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Monitoring intra-abdominal pressure for early detection of preeclampsia among pregnant women

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***Abstract*---**Background: Elevated intra-abdominal pressure (IAP) is commonly present in critically ill patients. Where the trigger mechanism of preeclampsia is related to increase abdominal hypertension. Aim: Monitoring the intra-abdominal pressure for early detection of preeclampsia among pregnant women. Design: A quasi-experiment clinical practice research. Methods: a sample of 60 pregnant women divided into an intervention group included a total of 30 patients diagnosed with preeclampsia and 30 normotensives as a control group. Setting: The study conducted at obstetric ICU and emergency unit, woman's Health Hospital, Upper Egypt. Results: There is a statistically significant difference between intra-abdominal pressure and preeclampsia and its clinical feature. The risk factors' effects on intra-abdominal pressure, such as age and gravidity, have no statistically significant relationship. Conclusions: The study confirms that the range of intra-abdominal pressure in the preeclamptic group significantly higher than the normotensive group, and there is a positive correlation between elevated IAP and preeclamptic complications. Relevance to clinical practice: Applied continuous nursing monitoring of intra-abdominal pressure for all critical patients in the obstetric field is an essential part of nursing care to avoid abdominal compartment syndrome and organ complications.

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***Keywords*---**preeclampsia, intra-abdominal pressure, early detection nursing role, complication.

Introduction

Preeclampsia is an important obstetric disorder that influences multiple organ (renal, hepatic, pulmonary, cerebral and placental) systems and complicates 3–7% of pregnancies worldwide, and has a high rate of recurrence in subsequent pregnancies (Marshalov, et al, 2017 and Surapaneni, et al, 2015). Intra-abdominal hypertension (IAH) has damaging effects on hemodynamics, respiratory and renal function and may ultimately lead to various-organ failure so it is stimulate mechanism of preeclampsia (Trikudanathan and Vege, 2014 and Sun, et al, 2015).

The hypothesis explains that preeclampsia elicit by the intra-abdominal hypertension is a new hypothesis proposed by Sawchuck, which established on the basic physical mechanics on the pressure rule (Sawchuck and Whitman, 2014). In any pregnant women due to increasing size of uterus and fetus significantly changes of abdominal cavity that leads to increase in the intra-abdominal hypertension. So should be relevant to apply a management for the elevated intra-abdominal hypertension to reduce it. Hence it is a serious factor that intensifies to organ failure (Malbrain, et al, 2015).

Recent hypothesis support that elevated intra-abdominal pressure (IAP) in pregnancy, causes pre-eclampsia, because an increase in IAP compresses the venous system and decreases the venous flow. This further leads to edema of lower parts, fetal and placental ischemia. Placental ischemia results in decreased placental growth factors and can affect fetal growth. Restricted portal and splenic venous outflow results in inadequate blood supply to an organ or part “necrosis”, elevated liver transaminases and hypersplenism. Evident upgrading that IAP lead to IAH during pregnancy (IAH-P) and dangerous consequences on all organs of the body (Malbrain, et al, 2013, Sawchuck, 2014)

At the usual times the intra-abdominal pressure (IAP) in normal status is usually below 4 mmHg and even in most obese patients it does not exceed 8 mmHg. Highly increase in IAP occurs when the abdomen becomes subject to elevated pressure. Continuing or recurrent increase of IAP more than 12 mmHg, called intra-abdominal hypertension (IAH) which considered an important mortality risk factor in the intensive care unit (ICU). When the management is neglected, IAH has a series dangerous of outcomes, complicated to the abdominal compartment syndrome (ACS) which occur when IAP increases above 20 mmHg, and develops a failure of the body multisystem organs and death (Mohmand and Goldfarb, 2011 & Armaly and Abass, 2014)

Intra-abdominal hypertension (IAH) occurs in 20%-40% of intensive care patients’ outcome. IAH is refer as intra-abdominal pressure (IAP) when measuring is12 mmHg or more, whereas normal IAP is in the range of 0 to 11 mmHg, and IAH is refer as the abnormal steady-state pressure in the abdominal cavity characterized by a continuing or recurrent raise in IAP to 12 mmHg, and graded into four levels.

