DIAGNOSTIC ACCURACY OF COLOR DOPPLER OF CEREBRAL AND UMBILICAL PULSATALITY IN DIAGNOSING IUGR, TAKING BIRTH WEIGHT AS GOLD STANDARD.

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ABSTRACT… Objectives: To determine the diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard. Study Design: Descriptive, Cross Sectional Study. Setting: Department of Radiology, DHQ Hospital, Faisalabad. Period: 30th May 2016 to 29th November 2016. Material & Methods: Total 129 clinically suspected IUGR, 18 to 40 years of age with singleton pregnancy were included. Patients having Hb< 8.5 g/dl, chromosomal abnormality, chronic infections, severe systemic illness like uncontrolled diabetes mellitus, cardiac disease, renal or hepatic disease were excluded. Colour Doppler Ultrasonography of the cerebral and umbilical artery was performed in every patient and looked for IUGR. Colour Doppler sonography findings were compared with birth weight of baby. Results: Mean age was 30.26 ± 4.67 years. The mean gestational age was 38.60 ± 1.27 weeks. Mean parity was 2.68 ± 0.74. In Colour Doppler Ultrasonography positive patients, 64 were true positive while 09 were false positive. Among, 56 Colour Doppler Ultrasonography negative patients, 07 were false negative while 49 were true negative. Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively. Conclusion: This study concluded that diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR is quite high.

Key words: Doppler Ultrasound, IUGR, Uterine Artery.

INTRODUCTION

Intrauterine growth restriction is demarcated as a birth weight less than 10th percentile for a given gestational age. Fetus having birth weight less than 10th centile for gestational age are said to be Small for gestational age (SGA) infants.1 Another way of explaining SGA is when the sonographic measurements of the fetal abdominal circumference are below an arbitrary percentile usually between the 2.5th and 10th on the representative chart.2 Size criteria is not solely important, so some people include Doppler study of umbilical artery (showing abnormal spectral pattern) in the diagnosis of fetal growth restriction.

The etiology of IUGR is multifactorial.3 Symmetrical IUGR is caused by congenital infections and chromosomal abnormalities, whereas asymmetrical IUGR is caused by uteroplacental abnormality4, maternal malnutrition and multiple pregnancies.4 Its incidence is shown to be 65.0% in a study by Singh S et al.5 IUGR is associated with large number of complications responsible for significant catatony, in the form of hyaline membrane disease, hypoglycemia, early onset sepsis, intra-partum asphyxia, meconium aspiration syndrome and stillbirth in extreme cases.6 American College of Obstetricians and Gynecologists, emphasizes that IUGR is “one the most common and complex problems in modern obstetrics”.7

Inspite of much advances in perinatal medicine, raised blood pressure remains one of the most important cause of fetal growth restriction, and the death rate among these fetuses remains
higher than in normal pregnancies. As fetal growth restriction is linked with increased death rate so in order to reduce mortality it is essential to detect the reduced fetal growth antenataly, so that proper intervention could be planned to increase the fetal survival rate. Blood flow to the fetus and maternal blood flow can be assessed using non-invasive means such as doppler ultrasound and is an excellent replacement of various invasive means.

Fetal size can be best assessed using the gold standard Ultrasonography. The application of Doppler Sonography is excellent in diagnosing various fetal abnormalities and associated factors, intrauterine growth restriction, hypertension, fetal hypoxia and cardiac malformations.

24 hours before biophysical profile score decline Doppler decline is observed. Fetal intrauterine growth restriction can best managed by the aid of combined monitoring of multiple vessel (Uterine artery, Umblical artery, Middle cerebral artery and Ductus venosus)

Fetal venous circulation (Ductus venosus) can be best assessed using Doppler sonography and plays an important role in monitoring growth restriction in order to maximize the efficiency at the time of delivery. Cerebral/umbilical ratio found to be the best parameter to diagnose small for gestational age fetus and also for diagnosing hostile upshots during pregnancy. Hypoxic events which happen before labour is much more important than what happens during and after labour. In a study, the sensitivity and specificity of colour Doppler cerebral/umbilical pulsatility in diagnosing IUGR was found to be 70.8% and 65.7% respectively. In another study, it was found to be 80.0% and 45.0% respectively. Similarly Bano S et al in his study has shown this sensitivity and specificity of 44.4% & 100.0% correspondingly.

