A Comparison between the effects of crystalloids and colloids on lung ultrasound score in preeclamptic patients: A Randomized double blinded controlled Trial

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Abstract

Background: Ultrasound is now widely used in many medical specialties, being safe tool for both the parturient and the baby. There is no epidemiological evidence to support the choice of colloidal solutions over crystalloids and it is not clear that colloidal solutions would be more effective and less likely to cause harm than crystalloids in preeclamptic patients **Aim:** Comparison between the effects of crystalloids and colloids on the lung ultrasound score in preeclampsic patients during cesarean delivery. **Patients and methods:** Forty-four pre-eclampsia patients were enrolled in the study at Kasr Al-Ainy Hospital, Department of Obstetrics and Gynecology, after taking a written consent to participate. Medical history and vital signs were recorded, and 500 milliliters of crystalloid or colloid according to the blind randomization was given to both groups to compare fluids effect on lung ultrasound score, thoracic fluid content and cardiac output were measured at the beginning and after thirty minutes by ultrasound and electrocardiometry. **Results:** LUS shows that's there no effective difference between the 2 groups of fluids in affecting the lung congestion degree measured by the lung ultrasound score. Thoracic fluid content comparison between the two groups showed non- statistical difference between the groups. The measurement of the TFC after 30 minutes showing no effective difference between the 2 groups in increasing congestion and the lung fluid content measured by icon cardiometry. Both fluids could maintain proper perfusing COP that maintained blood pressure and perfusion without congestion **Conclusion:** We recommend conducting more studies on bigger number of patient and may be with applying bigger intravenous volume as we started a step in identifying the proper intravenous fluid in preeclampsia cases.

Keywords: crystalloids, colloids, lung ultrasound score, preeclamptic patients

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Introduction

Hypertensive disorders are the most common complications of pregnancy. They occur in 6-8% of pregnancies and account for approximately 15% of maternal deaths in the United States Pre-eclampsia is a pregnancy-specific syndrome of unknown etiology that is defined as systolic blood pressure (SBP) > 140 mmHg and/or diastolic blood pressure (DBP) > 90 mmHg presenting after 20 weeks of gestation with significant proteinuria **(1).**

Because patients with pre-eclampsia may have significant intravascular volume deficit and reduced uteroplacental perfusion, it is prudent to administer fluids before any anesthetic interventions. **(2)** however it may increase their risk of developing pulmonary oedema **(3).**

Colloids and crystalloids are two types of fluids that are used for fluid replacement, as volume expanders. Crystalloids are low-cost salt solutions (e.g. saline) with small molecules, which can move around easily when injected into the body. Colloids can be man-made (e.g. starches, dextrans, or gelatins), or naturally occurring (e.g. albumin or fresh frozen plasma (FFP)), and have bigger molecules, so stay in the blood for longer before passing to other parts of the body.**(4).**

Women with pre-eclampsia lose protein through renal excretion and may also extravasate protein into the interstitial tissues, oncotic pressure falls because of this and the tendency to lose fluid from the intravascular space is partially determined by this mechanism. Filling the vascular space with fluid will lead to increasing peripheral oedema. Colloids will remain in the vascular compartment for longer periods than crystalloids although the loss of colloid into the interstitial tissues will also contribute to the development of oedema. Changes in capillary permeability will have an independent influence**.(5).**

Ultrasound is now widely used in many medical specialties, being safe tool for both the parturient and the baby, ultrasound is basically used by the obstetricians in pregnant females for diagnosis of fetal presentation, placental position, fetal organs, amount of liquor and in some interventions amniocentesis. In the last 15 years, a new imaging application of sonography has emerged in the clinical arena: lung ultrasound (LUS), it can give valuable data in diagnosing and management of pneumothorax, pleural effusion, lung consolidation and pulmonary congestion. **(6).**

The electrical cardiometry can be used to measure and calculate hemodynamic parameters such as cardiac output, stroke volume, systemic vascular resistance, ICON (index of contractility), and thoracic fluid content.**(7).**

In general, there is no epidemiological evidence to support the choice of colloidal solutions over crystalloids and it is not clear that colloidal solutions would be more effective and less likely to cause harm than crystalloids in preeclamptic patients. A meta-analysis was done to investigate crystalloid versus colloid resuscitation in critically ill patients however pregnant women and neonates were excluded. **(8)** Consequently, there is inadequate evidence supporting one view or another in the management of pre-eclampsia.

We aimed at this work Comparison between the effects of crystalloids and colloids on the lung ultrasound score in preeclampsic patients during cesarean delivery.

Patients and Methods:

This double blinded randomized controlled study was conducted in obstetric theatre, Cairo University Hospital from December 2020 to November 2021 after institutional ethics committee approval and clinical trail registration and patients were recruited after obtaining written informed consent.

