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The Effect of Changing Maternal Position from Left Lateral to Supine Position on Umbilical and Fetal Cerebral Blood Flow Indices

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Abstract

To investigate whether changing maternal position from left lateral to supine position in pregnant women between 36 and 40 weeks gestation, can affect umbilical and cerebral blood flow indices in low and high risk pregnancies. This study was a cross sectional study carried out at Ain Shams university maternity hospital on fifty pregnant women with singleton pregnancy between 36 and 40 weeks of gestation who attended the ultrasound special care unit of the fetus between December 2014 and August 2015 and were divided into two groups, Group A included 25 women with low risk pregnancy and Group B included 25 women with high risk pregnancy. The local medical ethics committee approved the study and oral informed consent was obtained from every patient involved in the study.This study included 2 groups of women: group A (low risk group) [n=25 women], and group B (high risk group) [n=25 women]. All indices were measured in the supine position then in the left lateral position and results were compared in the same group for proper correlation. In group A, our data demonstrated a statistically significant (p< 0.01) decrease in umbilical artery Systolic/Diastolic (S/D) (2.72±0.45 to 2.25±0.31), Pulsatility index (PI) (0.94±0.13 to 0.78±0.12) and Resistance index (RI) (0.63±0.06 to

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0.55±0.06) ratio after changing maternal posture from left lateral to supine position respectively. Similarly there was a statistically significant (p< 0.01) decrease in middle cerebral artery S/D (4.84±1.39 to 3.77±0.98), PI (1.52±0.26 to 1.36±0.27) and RI (0.78±0.05 to 0.72±0.06) ratios too by using paired t-test. In group B, our data demonstrated a statistically significant (p< 0.01) decrease in umbilical artery S/D (2.52±0.33 to 2.23±0.25), PI (0.91±0.16 to 0.81±0.13) and RI (0.60±0.05 to 0.55±0.05) ratios but not V mean after changing maternal posture from left lateral to supine position. Similarly there was a statistically significant (p< 0.01) decrease in middle cerebral artery S/D (3.51±0.86to 3.04±0.68), PI (1.30±0.30 to 1.15±0.27) and RI (0.70±0.07 to 0.66±0.07) ratios but not V mean by using paired t-test.Left lateral position avoids partial obstruction of inferior vena cava (IVC) and aorta by the gravid uterus and ensures best blood supply to the uterus and placental circulation. Left lateral position is more appropriate to detect reactivity and for performing non stress test (NST) test in a shorter period compared with the supine position. By using this position fetal reactivity is more quickly observed and could decrease the need for prolonged monitoring, thus leading to a more time effective evaluation of patients at risk. Supine positioning of pregnant women during any kind of lengthy diagnostic or therapeutic intervention should be avoided.

Keywords

Left Lateral maternal position - Supine Position - Umbilical cord blood flow - Fetal cerebral blood flow

I. Introduction

Fetal brain sparing is a well-known phenomenon in obstetrics. It aims to maintain sufficient blood flow towards vital organ such as the brain, myocardium, and adrenals [1].
This mechanism in fetuses with placental insufficiency associated with intrauterine growth restriction (IUGR) aims to protect the fetus by maintaining sufficient blood flow to the brain when fetal hypoxemia occurs. Vascular resistance of the fetal cerebral circulation decreases, suggesting a circulatory redistribution favoring cerebral blood flow [2]. This vascular adaptation takes place as a result of placental insufficiency that may occur in IUGR and preeclampsia. Animal studies have shown that in cases of IUGR attributable to

placental insufficiency, the central nervous system is preferentially perfused, which is intended to maintain the highest degree of oxygen supply to the brain [3-4]. Human studies have demonstrated that fetal blood flow redistribution is not limited to pathological conditions [5]. It may occur in association with acute or chronic stress such as hypoxemia or uteroplacental insufficiency and in relation to various maternal positions [5-6]. Impaired venous return due to compression of the inferior vena cava by the gravid uterus can also elicit supine hypotensive syndrome, occurring in 10–15% of women [7-8]. Maternal supine position in late gestation partially obstructs the aorta, due to the enlarged uterus, and leads to redistribution of blood flow [6] and more nonreactive fetal heart rate traces [9]. Furthermore, supine position was also shown to cause circulatory changes in the fetus. The umbilical artery S/D ratios were significantly higher in the supine than in other lateral positions, indicating that the umbilical artery vascular resistance is increased when the mother changes position [6].