Grade I: 12–15 mmHg; Grade II: 16–20 mmHg; Grade III: 21–25 mmHg; and grade above 25 mmHg, respectively. The extreme serious form is abdominal compartment syndrome (ACS), refer as continuing of IAP ≥ 20 mmHg (with or without an abdominal perfusion pressure (APP) of ≤ 60 mmHg) in combination with failure of body organs and lead to life-threatening (Kirkpatrick, et al, 2013 & American College of Obstetricians and Gynecologists 2013 and Maddison, 2016).

The life-threatening form of IAP is (abdominal compartment syndrome) which could be prevented by early awareness and detection of IAH which need a close nursing control through frequent monitoring for patients with increased risk of IAP elevation or aggravation. IAP measures are often performed and with a great deal by the bedside nurse or is prompted by critical care nurses. Critical care nurses (CCN) play an important role in constant observation and recognition of subtle and dynamic changes in the status of critically ill patients in the ICU. Therefore, a CCN must have a good understanding of the definitions of IAH and ACS and their clinical significance to promptly recognize and appropriately manage or control these cases as an essential member of the ICU group (Newcombe et al., 2012).

Significance of the study

Monitoring IAP and APP for signs of ACS has become an inexpensive and useful diagnostics tool for identifying complications. An integrated approach to screening and monitoring for IAH may improve patient outcomes and decrease hospital costs. Due to the high incidence of IAH and ACS, it is essential for critical care nurses to regularly monitor IAP and APP. Nurses should provide a standard of care in managing patients who are at risk of IAH and ACS from prehospital, emergency, operating theatre and intensive care areas (Hunt, et al. 2014). Therefore, Pre-eclampsia is a major and essential reason for increasing maternal and perinatal death rate and morbidity, contributing to about 18% of all maternal mortality at worldwide (70,000 cases die annually), most of women from low- and middle-income countries (LMIC) (Abalos, et al. 2014).

World health organization, records in 2014 confirmed that, the pregnancy induced hypertension diseases accounts for 14.9% of the causes of maternal mortality in Egypt. However, there are few studies in Egypt concerning the importance of monitoring IAH among pre-eclamptic patients. These studies discussed that monitoring enhances the early proof of identity and treatment of IAP which may prevent the development of ACS and enhance prognosis in critically ill patient and decrease morbidity and mortality. (Mahran & Abbas 2017; Mahran, et al 2018). So, this study aimed to monitor the relationship between the intra- abdominal pressure preeclampsia. Through the following objectives:

- Compare intra- abdominal pressure in group with preeclampsia and normotensive group.
- Assess relationship between intra-abdominal pressure and clinical features of preeclampsia include severity as (HELLP syndrome and imminent eclampsia)
- Determine the risk factors that may affect intra-abdominal pressure during pregnancy.

