพร่องสารน้ำ

Results: Sixty-two volunteers were enrolled and completed the study. SVI before and after overnight fasting were 40.0±8.7 mL/m^2 and 37.7±8.2 mL/m^2, respectively. SVI after fasting was decreased 5.5%. The percentage absolute change of SVI in individual volunteer was in a range between 3.1% to -17.0%. Twelve subjects (19.4%) have decreased in SVI. Stroke volume (SV), cardiac output (CO) and cardiac index (CI) were decreased 5.6%, 6.6% and 6.4%, respectively. All hemodynamic parameters except heart rate were statistically decreased after fasting ($p< 0.05$) but the absolute change less than 10%.

Conclusion: Overnight fasting does not clinically affect SVI measured by whole body impedance cardiography in healthy population. Some volunteers have significantly decreased in SVI after fasting and appropriate intravenous fluid therapy probably improves CO.

Keywords: Whole body impedance cardiography; stroke volume index; fasting, hypovolemia

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Introduction

Preoperative fasting before elective anesthesia is recommended for all patients to prevent pulmonary aspiration of gastric content.[1,2] Fasting induces hypovolemia, as a result of ongoing urine production and insensible perspiration. Intravenous fluid infusion is commonly given during anesthesia to minimize the risk of intraoperative hypotension.[3-5] However, intravenous fluid overload has been shown to deteriorate patient outcome.[6-8] From previous literatures, the effect of preoperative fasting on intravascular volume is still inconclusive. Bundgaard-Nielsen et al, estimated stroke volume (SV) by esophageal doppler in anesthetized patients and found that 70% of patients presented with intravascular volume deficit which needed about 200 mL to maximize SV.[9] Jenstrup et al, used maximal venous oxygen saturation to demonstrated that preoperative volume deficit was 500 mL in surgical patients.[10] By contrast, Muller et al, concluded that preoperative fasting did not alter transthoracic echocardiography dynamic and static preload indices.[11] Kiefer et al, found no significant difference of blood volume before and after 12-hour fasting.[12]

There is no previous study that assesses intravascular volume status before and after fasting using the whole body impedance cardiography (Non-invasive Cardiac System [NICaS]) which is a non-invasive, practical, reliable and operator-independent. Pulmonary artery thermodilution is considered to be the gold standard for cardiac output monitoring but invasive and causes serious complications.[13] Esophageal doppler and transthoracic echocardiography are less invasive but operator-dependent. Impedance cardiography technique is based on the theory that changes in blood volume in the aorta during each cardiac cycle result in impedance change that can be used to estimate stroke volume. The impedance changes can be derived by measuring voltage change to an applied electrical signal. From the studies of Gad, et al[14] and Oscar, et al[15], the correlation coefficient of cardiac output between electrical whole body impedance cardiography and pulmonary artery thermodilution was 0.89 and 0.91, respectively. The two methods were considered comparable. In this study, we assessed SVI before and after fasting for 8 to 10 hours using whole body impedance cardiography. The objective of this study is observation the change of SVI after overnight fasting for approximately 8-10 hours using the whole body impedance cardiography.

Methods

This is a single center, prospective observational study. After the approval by ethical committees Mahidol University(MURA2015/600), inform consent was obtained from all volunteers. We performed the study in Ramathibodi hospital Mahidol university between October 2015 to June 2016.

Inclusion and exclusion criteria

We included volunteers of American society of anesthesiologists (ASA) physical status classification I–II with age between 18-65 years old. We excluded volunteers with history of excessive fluid loss (diarrhea, vomiting, diuretic use), diagnosed diabetes mellitus and had limitations for whole body impedance cardiography (uncooperation, arrhythmia, aortic disease, peripheral arterial disease, peripheral edema, body mass index more than 45 kg/m^2 and height less than 1.30 m. or more than 2.00 m.)

Protocol

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were monitored when volunteers were in supine position. Hemodynamic parameters including SV, SVI, cardiac output(CO) and cardiac index(CI) were measured using the whole body impedance cardiography (Non-invasive Cardiac System [NICaS]). Two impedance cardiography (ICG) electrodes were attached to volunteers' left wrist and right ankle. (Figure1.) At the beginning of the procedure, researcher entered the volunteers' gender, age, weight and height to the laptop which was a part of the device. This data was used in conjunction with the impedance data obtained from the wrist and ankle electrodes to estimate stroke volume. The electrodes also provided heart rate and a single-channel electrocardiogram (ECG). The ECG waveform, the impedance waveform, and the hemodynamic parameters were all displayed on the laptop.