All preeclamptic Pregnant cases gestational age >32 weeks, Singleton pregnancy and age above 18 years were included.

Patients with associated severe cardiac disease or renal failure, HELLP (hemolysis, elevated liver enzymes, low platelets), eclampsia, difficult anatomical access or previous lung pathology hindering lung ultrasound score and gestational age less than 32 weeks were excluded

All patients were subjected to proper preanesthetic check up full monitors were applied to all patients (ECG, non invasive blood pressure, pulse oximetry, and cardiometry), a baseline readings of heart rate, blood pressure and cardiac output were recorded, baseline lung Ultrasound using (DP-2200-mindray) was recorded. Alveolo-interstitial syndrome was assessed by the measurement of multiple B-lines or "comet tails." **(6 & 7)**

An iv 18-gauge cannula was inserted, using spinal needle gauge 25 and total volume for spinal anesthesia was 2ml bupivacaine (10mg) and 0.5ml (25mic) fentanyl

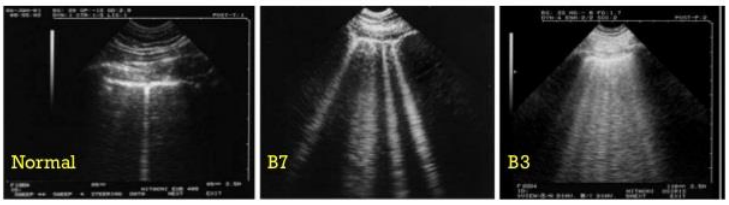
According to complete blinded randomization sequence patients were divided into two groups Group R received 500 ml of ringer acetate over 30 minutes and group V received 500 ml of hydroxyethyl starch (voluven) over 30 minutes

Ultrasonography videos were recorded, stored, and analyzed off-line. The average values during three consecutive measures were considered for the analysis.

B-lines are defined as discrete laser-like vertical hyperechoic reverberation artifacts that arise from the pleural line extend to the bottom of the screen without fading and move synchronously with lung sliding. **(6 & 7)**

Interstitial edema was seen by lung ultrasound as multiple B-lines 7 mm apart. **(6 & 7)**

However, **alveolar edema** appears as "ground-glass" areas and was seen as B-lines 3 mm or less apart. **(6 & 7)**



Lichtenstein DA, et al. Chest 2009;136:1014-1020

Figure 1: Differences between normal lung ultrasound, interstitial edema (B7) and alveolar edema (B3)

The lung ultrasound score (LUS) was obtained by scanning 12-rib interspaces with the probe longitudinally applied perpendicular to the wall. Each hemithorax was divided in six areas: two anterior areas, two lateral areas, and two posterior areas.

• The anterior chest wall (zone 1) was delineated from the parasternal to the anterior axillary line and was divided into upper and lower halves, from the clavicle to the third intercostal space and from the third to the diaphragm.

• The lateral area (zone 2) was delineated from the anterior to the posterior axillary line and was divided into upper and basal halves.

• The posterior area (zone 3) was considered as the zone beyond the posterior axillary line. **(7)**

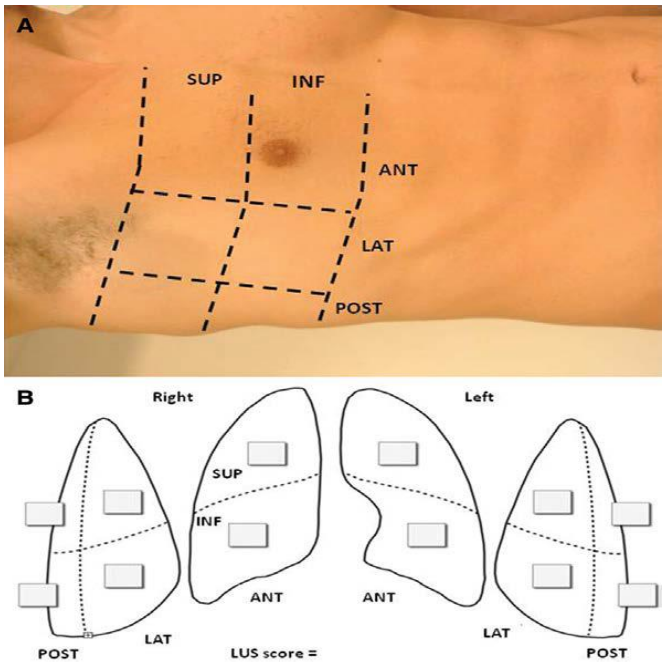


Figure 2: The Lung Ultrasound Score

The sum of B-lines found on each scanning site yields a score from 0 to 36:

- **0:** Absence
- **1:** B7 lines: Multiple B-lines 7 mm apart
- **2:** B3 lines: Multiple B-lines 3 mm apart
- **3:** Consolidation

Thoracic fluid content and cardiac output will be measured by cardiometry using (Icon non invasive electric cardiometry) it measures thoracic electrical bioimpedance utilizing four adhesive surface ECG electrodes placed on the left side of the neck and the left side of the thorax. The measurements were stored and analyzed off-line. The average values during three consecutive measures were considered for the analysis. **(9 & 10)**

Lung ultrasound score, thoracic fluid content and cardiac output measurements will be repeated after 30 minutes amount of fluid will be guided by cardiac output changes on cardiometry, restoration of blood pressure and dose of vasopressor needed we will stop infusing fluids if any sign of congestion in form of respiratory distress, crepitations and desaturation appear

The study personnel will be blinded to the results, the doctor responsible for performing lung ultrasound and cardiometry will not be informed about the type of the fluid given and another doctor is responsible for giving the fluids according to the computer-based randomization in closed envelopes.

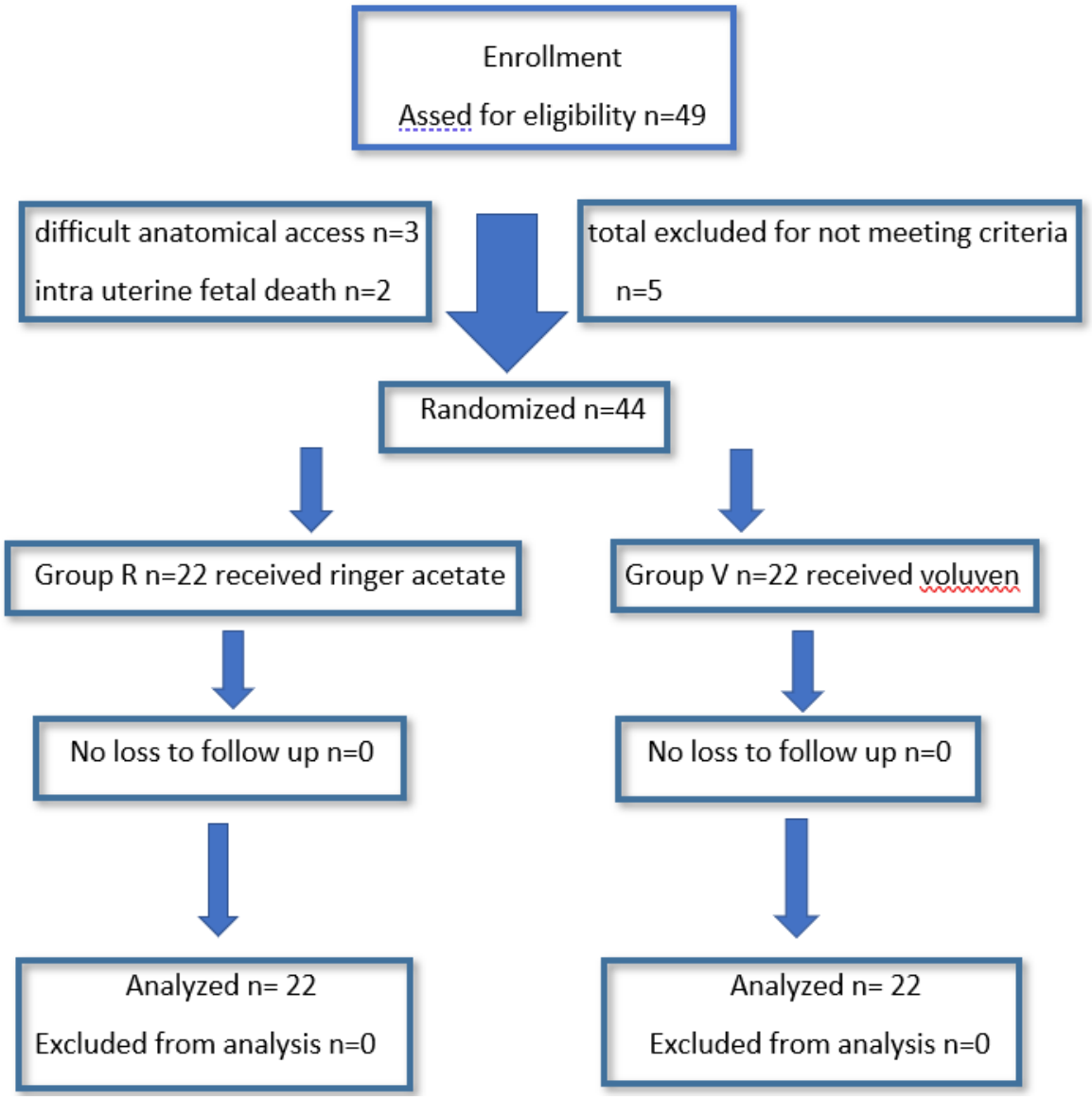
Study outcomes the primary outcome the lung ultrasound score