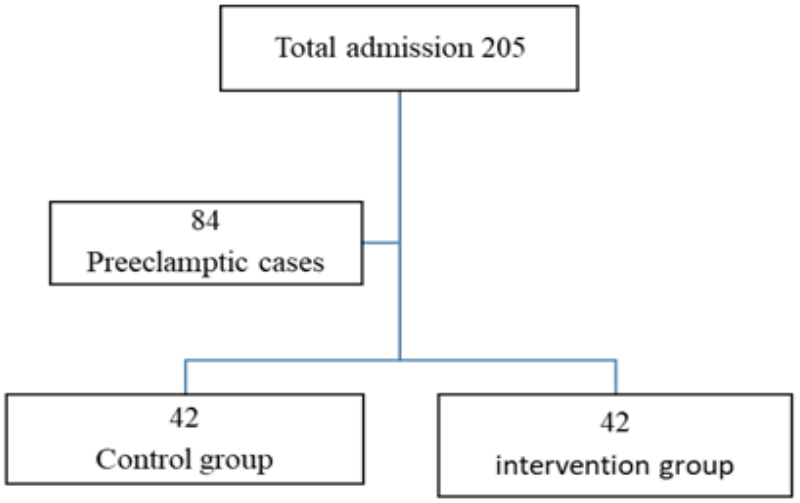
Hypothesis

H1. Monitoring of abdominal pressure will detect preeclampsia earlier
H2. There is a relationship between intra-abdominal pressure and clinical features of preeclampsia.

Materials and Methods

1. Research design: The study used an observational design. The researcher measured intra-abdominal pressure IAP at admission before starting routine nursing care for preeclampsia and measured the second IAP after 24 hours from the beginning of management for the intervention group. Then the observation was recorded by the researcher.
2. Study setting: The study was conducted at the obstetric intensive care unit for the preeclamptic patient group and emergency unit for an elective cesarean section to another group at Woman's Health Hospital (WHH), which is the largest teaching hospital in XXX and has several specialists' hospitals. WHH is a tertiary referral center with around 13,000 deliveries per year, and all maternity services and the intensive care unit branch are affiliated with it. Additionally, a general ICU can be used for case admission in the case of total capacity at WHH.
3. Study subjects: The participants were recruited based on the inclusion criteria: preeclamptic women, 34 weeks of gestation, applied a urinary catheter, confirmed to elective cesarean section, body weight within the normal range, and accepted to participate in the study. Excluded cases based on the following criteria: who have recent bladder surgery, age under 18 years old, morbidly obese (main factors elevated IAP), multiple pregnancies, polyhydramnios, fetal abnormalities, other diseases affect IAP such as diabetes tend to macrocosmic baby, chronic hypertension, nephritic syndrome, and abdominal masses, growth restriction and severe prematurity and any woman refused to participate in the study.
4. Sample size: Epi-Info 7.2.0.1 was used for the sample size equation to estimate a single proportion. The total number of pregnant women admitted to ICU during the data collection period was 205 women 84 out of them were preeclamptic with precision levels of 5%, where the confidence level is 95% and $p < 0.05$. The total participants were divided into the intervention group included 42 patients diagnosed with preeclampsia, and the control group included 42 normotensive pregnant women (figure 1.)

Figure 1. flowchart of the recruited sample.



Tools of the study: Three tools used for this study: These tools were developed and used by the researcher in this study after reviewing the related literature (World Society of Abdominal Compartment Syndrome (WSACS) Kirkpatrick, et al 2013; Fuchs, et al 2013; Hunt L., et al, 2017).

A tool I: A sociodemographic questionnaire: This tool is composed of two parts:

- Part I: included personal data such as age, level of education, occupation, and residence.
- Part II: included clinical data that had obstetric history, medical history, medical diagnosis, clinical features of preeclampsia as or complication HELLP syndrome, eminent eclampsia, …Etc., clinical measures for blood pressure and proteinuria.

Tool II: "IAP Intervention" to assess IAP using a urinary catheter. This tool is composed of Intra-abdominal pressure grading in which the normal IAP (0-11) is class 0; intra-abdominal hypertension is classified into four categories; class I: IAP from 12 to 15 mmHg, class II: IAP from 16 to 20 mmHg, class III: IAP from 21 to 25 mmHg, and class IV: IAP more than 25 mmHg.

Tool III: Patient evaluation Instrument tool: This instrument was developed to evaluate the patient's outcomes as complications or mortality. The tool's content validity was done by reviewing the questionnaire content by five experts of critical care nursing and obstetrics and gynecologic nursing at the college of nursing, Assiut University. The researcher used the SPSS program to assess the reliability of the study's tools by measuring the internal consistency using Cronbach's alpha method. (α =0.89) to the study tool.