In this study we investigate whether fetal blood redistribution, known as the brain sparing effect, can also be affected by a physiological stress associated with maternal posture in low and high risk pregnancies.

II. Patients and Methods

This study was a cross sectional study carried out at Ain Shams university maternity hospital on fifty pregnant women with singleton pregnancy between 36 and 40 weeks of gestation who attended the ultrasound special care unit of the fetus between December 2014 and August 2015 and were divided into two groups, Group A included 25 women with low risk pregnancy and Group B included 25 women with high risk pregnancy. The local medical ethics committee approved the study and oral informed consent was obtained from every patient involved in the study.

Inclusion criteria for group A: All women had an uneventful current pregnancy.

- Singleton pregnancy, gestational age between 36 to 40 weeks, not in labor.
- Had no history of past medical conditions, nonsmokers.
- Did not use any drugs or medication apart from iron supplementation.
- No intra uterine growth restriction or small for Gestational age infant.
- No previous history of IUGR.

Inclusion criteria for group B: Women with IUGR in current pregnancy and those associated with specific risk factors which have high likelihood of complicating into IUGR like**:** preeclampsia, maternal hypoxia due to any cause as anemia and congenital heart disease, autoimmune disease as SLE, anti-phospholipid antibody syndrome, and chronic renal disease.

Exclusion criteria of the study: Multiple gestations, congenital fetal malformation, rupture of membranes and antepartum hemorrhage.

For each woman in both groups, Doppler flow measurements were obtained from the MCA (pulsatility index and peak systolic velocity) and UA (pulsatility index and systolic/diastolic ratio) following 15 min rest in the left lateral decubitus position. Subsequently, the women were asked to change into the supine position for an additional 15 min, to allow feto-maternal adaptation to the new position and the same Doppler flow measurements were repeated.

Conventional and Doppler ultrasound were done with SonoAce R5 with a 2.5MHz to 5.0 Mhz C2-8 probe with pulsed and color Doppler flow options (Fig. 5.1). This equipment has an automatic adjustment of the high-pass filter. The mechanical index and thermal index were both under 1 for exposure to Doppler output energy.

Routine conventional ultrasound was performed basically with an aim for:

- Detection of fetal viability, fetal biometry.
- Exclusion of multiple pregnancies and major congenital anomalies.
- Estimation of gestational age and fetal body weight to screen for large, small for gestational age fetus and intrauterine fetal growth restriction.

Doppler ultrasound:

To minimize inter-observer error, only one operator performed the Doppler measurements. At least three good quality flow velocity waveforms were obtained from each vessel. A single investigator performed all Doppler measurements in the absence of fetal breathing and in the presence of a normal frequency fetal heart rate (FHR), because FHR alterations change the duration of the diastole and therefore may alter the end diastolic blood flow velocity. For example, in fetal tachycardia the end-diastolic flow velocity is increased only because of a shortened diastole.

1-Umbilical artery Doppler:

Initially an obstetric scan was performed and loops of the cord were identified. A free floating portion of the cord insonated the cursor line representing the beam path, which aligned to intersect the selected portion of the

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cord and the Doppler sample volume, was placed in that location. Zooming in the region and placing the Doppler ultrasound in a segment of cord flowing at close to 0 degrees to the transducer. The Doppler mode was then achieved and the umbilical arterial Doppler waveform was obtained. The pulsed wave Doppler of a free loop of the cord with the characteristic sound and shape of the umbilical artery was identified. When the screen showed at least 3 successive waveforms of similar height, the image was frozen and Doppler umbilical artery pulsatility index (UA-PI), resistance index (UA-RI) and systolic to diastolic ratio (S/D) were estimated by an automatic waveform analysis function integrated into the device. Absent or reversal of diastolic blood flow velocities (AEDV and REDV) was also noted.