The secondary outcomes are Cardiac output, Thoracic fluid content, Urine output, Diuretic dose if needed, Oxygen supplementation

Statistical Analysis Power analysis was performed using G power program on the level of LUS using student t test because it was the main outcome variable in the present study, all statistical analysis is performed using SPSS v15. P value ≤ 0.05 is considered statistically significant we performed pilot study on 10 patients which revealed mean (SD) of LUS in ringer acetate and voluven group was 10+/-1.3 and 8+/-2 respectively and for a power of 0.95 and an alpha error of 0.05, a minimum sample size of 20 patients for each group was calculated. A sample size was increased to 22 for each group to compensate for drop out.

Results

The flow chart of the patients through the study followed the current flow diagram as presented.



Baseline demographic data is shown table (1) Table 1:Baseline demographic data represented in mean and standard deviation

	Group R		Group V		
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**P value**
Age	28.73	5.17	28.68	6.51	0.980
Weight	86.45	11.88	83.95	8.64	0.429
Height	160.64	5.91	157.36	5.02	0.054
gest age	38.18	1.01	38.18	1.14	1.000

Table 2 ultrasound score between the 2 groups before and after the spinal by 30 minutes median and range

	Group R			Group V			
	Median	**Minimum**	**Maximum**	**Median**	**Minimum**	**Maximum**	**P value**
U/S 0	3.00	2.00	17.00	2.00	2.00	20.00	0.421
U/S 30	3.00	2.00	13.00	3.00	2.00	18.00	0.704

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The graph representation of LUS shows that's there no effective difference between the 2 groups of fluids in affecting the lung congestion degree measured by the lung ultrasound score

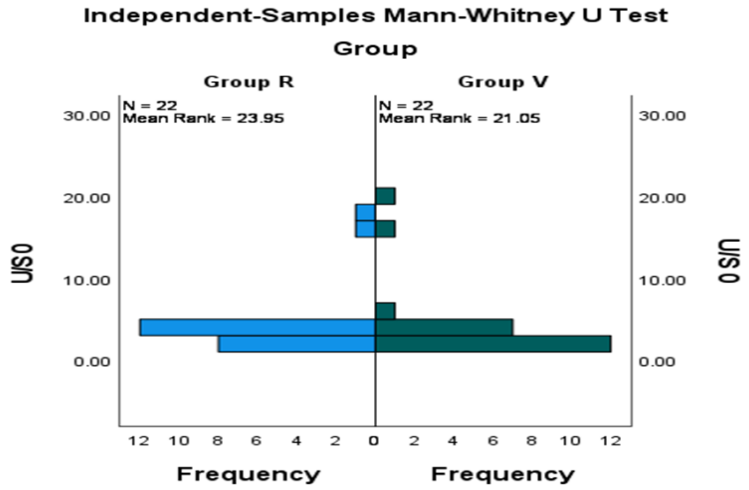

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Figure 3: Baseline ultrasound score in the 2 groups

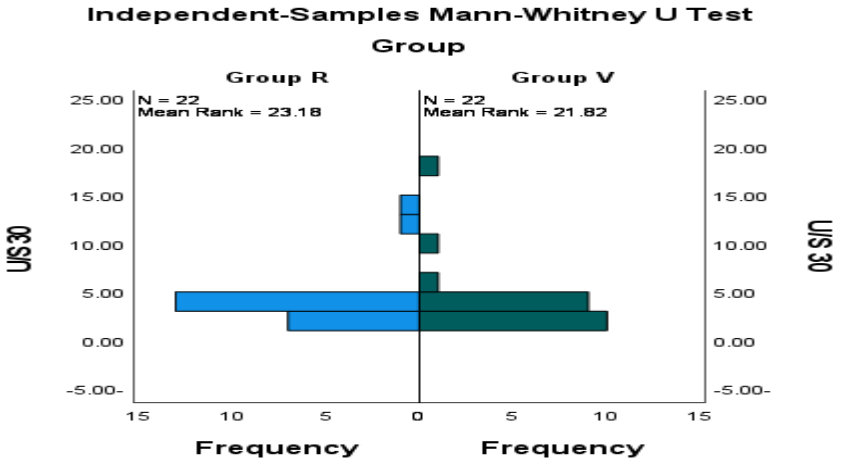

Figure 4: Graph demonstrating Ultrasound score after 30 mins

Hemodynamics data Heart rate and blood pressure were compared between the two groups with no statistical difference