Since there is a controversy in the previous literature, so we had planned to carry out this study to define the diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR, taking birth weight as gold standard. And if it’s diagnostic accuracy will be found high, then based on these results, some practical recommendations could be made in our routine practice guidelines for early detection of IUGR in this high risk group and subsequent adequate preventive measures could be taken in order to decrease the death rate in perinatal period as well as the catatonia of both fetus and mother.

MATERIAL & METHODS

Inclusion Criteria
- All patients with clinically suspected IUGR (as per-operational definition).
- Gestational age 32-41 weeks (assessed on LMP).
- Patients with singleton pregnancy (assessed on ultrasonography) and upto para-4.
- Patients 18-40 years of age.

Exclusion Criteria
- Patients having Hb< 8.5 g/dl, chromosomal abnormality, chronic infections (assessed on history and medical record).
- Patients with severe systemic illness like uncontrolled diabetes mellitus, cardiac disease, renal or hepatic disease (assessed on history and medical record).

Data Collection Procedure
Total 101 patients were included in this study. The patients were taken from Radiology department of DHQ/Allied Hospital, Faisalabad fulfilling the inclusion/exclusion criteria were selected after getting permission from ethical review committee. After taking informed consent and relevant history, colour Doppler Ultrasonography of the cerebral and umbilical artery was performed in every patient by using a high-resolution unit with a linear array probe centered at 7.5 MHz. All sonographic examinations were performed by senior consultant radiologist and experienced members of teaching staff in the presence of researcher and was looked for IUGR as per-operational definition. Colour Doppler sonography findings were compared with birth weight of baby which was delivered in the concerning gynecology ward. All this data was recorded on a specially...
designed proforma (Annexure-I).

Statistical Analysis
All the data gathered was scrutinized through computer software SPSS 20.0. Standard deviation and Mean were calculated for measurable variables i.e. gestational age, height, age, weight, BMI and parity. Frequency and percentage were calculated for qualitative variables i.e. pregnancy induced hypertension (yes/no), h/o previous IUGR (yes/no), socioeconomic status (poor/middle/upper) and IUGR on colour Doppler sonography and birth weight. Positive predictive value, negative predictive value, Sensitivity, specificity and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR was calculated using 2×2 contingency table and taking birth weight as gold standard.

Effect modifiers like age, gestational age, BMI, parity, pregnancy induced hypertension (yes/no), h/o previous IUGR (yes/no) and socioeconomic status (poor/middle/upper) were organized by stratification. Post-stratification likelihood ratio test was applied to see their effect on diagnostic accuracy and p-value ≤0.05 was considered substantial.

RESULTS
Patients included in this study were having age range from 18-40 years with mean age of 30.26 ± 4.67 years. Most of the patients 73 (56.59%), as shown in Table-I were falling in the range of 18 to 30 years.

The mean gestational age was 38.60 ± 1.27 weeks (Figure-1). Mean parity was 2.68 ± 0.74 (Table-II). Mean height was 150.34 ± 12.54 cm. Mean weight was 68.81 ± 7.59 kg. Mean BMI was 30.50 ± 2.11 kg/m² (Table-III). Distribution of patients according to pregnancy induced hypertension, h/o previous IUGR and socioeconomic status is shown in Table-IV, V & VI respectively.

It was compulsory for all the patients to undergo Colour Doppler Ultrasonography of cerebral and umbilical arteries. Colour Doppler Ultrasonography showed the IUGR in 73 (56.59%) patients. Birth confirmed IUGR in 71 (55.04%) cases where as 58 (44.96%) patients’ revealed no IUGR. In Colour Doppler Ultrasonography positive patients, 64 were true positive while 09 were false positive. Amid, 56 Colour Doppler Ultrasonography 07 were false negative and 49 were true negative as revealed in Table-VII. Overall negative predictive value, positive predictive value, sensitivity, specificity & diagnostic accuracy of Colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively.

Categorization of diagnostic accuracy according to age group is revealed in Table-VIII & IX. Gestational age categorical arrangement is shown in Table-X & XI. Categorization of patients according to parity is shown in Table-XII and XIII. Table-XIV & XV have shown the categorization of diagnostic accuracy according to BMI. Categorization of diagnostic accuracy with respect to PIH is shown in Table-XVI & XVII. H/o previous IUGR categorization is revealed in Table-XVIII & XIX. Categorization of patients according to socioeconomic status is revealed in Table-XX, XXI and XXII.

| Age (years) | No. of Patients | % Age |
|-------------|----------------|-------|
| 18-30       | 73             | 56.59 |
| 31-40       | 56             | 43.41 |
| Total       | 129            | 100.0 |