2-Middle cerebral artery Doppler

In the same way, Middle cerebral artery Doppler measurements were obtained at a physiologic fetal heart rate of 120 to 160 beats per minute in the absence of maternal or fetal breathing movements. The transducer on the maternal abdomen, as fetal intracranial pressure, applied minimal pressure and consequently arterial flow velocity waveforms can be altered by fetal head compression. The fetal head was initially viewed in the plane typically used for biometric measurement and subsequently lowered more caudal to the base of the brain. Immediately below the thalamus, a round, slightly echogenic pulsation was visualized, which corresponded to the circle of Willis. The MCA branches off the circle of Willis at both sides, and continues anterolateral to the orbits, at the level of the sphenoid bone. In using color Doppler imaging, the Doppler gate was positioned in the proximal third of the middle cerebral artery (MCA) and the blood flow velocities were derived at an angle of insonation of less than 10°. When the screen showed at least 3 successive waveforms of similar height, the image was frozen and Doppler MCA artery pulsatility index (MCI-PI), middle cerebral artery peak systolic velocity (MCA PSV) and systolic to diastolic ratios (S/D) were estimated by an automatic waveform analysis function integrated into the device.

3-Cerebral umbilical index ratio (CPR)

As CPR quantifies the redistribution of cardiac output and is considered an indicator of the brain sparing effect. It is also an applicable tool for the obstetric practice. Additionally, the ratio between the PI of the MCA and the PI of the umbilical artery was calculated in both positions. A MCA/umbilical artery PI ratio < 1.08 was considered a sign of fetal circulation redistribution or brain-sparing [10].

***Sample size justification*:**

The required sample size has been estimated using the power Analysis and Sample size software version 08.0.9(PASS; NCSS, LLC, Kaysville, Utah). Sample size has been calculated using the paired–sample Student t-test and setting the α-error at two-sided value of 0.05 (confidence level, 95 % (1- α). So, a sample of 50 patients divided into two equal groups would be adequate for the purpose of the current study.

Description of quantitative variables as mean, SD and range

Unpaired t-test was used to compare quantitative variables, in parametric data (SD<50% mean). Paired t-test was used to compare quantitative variable in the same group.

Spearman Correlation co-efficient test was used to rank variables versus each other positively or inversely: P value >0.05 insignificant, P<0.05 significant & P<0.001 highly significant.

III. Results

Comparison of the study data of both groups is collected in table 1, with values are given as mean ± SD or number (percentage) or median.

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Table 1: Comparison between group (A) and group (B) as regard the demographic data

	A (n = 25)	B (n = 25)	t-test	P-value
	Mean ± SD	**Mean ± SD**		
Maternal Age	27.2±3.5	26.7±4.2	0.457	0.649
work			9.742	0.002*
1. Yes	17(68.0%)	6 (24.0%)		
2. No	8(32.0%)	19(76.0%)		
Parity			0.739	0.390
1. **Primigravida**	9(36.0%)	12(48.0%)		
2. **Multipara**	16(64.0%)	13(52.0%)		
Gestational Age	37.4±1.2	37±1.3	1.130	0.264
Fetal weight	3156.1±124.0	2987.0±190.0	3.724	0.195
Presentation			3.243	0.198
1. **Cephalic**	17(68.0%)	20(80.0%)		
2. **Breech**	5(20.0%)	5(20.0%)		
3. **Other**	3(12.0%)	0(0.0%)		
Fetus sex			2.013	0.156
1. **Male**	9(36.0%)	14(56.0%)		
2. **Female**	16(64.0%)	11(44.0%)		

SD: standard deviation, P-value < 0.05 (Significant), P-value >0.05(Non-Significant)
This table shows no significant difference (P-value < 0.05) between case and control groups as regards maternal age and parity

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Table 2: Medical disorders distribution in group (B)

Variables	NO.	%
DM		
1-Gestational DM	4	16.0
2-Pregestational DM	3	12.0
Hypertensive disorders		
1-gestational HTN	6	24.0
2-Chronic HTN	4	16.0
3-PET	5	20.0
Others		
1-Anemia	2	8.0
2-Cardiac	1	4.0
3-SLE	0	0.0

This table shows that 28% of patients were diabetic and 60% were suffering from hypertensive disorders with pregnancy while 4% were cardiac and8% were anemic.