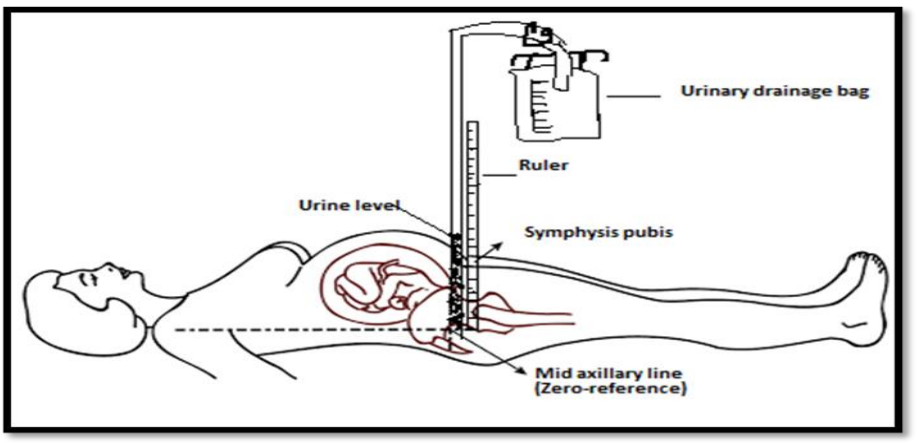
Data collection

The researcher collected the data from admitted patients in Woman's Health ICU (intervention group) according to the inclusion criteria and recorded it in the questionnaire. The monitoring of the second IAP measure continued after 24 hours from the beginning of management for this group. On the other hand, in the Emergency unit (the control group), the researcher followed the same steps of measuring IAP at admission and before the cesarean section. Then as soon as the participants were transferred to the operating room, the researcher measured the 2nd IAP after the first 24 hours of the cesarean section and until IAP returned to typical values.

Steps for measuring intra-abdominal pressure: The researcher explained the purpose and benefits of the study, and written consent information was taken from the participated women. Confidentiality and anonymity were assured by coding the participants' names and hospital records. The IAP data collection and measuring took about 40 minutes for each participant. The IAP was measured by placing the patients in the supine position, where a transurethral urinary Foley catheter was inserted into the bladder and then emptied under the aseptic technique.

The symphysis pubis was considered the zero-reference line for the CVP measuring tape. The researcher injected 25 ml of saline (warm, sterile isotonic sodium chloride solution into the bladder via syringe 50cc, and after the system was filled with a solution, the urinary collecting tube was clamped until connected to the bladder tube by an IV infusion set placed on the CVP measuring instrument which fixed in the vertical position at the hip bone. After a fixation period of 30–60 seconds and at the end of respiratory expiration to allow for pressure stabilization and balance has occurred. The clamp was removed, and the amount of saline measured IAP used was subtracted from the patient's urinary output to the CVP measuring instrument and held until saline was fixed on the CVP measuring device, which refers to the IAP of women then recorded (Figure 1).

Figure (2) Staelens, et al. (2014), modification (adding of the ruler and urinary bag labels) by H. F



Ethical consideration

Before implementing the study, the proposal obtained the IRB approval (No. 123/2020) to conduct the study. In addition, the required consent approval was obtained from the manager of the woman's Health Hospital to carry out the analysis. Also, the researcher got the written informed consent from the study participants after explaining the aim of the study and procedure. The confidentiality and anonymity of participants are maintained. Also, the participant assured their voluntary participation, or not without effect on receiving all the services they usually do.

Statistical management

The statistical software package for the social sciences (SPSS) version 20 Program is used for data analysis. Data were presented using descriptive statistics in the form of frequencies and percentages. Also, Mean and standard deviations were calculated. The correlation between variables used independent T-test, paired sample t-Test, Chi-square, and curve estimation regression analysis. Statistical significance is considered at P-value ≤ 0.05.