Table-I. Distribution of patients according to Age. Mean ± SD = 30.26 ± 4.67 years
Table-II. Distribution of patients according to parity (n=154). Mean ± SD = 38.60 ± 1.27 weeks

| Parity | Frequency | %Age |
|--------|-----------|------|
| 1-2    | 52        | 40.31|
| 3-4    | 77        | 59.69|

Table-III. Distribution of patients according to BMI (n=129). Mean ± SD = 2.68 ± 0.74

| BMI (kg/m$^2$) | Frequency | %Age |
|---------------|-----------|------|
| ≤30           | 76        | 58.91|
| >30           | 53        | 41.09|

Table-IV. Distribution of patients according to pregnancy induced hypertension (n=129). Mean ± SD = 30.50 ± 2.11 kg/m$^2$

| Pregnancy induced hypertension | Frequency | %Age |
|-------------------------------|-----------|------|
| Yes                           | 43        | 33.33|
| No                            | 86        | 66.67|

Table-V. Distribution of patients according to h/o previous IUGR (n=129).

| Socioeconomic Status | Frequency | %Age |
|----------------------|-----------|------|
| Poor                 | 33        | 25.58|
| Middle               | 62        | 48.06|
| Upper                | 34        | 26.36|

Table-VII. Diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR, taking birth weight as gold standard.

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 64 (TP)* | 09 (FP)** | 0.0001 |
| Negative result on colour Doppler | 07 (FN)** | 49 (TN)**** | |

Table-VIII. Stratification of age 18-30 years (n=73).

Sensitivity: 87.88%, Specificity: 87.50%
Positive Predictive Value (PPV): 85.29%
Negative Predictive Value (NPV): 89.74%
Diagnostic Accuracy: 87.67%

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 29 (TP) | 05 (FP) | 0.001 |
| Negative result on colour Doppler | 04 (FN) | 35 (TN) | |

Table-IX. Stratification of age 31-40 years (n=56).

Sensitivity: 92.11%, Specificity: 77.78%
Positive Predictive Value (PPV): 89.74%
Negative Predictive Value (NPV): 82.35%
Diagnostic Accuracy: 87.50%

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 35 (TP) | 04 (FP) | 0.001 |
| Negative result on colour Doppler | 03 (FN) | 14 (TN) | |

Table-X. Stratification of gestational age 32-37 weeks (n=29).

Sensitivity: 94.44%, Specificity: 72.73%
Positive Predictive Value (PPV): 85.0%
Negative Predictive Value (NPV): 88.89%
Diagnostic Accuracy: 86.21%
### Table XI. Stratification of gestational age 38-41 weeks (n=100).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 47 (TP)                  | 06 (FP)                  | 0.001   |
| Negative result on colour Doppler | 06 (FN)                | 41 (TN)                  |         |

**Sensitivity**: 88.68%, **Specificity**: 87.23%
**Positive Predictive Value (PPV)**: 88.68%
**Negative Predictive Value (NPV)**: 87.23%
**Diagnostic Accuracy**: 88.0%

### Table XII. Stratification of parity 1-2 (n=52).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 26 (TP)                  | 04 (FP)                  | 0.001   |
| Negative result on colour Doppler | 03 (FN)                | 19 (TN)                  |         |

**Sensitivity**: 89.66%, **Specificity**: 82.61%
**Positive Predictive Value (PPV)**: 86.67%
**Negative Predictive Value (NPV)**: 86.36%
**Diagnostic Accuracy**: 86.54%

### Table XIII. Stratification of parity 3-4 (n=77).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 38 (TP)                  | 05 (FP)                  | 0.001   |
| Negative result on colour Doppler | 04 (FN)                | 30 (TN)                  |         |

**Sensitivity**: 90.48%, **Specificity**: 85.71%
**Positive Predictive Value (PPV)**: 88.37%
**Negative Predictive Value (NPV)**: 88.24%
**Diagnostic Accuracy**: 88.31%

### Table XIV. Stratification of BMI ≤30 kg/m² (n=76).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 39 (TP)                  | 07 (FP)                  | 0.001   |
| Negative result on colour Doppler | 04 (FN)                | 26 (TN)                  |         |

**Sensitivity**: 90.70%, **Specificity**: 78.79%
**Positive Predictive Value (PPV)**: 84.78%
**Negative Predictive Value (NPV)**: 86.67%
**Diagnostic Accuracy**: 85.53%