Table3: Comparison between Umbilical artery hemodynamic parameters between supine versus left lateral in group (A)

Group A	**Position**							
	Left lateral position			**Supine position**			**T-test**	
	Mean	±	SD	Mean	±	SD	T	P-value
UA PSV	42.56	±	9.24	39.69	±	8.52	9.023	<0.001*
UA EDV	15.97	±	4.39	17.85	±	4.73	7.264	<0.001*
UA Vmean	29.68	±	6.54	27.80	±	6.35	4.754	<0.001*
UA S/D	2.72	±	0.45	2.25	±	0.31	8.475	<0.001*
UA RI	0.63	±	0.06	0.55	±	0.06	10.362	<0.001*
UA PI	0.94	±	0.13	0.78	±	0.12	6.137	<0.001*

UA: Umbilical artery, PSV: Peak systolic velocity, EDV: End diastolic velocity, PI Pulsatility index, S/D: Systolic diastolic ratio, RI: Resistance index

This table shows a highly statistically significant decrease in UA S/D, UA RI and UA PI between supine and left lateral positions by using paired t-test.

Table 4: Comparison between Middle cerebral artery hemodynamic parameters between supine versus left lateral in group (A)

Group A	Position							
	Left lateral position			Supine position			T-test	
	Mean	±	SD	Mean	±	SD	T	P-value
MCA PSV	43.48	±	12.55	40.19	±	12.10	7.770	<0.001*
MCA EDV	9.61	±	4.14	11.30	±	4.83	6.252	<0.001*
MCA Vmean	22.02	±	7.20	21.28	±	7.96	4.057	<0.001*
MCA S/D	4.84	±	1.39	3.77	±	0.98	8.542	<0.001*
MCA RI	0.78	±	0.05	0.72	±	0.06	11.947	<0.001*
MCA PI	1.52	±	0.26	1.36	±	0.27	3.092	0.007*

MCA middle cerebral artery PSV Peak systolic velocity PI Pulsatility index
EDV End diastolic velocity S/D Systolic diastolic ratio RI Resistance index
This table shows a highly statistically significant decrease in MCA S/D, MCA RI and MCA PI between supine and left lateral positions by using paired t-test.

Table 5: Comparison between CPR between supine versus left lateral in group (A).

Group A	Position							
	Left lateral position			Supine position			T-test	
	Mean	±	SD	Mean	±	SD	T	P-value
CPR PI	1.38	±	0.65	1.39	±	0.87	0.736	0.471
CPR RI	1.25	±	0.13	1.33	±	0.17	3.367	0.003*

CPR PI: cerebroplacental ratio pulsatility index, CPR RI cerebroplacental ratio resistance index
This table shows a statistically significant decrease between supine and left lateral positions as regard CPR using the RI but not the PI for group (A).

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Table 6: Comparison between Umbilical artery hemodynamic parameters between supine versus left lateral in group (B)

Group B	Position							
	Left lateral position			**Supine position**			**T-test**	
	Mean	±	SD	Mean	±	SD	t	P-value
UA PSV	40.14	±	8.67	36.85	±	7.69	5.829	<0.001*
UA EDV	16.22	±	4.11	16.70	±	4.04	2.673	0.013*
UA Vmean	26.56	±	6.04	25.00	±	6.09	2.015	0.163
UA S/D	2.52	±	0.33	2.23	±	0.25	5.426	<0.001*
UA RI	0.60	±	0.05	0.55	±	0.05	6.739	<0.001*
UA PI	0.91	±	0.16	0.81	±	0.13	3.282	0.004*

UA Umbilical artery PSV Peak systolic velocity EDV End diactolic velocity PI Pulsatility index S/D Systolic diastolic ratio RI Resistance index

This table shows a statistically significant decrease between supine and left lateral positions as regard UA PSV, EDV, S/D, RI and PI but not Vmean by using paired t-test.