- At 0: baseline before spinal
- 1: after spinal
- 30: after minutes

Table 1:systolic blood pressure mean and standard deviation

	Group R		Group V		
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**P value**
Systole 0	145.77	7.53	144.09	7.04	0.448
Systole 1	107.36	14.36	111.68	13.41	0.309
Systole 30	126.64	5.96	125.55	8.10	0.614

Table 2:diastolic blood pressure mean and standard deviation

	Group R		Group V		
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**P value**
Diastole 0	89.23	10.64	83.91	11.61	0.121
Diastole 1	60.73	12.51	64.68	12.20	0.295
Diastole 30	76.82	7.33	78.00	5.87	0.558

Table 3:heart rate mean and standard deviation

	Group R		Group V		
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**P value**
HR 0	103.45	11.40	103.64	14.13	0.963
HR 1	89.14	5.78	93.95	10.42	0.065
HR 30	79.05	7.68	83.36	6.47	0.050

Thoracic fluid content comparison between the two groups showed non- statistical difference between the groups.

Table 4:TFC measurement between the 2 groups before and after the spinal by 30 minutes median and range

	Group R			Group V			
	Median	Minimum	Maximum	Median	Minimum	Maximum	P value
TFC 0	27	26	44	27	25	48	0.306
TFC 30	28	25	38	28	25	45	0.796

Graph representation shows the measurement of the TFC after 30 minutes showing no effective difference between the 2 groups in increasing congestion and the lung fluid content measured by icon cardiometry

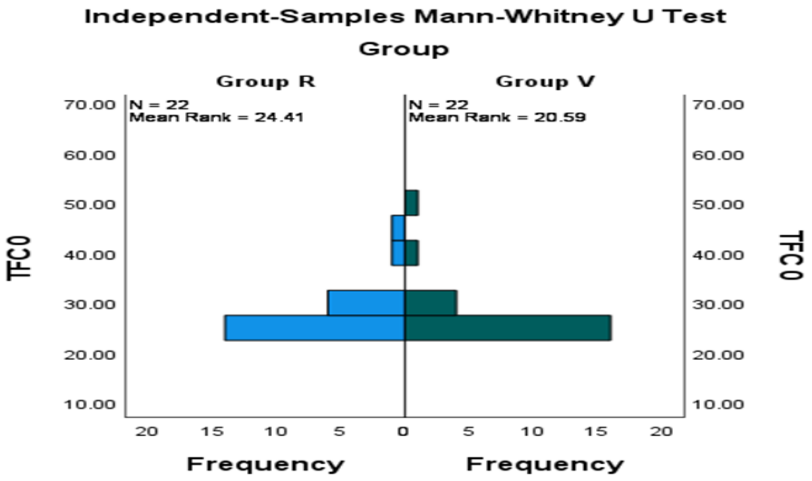

Figure 5: Graph showing the measurement of the thoracic fluid content baseline before spinal

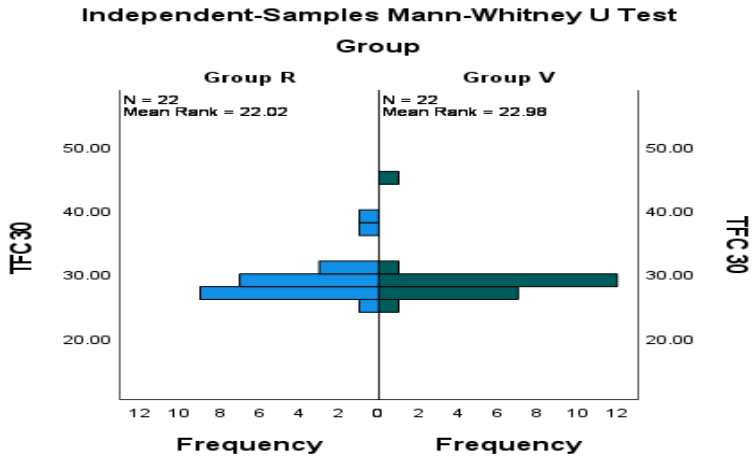

Figure 6 : Graph showing the measurement of the TFC after 30 minutes

Cardiac output measurement was compared between the two groups with no statistical differences

Table 5: 7baseline and after 30 minutes measurement of COP

	Group R			Group V			
	Median	Minimum	Maximum	Median	Minimum	Maximum	P value
Cop 0	5.9	4.4	7.7	5.4	4.3	6.1	0.112
Cop 30	5.9	5	7.5	5.45	4.8	6.4	0.061

From the graph both fluids could maintain proper perfusing COP that maintained blood pressure and perfusion without congestion