Results and Discussions

- Table 1. According to their age, participants' data ranged from 18 to 42 years, with the mean maternal age of intervention and control group being (26.2 ± 5.95 & 27.7 ± 6.08), respectively. Most women in both groups were housewives (92.9% & 85.7%). For residence (73.3% & 60.0) respectively from rural. About half of women have secondary education in both groups (57.1% & 50.0%).
- Table 2. Reveals that half of the women were primigravida and the other half were multigravida and grand multigravida with a mean of (2.96 ± 2.64) in the intervention group, while most women were in the control group multigravida and grand multigravida with a mean of (4.03 ± 1.99). Regarding obstetric complications of preeclampsia (clinical features of preeclampsia), it found that about one-third of preeclamptic women complained of imminent eclampsia and HELLP syndrome, and the mean (SD) of gestational weeks between both groups was (33.9 ± 4.2 &37.1 ± 1.5) with no significant difference between both groups related to body weight.
- Table 3. The nurses who measured the first IAP in both groups showed that less than one-third of the control group had a slight elevation (28.6%) in grade 1 and returned to standard measures after labor. In comparison with the intervention group, about two-fifths and more than one-third of the group were in grades 2 and 3, respectively. After management, more than one-third (35.7%) of women were still in grade 1, with significant differences in both first and second IAP measures between the two groups at (P-value = 0.001**).
- Figure 3. Display the relationship between intervention and the control group in the first and second IAP measures. The mean is (16.31 ± 3.20 & 10.20 ± 2.15) respectively in first measures and (10.40 ± 2.74 6.81 ± 1.40) in the second measures with a statistically significant difference (P-value = 0.001**).

- Figure 4. Relationship between IAP and obstetric complications of preeclampsia (a clinical feature of preeclampsia) in the intervention group. Illustrates the relationship between IAP grades and obstetric complications (HELLP syndrome and imminent eclampsia) among participants, and the finding reveals that high grade of IAP (grade 3 and 4) complicated abdominal compartment syndrome (ACP).
- Figure 5. Displays the risk factors that may affect IAP increasing level in curve estimation regression, reflecting a negative relationship between age and gravidity as risk factors increase the IAP in pregnant women in both groups with P-value as above.

Table (1): Distribution of study participants according to their data

Personal data	Intervention group (n= 42)		Control group (n= 42)		P-value
	No.	%	No.	%	
Age/ years (Mean ± SD)	26.2 ± 5.95		27.7 ± 6.08		0.317
<20	11	26.2	7	16.7	0.612
20-30	20	47.6	24	57.1	
>30	11	26.2	11	26.2	
Educational level					0.960
Illiterate & read and write	10	23.8	11	26.2	
Basic education	6	14.3	7	16.7	
Secondary school	24	57.1	21	50.0	
University	2	4.8	3	7.1	
Residence					0.273
Urban area	11	26.2	17	40.5	
Rural area	31	73.8	25	59.5	
Occupation					0.389
Housewife	39	92.9	36	85.7	
Employee	3	7.1	6	14.3	

Table (2): Relationship between participant maternal clinical data and their clinical features of preeclampsia

Maternal data	Intervention group (n= 42)		Control group (n= 42)		P-value
	No.	%	No.	%	
Number of gravidities (Mean ± SD)	2.96 ± 2.64		4.03 ± 1.99		0.83
Primigravida	21	50.0	6	14.3	0.009*
Multigravida	9	21.4	17	42.5	
Grandmulti	12	28.6	19	45.2	
Obstetric Complications:					
No	0	0.0	42	100	

Severe preeclampsia	28	66.7	0	0.0	0.001**
Imminent eclampsia	10	23.8	0	0.0	
HELLP syndrome	4	9.5	0	0.0	
Gestational age/ weeks	33.9 ± 4.2		37.1 ± 1.5		
34-37	27	64.3	22	52.4	
>37	15	35.7	20	47.6	0.003*
Bodyweight	74.90 ± 5.32		73.66 ± 6.47		0.424