### Table XV. Stratification of BMI >30 kg/m² (n=53).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 25 (TP)                  | 02 (FP)                  | 0.001   |
| Negative result on colour Doppler | 03 (FN)                | 23 (TN)                  |         |

**Sensitivity**: 89.29%, **Specificity**: 92.0%
**Positive Predictive Value (PPV)**: 92.59%
**Negative Predictive Value (NPV)**: 88.46%
**Diagnostic Accuracy**: 90.57%

### Table XVI. Stratification of presence of pregnancy induced hypertension (n=43).

|                      | Positive Result on Birth | Negative Result on Birth | P-Value |
|----------------------|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 25 (TP)                  | 01 (FP)                  | 0.001   |
| Negative result on colour Doppler | 01 (FN)                | 16 (TN)                  |         |

**Sensitivity**: 96.15%, **Specificity**: 94.12%
**Positive Predictive Value (PPV)**: 96.15%
**Negative Predictive Value (NPV)**: 94.12%
**Diagnostic Accuracy**: 95.35%
### Table-XII. Stratification of absence of pregnancy induced hypertension (n=86).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 39 (TP) | 08 (FP) | 0.001 |
| Negative result on colour Doppler | 06 (FN) | 33 (TN) | |

**Sensitivity:** 86.67%, **Specificity:** 80.49%
**Positive Predictive Value (PPV):** 82.98%
**Negative Predictive Value (NPV):** 84.62%
**Diagnostic Accuracy:** 83.72%

### Table-XX. Stratification of poor socioeconomic status (n=33).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 18 (TP) | 03 (FP) | 0.001 |
| Negative result on colour Doppler | 01 (FN) | 11 (TN) | |

**Sensitivity:** 94.74%, **Specificity:** 78.57%
**Positive Predictive Value (PPV):** 85.71%
**Negative Predictive Value (NPV):** 91.67%
**Diagnostic Accuracy:** 87.88%

### Table-XIII. Stratification of presence of h/o previous IUGR (n=34).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 18 (TP) | 02 (FP) | 0.001 |
| Negative result on colour Doppler | 01 (FN) | 13 (TN) | |

**Sensitivity:** 94.74%, **Specificity:** 86.67%
**Positive Predictive Value (PPV):** 90.0%
**Negative Predictive Value (NPV):** 92.86%
**Diagnostic Accuracy:** 91.18%

### Table-XXI. Stratification of middle socioeconomic status (n=62).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 30 (TP) | 05 (FP) | 0.001 |
| Negative result on colour Doppler | 03 (FN) | 24 (TN) | |

**Sensitivity:** 90.91%, **Specificity:** 82.76%
**Positive Predictive Value (PPV):** 85.71%
**Negative Predictive Value (NPV):** 88.89%
**Diagnostic Accuracy:** 87.10%

### Table-XIV. Stratification of absence of h/o previous IUGR (n=95).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 46 (TP) | 07 (FP) | 0.001 |
| Negative result on colour Doppler | 06 (FN) | 36 (TN) | |

**Sensitivity:** 88.46%, **Specificity:** 83.72%
**Positive Predictive Value (PPV):** 86.79%
**Negative Predictive Value (NPV):** 85.71%
**Diagnostic Accuracy:** 86.32%

### Table-XXII. Stratification of upper socioeconomic status (n=34).

| Positive Result on Birth | Negative Result on Birth | P-Value |
|--------------------------|--------------------------|---------|
| Positive result on colour Doppler | 16 (TP) | 01 (FP) | 0.001 |
| Negative result on colour Doppler | 03 (FN) | 14 (TN) | |

**Sensitivity:** 84.21%, **Specificity:** 93.33%
**Positive Predictive Value (PPV):** 94.12%
**Negative Predictive Value (NPV):** 82.35%
**Diagnostic Accuracy:** 88.24%
DISCUSSION

In uterus fetal developmental restriction is owed by many causative agents that are directly or indirectly responsible for Placental insufficiency, including maternal factors such as raised blood pressure, poor nutrition, etc. IUGR is an important obstetrical problem owing to its associated high perinatal death rate and significant morbidity. This major cause of IUGR (placental insufficiency) needs early diagnosis and prompt treatment in order to reduce its hazardous complications. Color Doppler sonography owns important role in diagnosing fetomaternal hemodynamic disturbances, so are used frequently to diagnose placental insufficiency in high-risk pregnancies so as to decrease fetomaternal mortality and morbidity rate. In this study was conducted by me to diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatality in diagnosing IUGR, taking birth weight as gold standard.