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Table 7: Comparison between Middle cerebral artery hemodynamic parameters between supine versus left lateral among group (B)

Group B	Position							
	Left lateral position			**Supine position**			**T-test**	
	Mean	±	SD	Mean	±	SD	t	P-value
MCA PSV	38.24	±	13.48	34.82	±	12.89	7.685	<0.001*
MCA EDV	11.38	±	4.86	11.84	±	4.99	4.207	<0.001*
MCA Vmean	21.11	±	9.18	20.72	±	8.73	2.005	0.095
MCA S/D	3.51	±	0.86	3.04	±	0.68	6.836	<0.001*
MCA RI	0.70	±	0.07	0.66	±	0.07	3.021	0.042*
MCA PI	1.30	±	0.30	1.15	±	0.27	5.255	<0.001*

MCA: middle cerebral artery PSV Peak systolic velocity PI Pulsatility index
EDV: End diastolic velocity S/D Systolic diastolic ratio RI Resistance index
The table shows a statistically significant decrease between supine and left lateral positions as regard MCA PSV, EDV, S/D, RI and PI but not Vmean.

Table 8: Comparison between CPR between supine versus left lateral among group (B)

Group B	Position							
	Left lateral position			**Supine position**			**T-test**	
	Mean	±	SD	Mean	±	SD	t	P-value
CPR PI	1.34	±	0.60	1.37	±	0.55	0.952	0.353
CPR RI	1.18	±	0.15	1.25	±	0.17	2.596	0.024*

CPR PI: cerebroplacental ratio using pulsatility index
CPR RI: cerebroplacental ratio using resistance index
This table shows a statistically significant difference between supine and left lateral positions as regard CPR using the RI but not the PI from group (B).

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IV. Discussion

Several reports concerning the effect of maternal posture on maternal and fetal hemodynamics have been already published. These reports, however, concern differences in the uterine, umbilical and middle cerebral arterial flow with the subject in the supine and the left lateral position, or in the sitting and the standing position.

For instance uterine blood flow in the ascending branch of the uterine artery decreases by 34% at supine rest compared to the left lateral position [11]. These changes could compromise fetal oxygenation and elicit the fetal brain sparing effect. For example, Aldrich et al., reported a significant decrease in fetal cerebral oxygenation in changing maternal position from left lateral to supine position [12]. In another study, it was found that maternal supine position during labor is associated with lower fetal oxygen saturation than the left lateral position [13]. Animal studies have shown that compression of the maternal aorta is associated with fetal brain sparing, even during transient acute hypoxia without acidemia over a short time of period [14].

The cause of changing fetal oxygenation with altering maternal position seems to be complex. Compression of the abdominal aorta by the uterus may directly lower the flow in the uterine arteries; compression of the inferior vena cava decreases venous return at once and systolic velocity (SV). Also, in the supine position, the lung function is also worsened in late pregnant women, causing a lower oxygen tension of the blood [13].

There have been a number of studies on the association between blood flow velocimetry of the umbilical artery and supine maternal position. Marx et al. reported a significant decrease in the umbilical arterial systolic/diastolic (S/D) ratio resulting from maternal posture change from supine to the left semi-lateral position [15].

It was reported that a change in maternal posture from the standing to the supine position after four minutes in each position resulted in a statistically significant ($p< 0.01$) increase in the pulsatility index (PI) of the umbilical artery in the supine position than the standing position [16].

Nakai et al. reported that, the umbilical arterial S/D ratio in the prone position significantly decreased compared with that in the supine position [17].

This cross sectional study was carried out at Ain Shams university maternity hospital on fifty pregnant women with singleton pregnancy between 36 and 40 weeks of gestation who attended the ultrasound special care unit of the fetus between December 2014 and August 2015 and were divided into two groups, Group A included 25 women with low risk pregnancy and Group B included 25 women with high risk pregnancy.

The goal of the study was to demonstrate if there is a change in middle cerebral and umbilical blood flow indices in response to change in maternal position from supine to left lateral - after 15 minutes resting in each position -or not. In group A, our data demonstrated a statistically significant ($p< 0.01$) decrease in umbilical artery S/D, PI and RI ratios after changing maternal posture from left lateral to supine position as shown in Table 3.Similarily there was a statistically significant ($p< 0.01$) decrease in middle cerebral artery S/D, PI and RI ratios too by using paired t-test Table 4.