Table (3): Comparison of the study groups according to the maternal outcomes grading of IAP measurements

Maternal outcomes	Intervention group (n= 42)		Control group (n= 42)		P-value
	No.	%	No.	%	
Maternal blood pressure:					
Normal	0	0.0	42	100.0	0.001*
150/100	9	21.4	0	0.0	
160/100 -170/110	22	52.4	0	0.0	
> 170/110	11	26.2	0	0.0	
Maternal proteinuria:					
Negative	2	4.8	42	100.0	0.001*
3+	10	23.8	0	0.0	
4+	30	71.4	0	0.0	
First IAP grade (Mean ± SD)	16.31 ± 3.20		10.20 ± 2.15		0.001**
Normal grade < 12 mm Hg	2	4.2	30	71.4	0.001**
Grade 1:12-15 mm Hg	18	42.9	12	28.6	
Grade 2:16-20 mm Hg	15	35.7	0	0.0	
Grade 3:21-25 mm Hg	7	16.7	0	0.0	
Grade 4:> 25 mm Hg	0	0.0	0	0.0	
Second IAP grading (Mean ±SD)	10.40 ± 2.74		6.81 ± 1.40		0.001**
Normal grade < 12 mmhg	25	59.5	42	100	0.001**
Grade 1:12-15 mmhg	15	35.7	0	0.0	
Grade 2:16-20 mmHg	2	4.8	0	0.0	
Grade 3:21-25 mmhg	0	0.0	0	0.0	
Grade 4:> 25 mmhg	0	0.0	0	0.0	

Figure (3): Relationship between mean (SD) among intervention and control groups

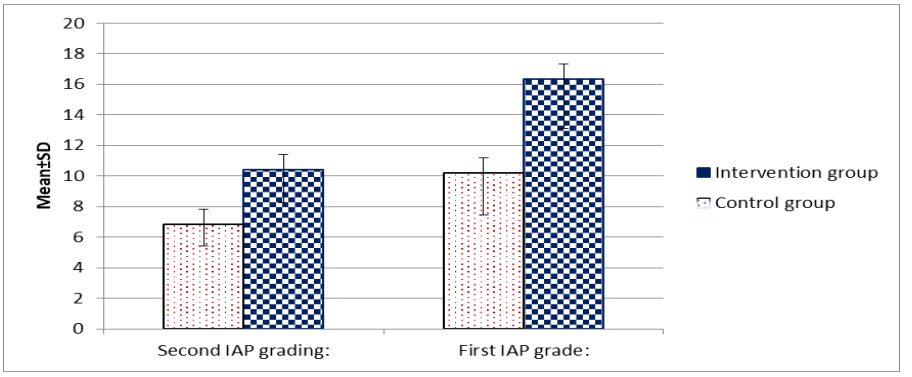


Figure (4): Relationship between IAP grades and obstetric complications of preeclampsia (a clinical feature of preeclampsia) in the intervention group