Individuals with 18-40 years age range and with mean age of 30.26 ± 4.67 years were taken. Most of the patients 73 (56.59%) were between 18 to 30 years of age. The mean gestational age was 38.60 ± 1.27 weeks. All the patients were supposed to undergo colour Doppler Ultrasonography of the cerebral and umbilical arteries. Colour Doppler Ultrasonography showed the IUGR in 73 (56.59%) patients. Birth confirmed IUGR in 71 (55.04%) cases where as 58 (44.96%) patients’ revealed no IUGR. In Colour Doppler Ultrasonography of positive ones, 09 were false positive & 64 were true positive. Among, 56 Colour Doppler Ultrasonography negative ones, 49 were true negative and 07 were false negative. Overall positive predictive value, negative predictive value, sensitivity, specificity and diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR, taking birth weight as gold standard was 90.14%, 84.49%, 87.67%, 87.50% and 87.60% respectively. In a study specificity and sensitivity of colour Doppler of cerebral/umbilical pulsatility in diagnosing IUGR was found to be 70.8% and 65.7% respectively. In another study, it was found to be 80.0% and 45.0% respectively. Similarly Bano S et al in his study has revealed this sensitivity and specificity of 44.4% and 100.0% correspondingly.

According to another study, Dhand et al the specificity and sensitivity of 61.5% and 44 %, was reported, in forecast of the IUGR product. The positive and negative prognostic values in their study were in 83 and 20 %, respectively. According to the current again low negative predictive value and high positive predictive value and specificity were obtained. The IUGR diagnosed cases on grayscale were included in the study and were the causative agent of low negative predictive value and thus responsible for increased pervasiveness. Negative predictive value is destined to decrease in a higher pervasiveness scenario. Narula et al who stated sensitivity of 94 % for collective indices of the UA however significantly decreased sensitivity of 53.3% and specificity of 87.9 % is reported by Mulders et al at around 32–34 weeks of pregnancy.

Patients after 30 weeks of gestation suffering from intrauterine growth restriction and severe pre-eclampsia are at an increased risk of developing fatal outcomes of the pregnancies and this was report with a sensitivity of 44.4%, specificity of 81.8%, NPV of 47.3% and PPV of 80%, by Lakhkar et al. The author stated that the Umblical artery resistive index had a sensitivity of 58%, specificity of 71.7 %, positive predictive value of 35%, and NPV of 86.8%, thus demonstrating diagnostic accuracy of 56.8% for a catastrophic results in high risk IUGR cases and a sensitivity, specificity, PPV, and NPV of 44.4, 81.8, 80, and 47.3%, respectively, for trivial fatal results. Resistive index of umbilical artery was gauged for detection of pregnancy related adverse effects by Aali et al in a study and he found that a cut-off value of 0.64, it was 100% sensitive, but only 44% specific; however, at a increased cut-off of 0.81, it was 28% sensitive only and 100% specific.

For forecasting fatal perinatal results it was concluded in one study that a C/U pulsatility ratio of less than 1.08 had a specificity 98.4%, sensitivity of 68%, negative predictive value 88.8%, positive predictive value 94.4%, and diagnostic accuracy of 90%. One more study using C/U PI ratio of less than 1.08 established
specificity 100%, sensitivity of 83.3%, negative predictive value 94.3%, positive predictive value 100%, and diagnostic accuracy 95.6% for forecasting fatal perinatal products in Intrauterine growth restriction. North et al25 (1994) reported a specificity of 47% and a sensitivity of 91% for prediction of FGR.

Gramellini D, Folli MC, et al26 clinched that small for gestational age newborns and other fatal perinatal outcomes can be better predicted by using cerebral umbilical Doppler ratio rather than using the umbilical artery or middle cerebral artery alone. In actual fact, in forecasting small for gestational age new borns, cerebral-umbilical ratio demonstrates high diagnostic accuracy of 70% in comparison to the diagnostic accuracy of 65.5% for the umbilical artery and 54.4% for the middle cerebral artery. The fallouts were more cheering for forecasting of fatal perinatal products; diagnostic accuracy for the cerebral-umbilical ratio was 90%, equated with 78.8% for the MCA and 83.3% for the umbilical artery.

**CONCLUSION**

This study concluded that diagnostic accuracy of colour Doppler of cerebral and umbilical pulsatility in diagnosing IUGR is quite high. So, we recommend that there should be colour Doppler of cerebral and umbilical pulsatility of this high risk group for early detection of IUGR in order to take subsequent adequate preventive measures for decreasing perinatal death and disease rates of both fetus and mother.

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