



# The influence of the menstrual cycle on diameter and respiratory collapsibility of inferior vena cava in the population of young, healthy women – preliminary results

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## Abstract

**Introduction:** Echocardiographic assessment of inferior vena cava (IVC) is a part of estimation of right atrial pressure. In young women values exceeding norm are observed. The aim of our study was an echocardiographic assessment of IVC dimension depending on the phase of menstrual cycle among young, healthy women. **Materials and methods:** Female students of Medical University of Gdańsk were enrolled to the study. Each volunteer underwent echocardiographic examination of IVC diameter (d-IVC) and respiratory decrease in dimension in two time points, depending on the phase of menstrual cycle: in the first days of menstruation (Phase M), in the second part of menstrual cycle (Phase L). **Results:** 31 patients completed the study. There was a significant difference between the d-IVC in Phase M and Phase L ( $1.98 \pm 0.25 \text{ cm}$  vs  $1.86 \pm 0.3 \text{ cm}$ ;  $p < 0.05$ ). We did not observe correlation in terms of the inspiratory collapsibility. In the Phase M 77% patients achieved at least 50% decrease in dimension during inspiration comparing to 87% in Phase L ( $p = 0.89$ ). 35% patients had d-IVC exceeding reference values. **Conclusions:** In population of young women diameter of IVC exceeding reference values can be observed. IVC dimension depends on the menstrual cycle.

**Keywords:** echocardiography • menstrual cycle • inferior vena cava

## Citation

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## Introduction

Assessment of the inferior vena cava (IVC) from the subcostal window is part of a routine echocardiographic examination. Measurement of the IVC dimension and collapsibility during inspiration is used to noninvasively estimate right atrial pressure [1]. According to the 2010 American Society of Echocardiography guidelines, IVC diameter  $<2.1$  cm and inspiratory collapse  $>50\%$  correspond with normal right atrial pressure of 0-5 mm Hg [2]. Clinical practice shows that IVC values exceeding norms can be observed as an isolated abnormality in the population of young women.

The influence of female sex hormones on the cardiovascular system is well-acknowledged. Estrogen and progesterone affect cardiac performance and have an important role in atheroprotection. In addition, those hormones have direct impact on vessels through non-genomic mechanisms [3]. Female sex hormones have an effect on body fluid regulation, induce dilatation of the peripheral vessels and decrease venous flow. Furthermore, estrogen affects the synthesis of nitric oxide, while progesterone has diuretic activity. The concentration of female sex hormones depends on cyclic changes and present the lowest level of estrogen and progesterone during firsts days of menstrual cycle [4-5]. There is a lack of studies regarding the influence of those changes on IVC diameter measurement.

Therefore, the aim of our study was an echocardiographic assessment of IVC dimensions depending on the phase of menstrual cycle among young, healthy women.

hormonal contraception, menstrual disorders, cardiovascular and respiratory diseases and competitive sport activity. Each patient had 2 echocardiographic examinations of IVC diameter (d-IVC) and respiratory decrease in dimension in two time points: in the first days of menstruation (Phase M) and in the second part of cycle (Phase L). We estimated Phase L as 14 days before beginning of the next cycle. All examinations were conducted on fasting volunteers. The d-IVC was measured while supine, in the subcostal window and in longitudinal projection, 3 cm from the right atrium outlet (Figure 1). IVC diameter  $<2.1$  cm was considered normal. Additionally, questionnaires concerning data about menstrual cycle characteristics (length, regularity, day of cycle during examination) fluid intake, amount of weekly physical exercise and anthropometrics were collected. Extended echocardiographic study was conducted in each volunteer with IVC abnormalities

## Statistical analysis

All data were tabulated in MS Excel and analyzed using the standard Statistica v.12.0 package (StatSoft, Tulsa Inc., USA). Data with normal distribution (based on Shapiro- Wilk test) were compared with student's t-test. Non-normally distributed variables were compared with non-parametric test (Wilcoxon's test). Chi-squared test was used to analyze the number of cases between dichotomized subgroups. P-value  $<0.05$  was considered statistically significant.