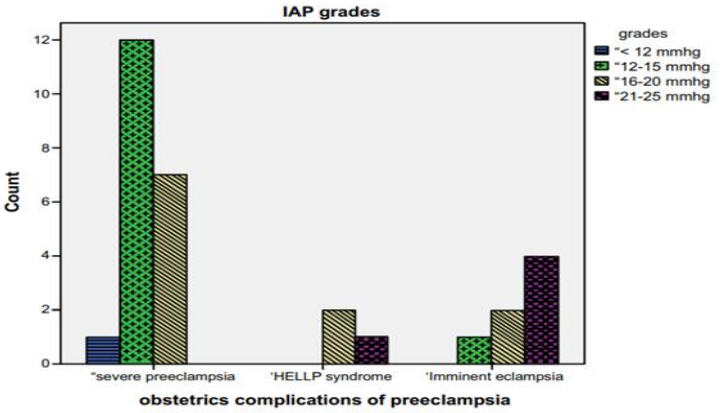
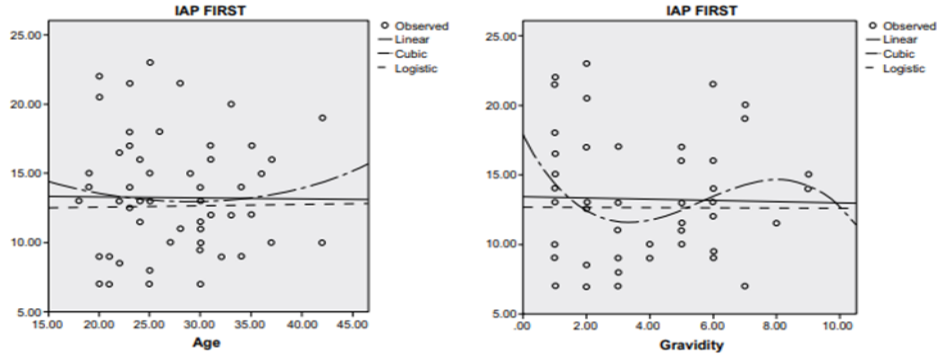


Figure (5): Curve estimation regression between first IAP measures in both groups and its relation to age and gravidity.



(P-value=0.936) (P-value =0.836)

Discussion

Preeclamptic patients have higher intra-abdominal pressure levels than normal pregnant women. Increased abdominal pressure may have a role in clinical manifestations or pathogenesis of preeclampsia because elevated abdominal pressure may cause placental hypo-perfusion and increase oxidative stress in pregnant women of endothelial dysfunction, increased capillary leakage, and increased third space volume (Mesut., et al, 2017). This study assessed the relationship between IAP and preeclampsia and compared it with the normotensive patient (elective cesarean section). The current study's findings revealed a statistically significant relationship between elevated intra-abdominal pressure and preeclampsia compared with the normotensive group, evident by (P-Value = 0.001). In harmony with a study by Sigrid, 2016, these findings hypothesized that sustained increases in intra-abdominal pressure (IAP) above 12 mmHg might be associated with preeclampsia. It limited the venous return, so measuring IAP could be useful in prenatal care. Similarly, the findings confirmed by pre-eclampsia study Marshalov, et al., (2016) in which the data was a large representative sample of "more than six hundred" patients at various stages of gestation and demonstrated that an increase in intra-abdominal pressure at 20-24 weeks of pregnancy preceded the development of preeclampsia with significantly as higher than regular patients ($p < 0.001$) and the rate of its elevation considered as an essential part in the development of preeclampsia.

In the same line, a study conducted by Mesut and colleagues (2017) on a similar sample size to our study (35 preeclamptic versus 35 normotensives) of pregnant women at the university hospital of Trabzon, Turkey, to measure abdominal pressure and placental levels in patients with preeclampsia and reported that the majority of women with abdominal hypertension identified as preeclamptic patients. Hence the finding of the current study attested to the recent hypothesis Sawchuck and Whitman, 2014, which established the basal physical mechanics/technique on the pressure rule and confirmed intra-abdominal hypertension-induced preeclampsia.

Though, these findings are inconsistent with the Malbrain and colleagues, 2015 study, which revealed that intra-abdominal hypertension is expected in any pregnant woman who has significant changes in the abdominal cavity due to increasing the size of the uterus. Similarly, Chun and colleagues, (2012) measured the intra-abdominal pressure in pregnancy and innate that pregnant patients were uniquely at risk of IAH/ACS due to IAP elevation in response to the hormonal influences during pregnancy. This difference is due to the nature of our study's focus points. Hence, our study focused only on the relationship between IAP elevation and induced preeclampsia without the study of other pregnancy co-factors such as uterine pressure or hormonal effects during pregnancy.