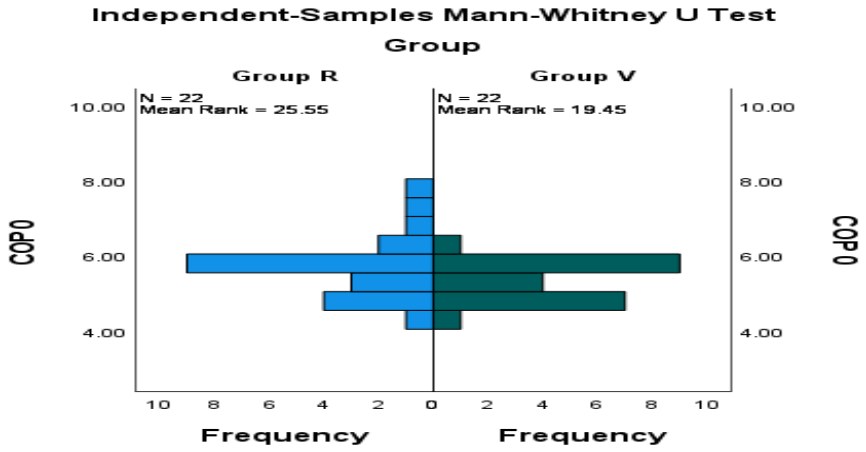

Figure 7: Graph showing COP measurement baseline before spinal

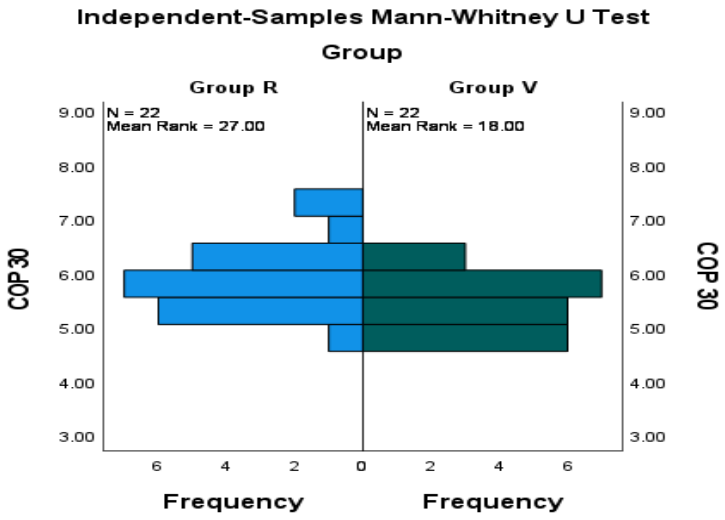

Figure 8: Graph showing the measurement of COP after 30 minutes

Statistical data for the clinical crepitations, diuretic use ,02 supplementation and urine output

		Group R		Group V		P value
		Count	%	Count	%	
CREPS0	**yes**	2	9.1%	2	9.1%	1
	No	20	90.9%	20	90.9%	
CREPS30	**yes**	0	0.0%	1	4.5%	1
	No	22	100.0%	21	95.5%	
Diuretic 0	**yes**	1	4.5%	1	4.5%	1
	No	21	95.5%	21	95.5%	
Diuretic 30	**yes**	0	0.0%	1	4.5%	1
	No	22	100.0%	21	95.5%	
O2 0	**yes**	0	0.0%	1	4.5%	1
	No	22	100.0%	21	95.5%	
O2 30	**yes**	0	0.0%	1	4.5%	1
	No	22	100.0%	21	95.5%	

	Median	Minimum	Maximum	Median	Minimum	Maximum
UOP 0	0.00	0.00	600.00	15.00	0.00	350.00
UOP 30	250.00	100.00	700.00	250.00	150.00	700.00

Discussion

In this study we compared the effect of crystalloids and colloids on lung ultrasound score in preeclamptic pregnant cases to identify the ideal fluid to maintain proper intravascular volume in preeclamptic patients that allows organ perfusion without causing lung congestion or pulmonary edema

From analysis of the data collected we found that after infusing a crystalloid (ringer acetate) in precclamptic patients the COP was maintained with no congestion to be detected on the LUS or the TFC the same was with the colloid (voluven) group which also maintained COP without affecting LUS or TFC

So, LUS of both fluids was nearly the same with no statical difference with p value > 0.05

Furthermore, the high sensitivity of the lung ultrasound detected lung congestion before clinical pulmonary edema after fluid infusion in preeclamptic in 4 out of 44 patients (9%) with b lines and lung congestion and crepititions

Zieleskiewicz L et al (4), study on 20 paturients to assess the ability of lung ultrasound to detect pulmonary edema in severe pre-eclampsia, they found that B-pattern was associated with lung congestion compared to Echo Comet score with excellent sensitivity 100% and good specificity 82%. They also found that lung ultrasound can detect extravascular lung water accumulation early during lung injury before the ratio of arterial oxygen pressure to the fraction of inspired oxygen concentration is impaired. The detection of B-lines was associated with a slight deterioration of arterial oxygenation easily treated by exogenous oxygen. So, they found that lung ultrasound detects lung edema early before severe deterioration of arterial oxygenation.