## Materials and methods

Female volunteer students of Medical University of Gdańsk aged 19 to 30 were enrolled into the study. The exclusion criteria included pregnancy, use of

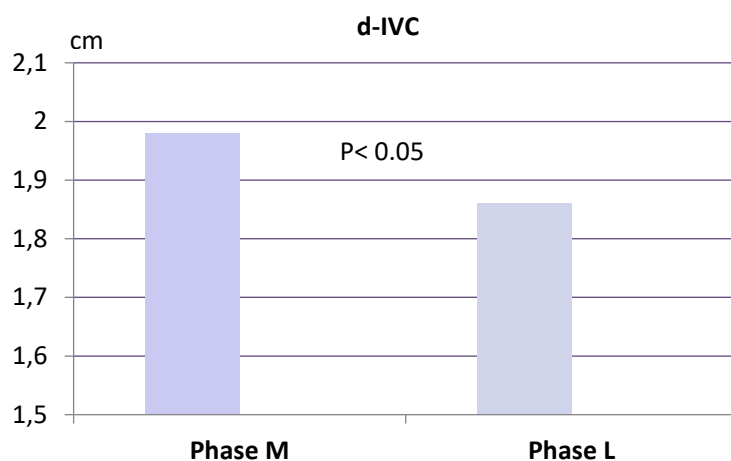


Figure 1. d-IVC depending on the phase of menstrual cycle

## Results

31 volunteers completed the study. Average age was  $23.7 \pm 4.2$  years and BMI  $20.97 \pm 2.4$  kg/m<sup>2</sup>. There was a significant difference between the d-IVC in Phase M and Phase L ( $1.98 \pm 0.25$  cm vs  $1.86 \pm 0.30$  cm, respectively;  $p < 0.05$ ; Figure 1). On the contrary, we did not observe that correlation in terms of the inspiratory collapsibility. In the Phase M 77% patients achieved at least 50% decrease in dimension during inspiration comparing to 87% in Phase L ( $p=0.89$ ). Physical exercise time did not affect a d-IVC ( $1.9 \pm 0.36$  cm for  $>2.5$  hours/week group and  $1.87 \pm 0.23$  cm for  $\leq 2.5$  hours/week group;  $p=0.74$ ). Also, there was no difference in d-IVC due to the amount of fluid intake ( $1.9 \pm 0.42$  cm for  $\geq 2$  liter/day group versus

1.88±0.2cm for <2liter/day group; p=0.8). 35% patients had d-IVC exceeding reference values at least in one examination but full echocardiography did not reveal any other clinically significant abnormalities.

## Discussion

As the availability of the right heart catheterization is limited, echocardiographic methods to assess right atrial pressure including IVC measurement are commonly performed. In several causes (e.g. athletic training, obesity or narrowing of the IVC-right atrium junction) IVC enlargement is observed in the presence of normal right atrial pressure [6]. Furthermore, the accuracy of IVC assessment depends on patient's body shape and also on examiner's technique [7-8]. In clinical practice, isolated IVC dilation may be noticed among patients without any other echocardiographic abnormalities [9].

There are several reports assessing the impact of the menstrual cycle on echocardiographic parameters. Changes in female sex hormones level may affect left ventricular diastolic function without significant influence on the right and left atrial volumes, left ventricular volumes and ejection fraction [10]. Our data show that in the population of young, healthy women, IVC diameter is dependent on the phase of menstrual cycle. First days of menstruation are associated with the larger dimension of IVC, which corresponds with the lowest level of vasodilatory sex hormones (estrogen, progesterone) during that phase [11-12]. We did not

Table 1. Studied group characteristics

<b>Age (years)</b>	23.7 ± 4.2	
<b>BMI (kg/m<sup>2</sup>)</b>	20.97 ± 2.4	
	<b>PHASE M</b>	<b>PHASE L</b>
<b>d-IVC (cm)</b>	1.98 ± 0.25	1.86 ± 0.3
<b>Respiratory collapsibility (%)</b>	65.1 ± 25.3	72.9 ± 25.3

observe similar correlation with IVC respiratory variation and cycle phase. Those discrepancies may arise from the less repeatability of IVC respiratory collapsibility measurements. Accuracy of the IVC diameter assessment during inspiration can be affected by respiratory motion in the position of the IVC [13]. Interestingly, over one third of the studied group had d-IVC exceeding reference values at least in one examination as an isolated abnormality in echocardiography. Therefore, it seems to be justified to extend the diagnostics with a question about menstrual cycle phase.

## Conclusions

Pilot results of our study shows that in the population of young women diameter of inferior vena cava exceeding reference values can be observed frequently. IVC dimension changes correspond with the menstrual cycle phases. However, it does not affect the IVC collapsibility during inspiration. The significance of this observation is not clear and requires further studies on larger groups.

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