This observation may be explained by aortocaval compression by the gravid uterus in supine position leads to decrease in placental blood flow and acute hypoxia which elicit a brain sparing effect leading to decrease vascular resistance in the cerebral and umbilical arteries to maintain sufficient blood supply to the brain to compensate for acute hypoxia resulted from pressure of the gravid uterus on the IVC and the aorta.

Also, when CPR ratio was compared, our data demonstrated a statistically significant difference between supine and left lateral positions as regard CPR using the RI but not the PI for group (A) Table 5. This finding may be explained by the fact that during RI = (S – D) / S while PI = (S – D) / Vmean so RI is not affected by changes in V mean which may be affected by other factors.

In group B, our data demonstrated a statistically significant ($p< 0.01$) decrease in umbilical artery S/D, PI and RI ratios but not Vmean after changing maternal posture from left lateral to supine position as shown in table 6. Similarly there was a statistically significant ($p< 0.01$) decrease in middle cerebral artery S/D, PI and RI ratios but not Vmean by using paired t-test Table 7.

This data shows that also mild cases of hypertensive disorders with pregnancy and controlled diabetic pregnant mothers also can respond in response to changing position from left lateral to supine position. Also, when CPR ratio was compared, our data demonstrated a statistically significant difference between supine and left lateral positions as regard CPR using the RI but not the PI for group (A) Table 6.5.This finding may be explained by the fact that during RI = (S – D) / S while PI = (S – D) / Vmean so RI is not affected by changes in V mean which may be affected by other factors specially in high risk groups of patients.

Kauppila et al., investigated the effect of position on uteroplacental blood flow. Twenty-two women with a normal (n = 12) or hypertensive (n = 10) pregnancy were examined using the intravenous 133Xe washout method, in both the supine and left-tilted (45°) lateral positions. The intervillous blood flow was lower in the supine position than in the left-tilted position ($P < 0.01$) [18].

Similar to our results, Khatib et al., found that the Doppler resistance indices of the umbilical and the middle cerebral arteries declined by changing from left lateral to supine position [19].

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In contrast to our results, some studies found no difference in healthy umbilical blood flow indices among positions, suggesting that these changes are not clinically significant [20-22]. Khatib et al., found that the there were no more decrease in Doppler resistance indices of the umbilical and the middle cerebral arteries in 23 IUGR patients when changing maternal position from left lateral to supine position [19].

The initial decubitus maternal position in our study as opposed to the initial standing position in previous studies may explain the different results obtained in our study.

The relatively late changes observed in our study may be due the time interval required for the fetal circulatory adaptation.

The changes in the Doppler indices were observed in our study 15 min after the change in maternal position, while in previous studies these changes were observed earlier. The fetal circulatory changes ensure sufficient blood flow to the brain. They probably occur also in women who sleep in supine position and have an uneventful pregnancy outcome.

These results raise the question whether the occlusion of umbilical artery is affected solely by maternal position or there are other factors, like maternal weight or neural factors, which affect the umbilical artery.

V. Conclusion

Maternal supine position in late pregnancy is a physiological stress, which may cause circulatory changes in the fetus. These circulatory changes may induce an acute hypoxia to which the fetus respond by trying to redistribute blood flow to the vital organs as the brain, heart and adrenals as a compensatory mechanisms maintain the volume of blood flow constant. Although all values are within normal range for gestational age, in low and high risk pregnant women at term there is a statistically significant decrease in umbilical and middle cerebral arteries blood flow indices in response to maternal change in supine position compared to left lateral after 15 minutes interval. Left lateral position is more appropriate to detect reactivity and for performing NST test in a shorter period compared with the supine position. By using this position fetal reactivity is more quickly observed and could decrease the need for prolonged monitoring, thus leading to a more time effective evaluation of patients at risk. Supine positioning of pregnant women during any kind of lengthy diagnostic or therapeutic intervention should be avoided.

Limitations of this study:

Various types of medical disorders with pregnancy were taken as a whole high-risk group rather than sub classification according to different medical disorders.

Conflict of interest

No conflict of interest to declare about this work

VI. References

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