The procedure was performed twice. The first measurement was performed in the evening between 6.00 to 8.00 pm. Volunteers were allowed to eat foods and drink fluids until 10 pm. Volunteers were assigned to come back for the second measurement in the next morning between 6.00 to 8.00 am to meet the fasting duration approximately 8 to 10 hours.

Figure1 Volunteers were in supine position and two impedance cardiography (ICG) electrodes were attached to left wrist and right ankle. (I = electrical current, V = electrical voltage)

Primary and secondary outcomes

The primary outcome was the absolute change of SVI before and after overnight fasting for 8-10 hours. Secondary outcomes were the absolute change of SV, CO and CI. The absolute change of all outcomes more than 10% indicated as clinical significance. Patients characteristics including gender, age, height, weight, body mass index (BMI), American society of anesthesiologists (ASA) physical status classification and duration of fasting time were also recorded.

Statistical analysis

From our pilot study, SVI before fasting was 39.95±10 mL/m^2. Forty-nine subjects were needed to detect 10% change of SVI to achieve a power of 80% at a significance level of 5%. The sample size was increased to a total of 62 subjects for 25% dropout compensation. Data was analyzed by using SPSS 18.0 software. Continuous data was presented as mean±SD. Qualitative data was presented as frequency (percentage). The changes of hemodynamic parameters were summarized with 95% confidence interval (CI). The difference of hemodynamic parameters before and after overnight fasting was analyzed by Paired t-test. P value <0.05 indicated statistically significance.

Results

Sixty-two volunteers were enrolled and completed the study. Demographic data including gender, age, height, weight, BMI, ASA classification and duration of fasting time are presented in Table1.

SVI before and after overnight fasting were 40.0±8.7 mL/m^2 and 37.7±8.2 mL/m^2, respectively. SVI after fasting was decreased 5.5%. (Table2.) The percentage absolute change of SVI in individual volunteer was in a range between 3.1% to -17.0%.

Table 1 Demographics and duration of fasting time (n=62)

Demographics	number (%) or mean ± SD
Gender	
- Male	37 (59.7%)
- Female	25 (40.3%)
Age (yr)	34.7±11.1
Weight (kg)	57.5±6.0
Height (cm)	162.0±8.0
BMI (kg.m^2)	20.9±3.0
ASA classification	
I	52 (83.9%)
II	10 (16.1%)
Duration of fasting (hr)	8.9±0.8

(BMI = Body mass index, ASA classification = The American Society of Anesthesiologists classification)

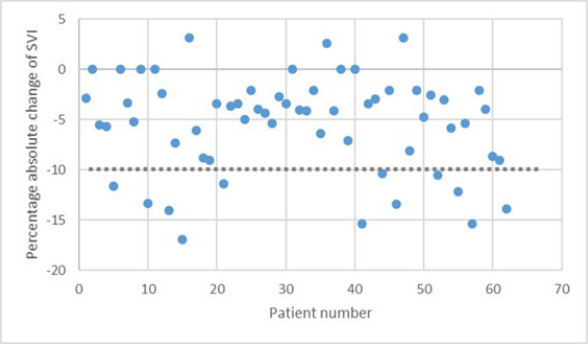

Figure 2 Percentage absolute change of Stroke volume index (SVI) of individual volunteer

Twelve subjects (19.4%) has decreased in SVI. (Figure 2.)

SV, CO and CI were decreased 5.6%, 6.6% and 6.4%, respectively after fasting. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were decreased 1.7% and 3.9%, respectively. Heart rate before and after fasting were comparable (Table 2).

All of hemodynamic parameters except heart rate were statistically decreased after overnight fasting

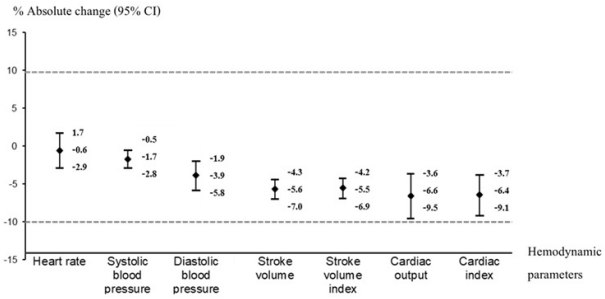

Figure 3 Percentage absolute change of hemodynamic parameters before and after overnight fasting

($p < 0.05$) but the percentage absolute change < 10% (Figure 3).