John Anthony and Leann K Schoeman (11) made a study about fluid management in preeclampsia found that Women with pre-eclampsia lose protein through renal excretion and may also extravasate protein into the interstitial tissues. Oncotic pressure falls because of this and the tendency to lose fluid from the intravascular space is partially determined by this mechanism. Filling the vascular space with fluid will lead to increasing peripheral oedema. Colloids will remain in the vascular compartment for longer periods than crystalloids although the loss of colloid into the interstitial tissues will also contribute to the development of oedema. Changes in capillary permeability will have an independent influence. It is not clear that colloidal solutions would be more effective and less likely to cause harm than crystalloids. In general, critical care there is no epidemiological evidence to support the choice of colloidal solutions over crystalloids.

T.Pretorius et al (12) made a systemic review included Six randomized controlled trials (RCTs), from nine publications, were included in the final analysis on the influence of fluid management on outcomes in preeclampsia and there were no differences between groups with respect to the incidence of pulmonary oedema, perinatal mortality, preterm delivery and caesarean section he concluded data on the ideal fluid strategy in women with preeclampsia is limited, and insufficient to make any strong recommendations. Further randomized controlled studies are needed to provide more evidence for which fluid management strategies are best.

Nowacka E. et al (13) conducted study on 42 parturients and compared TFC in normal cardiovascular parturient and in parturient with abnormal cardiovascular adaptation. **(13)** They concluded that TFC is a measurement of chest fluid status. Along with cardiac index, TFC can be very helpful to the clinician in pregnant patients. The electrical cardiometry demonstrated increase TFC and decrease cardiac indices in labouring woman who had an abnormal adaptation of their cardiovascular system during pregnancy.

Khaled H. M. et al (14) investigated in 30 patients the relation between changes in TFC and amount of fluid removal during haemodialysis (HD) session and tried to monitor hemodynamic parameters to avoid episodes of hemodynamic compromise during HD session. They found that TFC was significant in predicting persistent congestion (cut-off value was 37.02). They stated that electrical cardiometry is an evolving non-invasive tool for adjusting fluid status of critically ill patient on renal replacement therapy using thoracic fluid content as an indicator of fluid status. The latter could be used to avoid hemodynamic instability and persistent volume overload and congestion during and after HD session. This study resulted in almost the same cutoff value for TFC indicating lung congestion as our study with the difference in the population groups. **(14)**

In our study as we mentioned before, one of the main advantages of electrical cardiometry is its easy and simple application with very sensitivity in detecting pulmonary edema

Yahya hammad et al (15) on 60 parturients found in his study Both lung ultrasound score and thoracic fluid content measured by electrical cardiometry can be used as a very sensitive and

specific non-invasive monitor to diagnose increased lung water and clinically congested parturient with severe pre-eclampsia. They can also predict the need for diuretics, limited fluid balance and the need for both intra-operative and post-operative O2 therapy.

From all the previous studies we can depend on the high sensitivity and specify of LUS and thoracic fluid to give fluids in preeclampsia as a goal directed therapy as in the past fluids mostly was given conservatively by titration for risk of pulmonary edema we can now detect early lung congestion and avoid pulmonary edema by LUS and TFC which is a reliable method for examination in theatres

Anthony M Roche et al(16) Colloids and crystalloids in critical patients found Despite hydration remaining a key principle in fluid management in many patients, volume overload is of considerable concern and recent evidence also suggests that balanced electrolyte formulations are the most preferred also Oncotic load appears to be the most important factor in acute kidney injury associated with colloid fluid therapy.

Robert G Hahn (17) made a review study on adverse effects of colloids and crystalloids and found that Isotonic, or nearly isotonic crystalloid fluids are harmless up to a volume of 2 L for an example Increasing the crystalloid fluid load to 6–7 L in colon surgery increases the risk of wound infection, suture insufficiency, bleeding, pulmonary oedema, and pulmonary infection

For colloids anaphylaxis all colloid fluids are associated with a risk of allergic reactions, large amounts of albumin impose a metabolic burden on the patient, as the macromolecule is split into amino acids, voluven may be involved in kidney injury in septic patients.

From those studies we find that colloids have a potential risk and side effects like anaphylaxis, kidney injury and dilutional coagulopathy.