The current data almost establishes this finding. When comparing the pre-eclamptic group or critically ill group with the regular group, only one-third of the regular group had minimal elevated IAP during the antepartum period and returned to standard level postpartum. In line with studies Staelens and colleagues, 2014 and Mesut, et al, 2017, the intra-Abdominal Pressure measurements in terms of Pregnancy and Postpartum confirmed that IAP

significantly decreases to average values after delivery. However, current results are aside from the most previous studies (Mesut, et al., 2017, Wiwanitkit, 2017, Marshaloy, et al., 2017, Smit, et al., 2016, Fuchs, et al., 2013, Al-Khan, et al., 2011, Abdel-Razeq, et al, 2010). In which preeclampsia is considered a critically ill condition in pregnant women correlated to the increased IAP and reaches the abdominal compartment syndrome (ACS) by an elevated IAP than 20 mmHg, in the context of the symptomatic failure of body organs or dysfunction and is correlating to reported mortality ranging 50-100%. So, control and management of the IAP have become a vital indicator of hemodynamic stabilization in intensive care units. Pregnancy is a specific condition where multiple factors such as obesity, pre-eclampsia, or postpartum hemorrhage may lead to the over-diagnosis of ACS.

The current study declared a positive correlation between IAP elevation and obstetric complications such as abdominal compartment syndrome, which occurred in the seven cases of imminent eclampsia, and three cases of HELP syndrome in the intervention group. In line with many studies (Sun, et al, 2015, Trikudanathan , et al, 2014, Al-Khan , et al, 2011), these findings concluded that increasing intra-abdominal pressure (IAP) usually exists in emergent ill patients. Elevated intra-abdominal pressure eventually leads to respiratory, renal function, or multi-body organ failure. The mortality of patients with IAH is higher than those without IAH, so surveillance and early management of IAH are increasingly implemented in these IAH-prone patients. Interestingly, our findings showed that age and gravidity have a negative relation to IAP, which are not considered risk factors for elevated IAP in the same line with Spanish study (Sigrid, 2016), which reported that nulliparous women had slightly higher intravaginal pressure (IVP) and significantly higher bladder pressures compared to multiparous women. It suggested that IAP, and accordingly, the risk for preeclampsia, may be elevated in nulliparous women since their abdomen has not previously stretched.

Due to the small sample size and until now, no other studies have been found comparing IAP between nulliparous- and multiparous women. Consistently, Marshalov , (2017) Russian study on more than four hundred patients confirmed that age and gravidity are not significant with intra-abdominal pressure, only increase in body mass index effect on IAP. At the end of the discussion, the current findings of a study by Arora, (2020) match with the results of the Indian study that confirmed a higher IAP in preeclamptics. Moreover, there may be merit in further studies analyzing the effect on the severity of the disease and its manifestations Sugerman, (2011). The hypnosis that confirmed the preeclampsia is a venous disease secondary to increased intra-abdominal pressure and plays a central role in initiating the multisystem cascade of diminished perfusion and inflammation associated with the various clinical manifestations of preeclampsia and all critically ill obstetrical/gynecologic patients should undergo vigilant IAP monitoring.

Conclusion

In conclusion, the study shed light on a new role for maternity and critical care nurses who succeeded in measuring IAP and confirms that the range of IAP in the preeclamptic group is significantly higher than in the normotensive group, and

there is a positive correlation with elevated IAP and preeclamptic features or complications. Therefore, monitoring and measuring the relationship between IAP values and preeclampsia are critical in detecting organ dysfunction/failure when abdominal compartment syndrome occurs. Consequently, the prevention of ACS can be achieved quickly.

Relevance to clinical practice and recommendation

- The application of the continuous nursing monitoring of IAP among critical patients in the obstetric field is an essential part of nursing care. Blood pressure measures are evidence for obstetricians' management to avoid abdominal compartment syndrome and more organ complications.
- Further studies are needed to focus on the other co-factors during pregnancy, such as the mechanical pressure of the gravid uterus and pregnancy hormonal effects.

Acknowledgments Declared: none.

Limitation of the study

The small sample size of the study was due to limited financial support.

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