Discussion

This study found that overnight fasting for 8 to 10 hours has decreased SVI 5.5% which was not clinical significance. The result is similar to previous studies. Muller et al, concluded that preoperative fasting did not alter dynamic and static preload indices measured by transthoracic echocardiography.[11] Kiefer et al, found no significant difference of blood volume before and after 12-hour fasting.[12] By contrast,

Table 2 Hemodynamic parameters before and after overnight fasting (n=62)

Hemodynamic Parameters	Before fasting	After fasting	Absolute change (95%CI)	% Absolute change (95%CI)	P-value
HR (bpm)	68.0±9.6	68±10.1	-0.4 [(-2.0)-1.2)]	-0.6 [(-2.9)-1.7]	0.92
SBP (mmHg)	112.3±10.7	110.4±9.8	-1.9 [(-3.2)-(-0.6)]	-1.7[(-2.8)-(-0.5)]	0.005*
DBP (mmHg)	67.3±7.2	64.7±7.0	-2.6 [(-3.9)-(-1.3)]	-3.9[(-5.8)-(-1.9)]	<0.001*
SV (mL)	64.2±16.3	60.6±15.1	-3.6 [(-4.4)-(-2.8)]	-5.6[(-6.9)-(-4.3)]	<0.001*
SVI (mL/m^2)	40.0±8.7	37.7±8.2	-2.2 [(-2.7)-(-1.7)]	-5.5[(-6.9)-(-4.2)]	<0.001*
CO (L/min)	4.3±1.0	4.1±0.9	-0.3 [(-0.4)-(-0.2)]	-6.6[(-9.5)-(-3.6)]	<0.001*
CI (L/min/m^2)	2.7±0.6	2.5±0.5	-0.2 [(-0.3)-(-0.1)]	-6.4[(-9.1)-(-3.7)]	<0.001*

Data are represented as mean±SD

[HR = heart rate, SBP = systolic blood pressure, DBP = diastolic blood pressure, SV = stroke volume, SVI = stroke volume index, CO= cardiac output, CI= cardiac index, Absolute change = after fasting – before fasting, % Absolute change = [(after fasting –before fasting)/ before fasting] x 100, 95%CI = 95% confidence interval (lower bound-upper bound), * = p<0.05]

some studies has found different outcomes. Bundgaard-Nielsen et al, estimated SV by esophageal doppler and found that 70% of patients presented with intravascular volume deficit which needed about 200 mL to maximize SV.[9] Jenstrup et al, used maximal venous oxygen saturation to demonstrated that preoperative volume deficit was 500 mL in fasting patients.[10] There is a limitation from these two study, esophageal doppler and maximal venous oxygen saturation were measured after induction of general anesthesia. Anesthetic agents and positive pressure ventilation potentially impact hemodynamic status on blood volume, vascular tone and cardiac function. In order to avoid this potential bias, the present study was performed in volunteers without the effect of general anesthesia.

Consider SVI before and after overnight fasting, twelve volunteers (19.4%) have decreased in SVI more than 10% after overnight fasting. This could be assumed that an appropriate intravenous fluid loading could improves cardiac output in some healthy subjects. However, we did not perform subgroup analysis due to limited data and baseline cardiac contractile function was not assessed before the study.

Limitations of this study, the first we studied only in healthy population with ASA physical status classification I–II. We included subjects who met the inclusion criteria by interview and physical examination. So we might miss some information that affect SVI such as baseline cardiac contractility. Fasting in high-risk patients might affect hemodynamic status in different outcome. The second, we did not record intake and output of fluid. The physiologic fluid loss during fasting can be evaluated to be 0.5 mL kg^{-1} h^{-1} because of insensible perspiration and 0.5 mL kg^{-1} h^{-1} because of urine output.[16] In our study, we excluded subject who possibly has excessive fluid loss such as diarrhea, nausea, vomiting, diuretic use and diagnosed diabetes mellitus. So we assumed that insensible loss and urine output were comparable in study population. The third, we measured hemodynamic parameters when volunteers were in supine position as a static status. We did not measure while passive leg raising as dynamic status. The forth, the whole body impedance cardiography is not a gold standard for hemodynamic monitoring. Pulmonary artery thermodilution is gold standard method but it is invasive, causes serious complications and the accuracy is highly dependent on operator technique. As a result, thermodilution are not always reliable. Besides recent studies found good correlation of cardiac output measured by whole body impedance cardiography and pulmonary artery thermodilution.[14,15] This is the first study that determines SVI after overnight fasting in volunteers using whole body impedance cardiography which is non-invasive, safe, practical, reliable and the result is operator independent. The further research with minimized limitations should be study.

Conclusion

Overnight fasting does not clinically affect SVI measured by whole body impedance cardiography in healthy population. Some volunteers have significantly decreased in SVI after overnight fasting and appropriate intravenous fluid therapy probably improves CO.

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