However, lung ultrasound has some limitations. **(18 & 19)** One of these limitations is being Operator-dependent; the operator must have enough experience for both performing and interpreting ultrasound examination.

Also, there are some patient-dependent factors which make lung ultrasound technically difficult. Obese patients may be more difficult to examine due to the thickness of their ribcage and soft tissues. Pregnancy leads to difficult visualization through narrow intercostals spaces due to crowded ribs because of compression on the diaphragm by the gravid uterus at full term pregnancy. **(19)**

Our current study concluded that the crystalloids and colloids could supply proper perfusing cardiac output without causing a lung congestion and pulmonary edema

So, we can use crystalloids safely and avoid using the colloids in fluid management of preeclampsia and avoid its drawbacks causing dilutional coagulopathy, extravascular extravasation across leaky capillary membranes, and anaphylactoid reactions may all occur with administration of any colloid. Renal dysfunction has been associated with dextran, and hyperamylasemia with hetastarch and from economic point of view crystalloids are cheaper than colloids.

Conclusion

We recommend conducting more studies on bigger number of patient and may be with applying bigger intravenous volume as we started a step in identifying the proper intravenous fluid in preeclampsia cases.

References

1. **Dolley P et al: Acute pulmonary edema and pregnancy:** a descriptive study of 15 cases and review of the literature. J Gynecol Obstet Biol Reprod (Paris) 2012 Nov; 41(7):638-44.
2. **Dennis AT et al**: Acute pulmonary oedema in pregnant women. Anaesthesia 2012; 67:646–59.
3. **Sciscione AC et al:** Acute pulmonary edema in pregnancy. Obstet Gynecol 2003; 101:511–5.
4. **Zieleskiewicz L et al:** Lung ultrasound predicts interstitial syndrome and hemodynamic profile in parturients with severe preeclampsia. Anesthesiology. 2014 Apr;120(4):906-14.
5. **Volpicelli G et al:** Diagnosis of cardiogenic pulmonary edema by sonography limited to the anterior lung. Chest 2009; 135:883–4..
6. Lichtenstein D et al: Should lung ultrasonography be more widely used in the assessment of acute respiratory disease. Expert Rev Respir Med 2010; 4:533–8.
7. **Volpicelli G et al:** International Liaison Committee on Lung Ultrasound (ILC-LUS) for International Consensus Conference on Lung Ultrasound (ICC-LUS): International evidence-based recommendations for point-of-care lung ultrasound. Intensive Care Med 2012; 38:577–91.
8. **Baldi G et al:** Lung water assessment by lung ultrasonography in intensive care: A pilot study. Intensive Care Med 2013; 39:74–84.
9. **San-Frutos LM et al:** Measure of hemodynamic patterns by thoracic electrical bioimpedance in normal pregnancy and in preeclampsia. Eur J Obstet Gynecol Reprod Biol 2005; 121(2): 149-53..
10. **Petersen JR et al**: Electrical impedance measured changes in thoracic fluid content during thoracentesis. Clin Physiol 1994; 14(4): 459-66.
11. **John Anthony and Leann K Schoeman:** Fluid management in pre-eclampsia. Obstet Med. 2013 Sep; 6(3): 100–104.
12. **T.Pretorius et al:** The influence of fluid management on outcomes in preeclampsia: a systematic review and meta-analysis. International Journal of Obstetric Anesthesia.Volume 34, May 2018, Pages 85-95.
13. **Nowacka E. et al**: Total thoracic fluid volume in parturient patient for elective caesarean section. European Journal of Anaesthesiology June 2013; 30 :167–167.
14. **Khaled H M et al:** Non invasive adjustment of fluid status in critically ill patients on renal replacement therapy. Role of Electrical Cardiometry. The Egyptian Journal of Critical Care Medicine August 2016 ; 57–65.
15. **Yahya Hammad et al**: Thoracic fluid content: a novel parameter for detection of pulmonary edema in parturients with preeclampsia. J Clin Monit Comput 2019 Jun;33(3):413-418.
16. **Anthony M Roche et al:** Colloids and crystalloids: does it matter to the kidney. Current Opinion in Critical Care 2009 dec; Volume 15, p 520-524.
17. **Robert G. Hahn:** Adverse effects of crystalloid and colloid fluids. Anaesthesiology Intensive Therapy 2017; vol. 49, p 303–308.
18. **Belaïd B et al:** Ultrasound for “Lung Monitoring” of Ventilated Patients. Anesthesiology 2 2015, Vol.122, 437-447.
19. **Shankar H et al:** Potential adverse ultrasound-related biological effects: A critical review. Anesthesiology 2011; 115:1109–24.

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