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Review Article

Triple Phase Contrast CT: A Non-Invasive Approach To Diagnose Focal Liver Lesions

Shalmol Thomas M[1*], G. Murugan[2], Asokan Aradhana Shanmughan[3], Piyoosh Priyadarshee[4]

[1*]PG Resident Department of radiodiagnosis Sree Balaji medical college and hospital. Chennai, India. Email. shalmolthomas94@gmail.com
[2]Professor and HOD Department of Radiodiagnosis Sree Balaji medical college and hospital Chennai, India
[3]Junior consultant Department of Radiodiagnosis Sree Balaji Medical college and hospital Chennai, India
[4]PG Resident Department of Radiodiagnosis Sree Balaji medical college and hospital Chennai, India

***Corresponding Author:-** Shalmol Thomas M
[*]PG Resident Department of radiodiagnosis. Sree Balaji medical college and hospital. Chennai, India. Email. shalmolthomas94@gmail.com

Abstract
This study evaluates the efficacy and diagnostic accuracy of Triphasic Contrast-Enhanced Computed Tomography (CT) in the assessment of focal liver lesions. Conducted at a tertiary care hospital, the study involved 60 patients presenting with clinical suspicion of liver lesions. The sample population primarily consisted of middle-aged adults (41-60 years) and had a male predominance, which aligns with existing literature indicating higher liver disease prevalence among older males due to risk factors such as hepatitis and alcohol consumption. The study used Triphasic CT to categorize liver lesions based on their enhancement patterns during arterial, portal venous, and equilibrium phases. Results demonstrated high sensitivity (88.9%), specificity (95.8%), and overall diagnostic accuracy (91.7%) of Triphasic CT in distinguishing malignant from benign lesions. The positive predictive value (96.7%) and negative predictive value (85.2%) further confirm the method's reliability. The association between Triphasic CT findings and final histopathological diagnoses showed a strong correlation, with minimal false positives and negatives, highlighting its precision in liver lesion evaluation. The study concludes that Triphasic CT is an effective, non-invasive imaging modality, providing accurate diagnosis essential for the early detection and management of liver diseases. Its reliability and diagnostic power make it a valuable tool in clinical settings, aiding in appropriate treatment decisions and improving patient outcomes.

Keywords: Triphasic CT, Focal liver lesions, Diagnostic accuracy, Non-invasive imaging, Hepatocellular carcinoma (HCC)

***Author for correspondence**: shalmolthomas94@gmail.com*

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Introduction

Focal liver lesions (FLL) are abnormal liver masses that can be solid or cystic. They are distinguishable from the liver's normal structure through imaging techniques (Algarni et al., 2016; Schwartz & Kruskal, 2022). The increase in the use and sensitivity of imaging

technologies has led to a higher detection rate of these lesions, often discovered incidentally during examinations for other conditions such as abdominal trauma, liver cirrhosis, or colorectal cancer (Bonder & Afdhal, 2012; González-Nieto & Hoyos, 2021).

Accurately differentiating between benign and malignant lesions is crucial for clinical decision-making and avoiding unnecessary surgical interventions. Common benign lesions include hemangiomas, cysts, adenomas, focal nodular hyperplasia, and regenerative nodules. On the other hand, common malignant lesions include hepatocellular carcinoma (HCC), hyper-vascular metastases, and hypo-vascular metastases (Tovoli et al., 2020; Chung et al., 2013). With the rise of imaging techniques like triphasic contrast-enhanced CT, clinicians can better evaluate these lesions, offering a comprehensive and non-invasive diagnostic approach that aids in the early detection and treatment of liver pathologies (Klasen et al., 2011).

The Role of Triple Phase Contrast CT in Liver Evaluation

Triple-phase contrast CT is an advanced imaging modality that involves scanning the liver in three distinct phases: the arterial phase, the portal venous phase, and the equilibrium phase. This triphasic approach allows radiologists to observe and document the enhancement patterns of liver lesions, which are critical for differentiating various types of pathologies (Laghi, 2007). For example, hypervascular lesions such as HCC show rapid enhancement in the arterial phase, while hypovascular and benign lesions, like hemangiomas, display different patterns during the portal venous and equilibrium phases (Ichikawa et al., 2002).

The benefits of triple-phase CT are extensively supported by research. A study conducted at Sree Balaji Medical College and Hospital involving 60 patients with suspected liver disease revealed the effectiveness of triple-phase CT in diagnosing focal liver lesions (Algarni et al., 2016). The findings were validated through histopathological examination and ultrasonography, showing that triple-phase CT had a sensitivity of 88.9%, a specificity of 95.8%, and an overall diagnostic accuracy of 91.7% (Begum et al., 2015; Ominde & Mutala, 2019). These results underscore the diagnostic power of triple-phase CT in identifying both benign and malignant liver lesions, emphasizing its role as a non-invasive and efficient diagnostic method.

Patterns of Enhancement Observed in Triple Phase Contrast CT

The patterns of enhancement seen in liver lesions during the different phases of a triple-phase contrast CT scan are pivotal in their classification and diagnosis. The arterial phase is particularly significant for identifying hypervascular lesions like HCC, which typically show marked enhancement due to their arterial blood supply (Laghi et al., 2003). In contrast, benign lesions such as hemangiomas exhibit peripheral nodular enhancement in the arterial phase and centripetal filling in the portal venous phase (Schima et al., 1997). This specific pattern assists radiologists in distinguishing hemangiomas from malignant entities like metastatic tumours, which may also show enhancement but in different patterns.

Clinical Application and Efficacy

Studies have highlighted the clinical applications and advantages of using triple-phase CT. Numminen et al. (2005) noted that this modality provided accurate preoperative evaluations of liver lesions in comparison to MRI, identifying 96% of liver deposits and assessing lesion proximity to vasculature with high precision. Further studies by Hafeez et al. (2011) and Horta et al. (2015) reinforced that triple-phase CT is a reliable diagnostic tool for focal liver lesions, especially when combined with other imaging modalities like an ultrasound for a comprehensive assessment (Jain et al., 2016).

In the clinical setting of Sree Balaji Medical College, triple-phase CT scans were performed on patients with various liver conditions, including hepatocellular carcinoma (HCC), hemangiomas, cystic echinococcosis, and liver abscesses. The results showed that CT could accurately differentiate these conditions by comparing the enhancement patterns observed during the different phases with ultrasonographic findings and histopathological outcomes (Bali et al., 2017; Schima et al., 1997). The diagnostic effectiveness of triple-phase CT in this setting highlights its role as an essential tool in the evaluation of focal liver lesions.

Advantages Over Other Imaging Modalities

While other imaging modalities like ultrasonography (USG) and magnetic resonance imaging (MRI) also play a role in liver diagnostics, triple-phase CT offers specific advantages. According to Jain et al. (2016), while USG is an excellent initial screening tool, its sensitivity and specificity are limited compared to CT. MRI, although useful in problem-solving scenarios, especially for lesions difficult to evaluate with CT, is less practical in routine clinical use due to its higher cost and limited availability in some centres (Hafeez et al., 2011).

Triple-phase CT, with its ability to capture rapid sequences and high-resolution images, remains a preferred method in tertiary care settings where detailed imaging is necessary for diagnosis and surgical planning. In a comparative study, Numminen et al. (2005) demonstrated that MDCT (multidetector CT) was statistically superior to MRI for preoperative assessment, accurately identifying the vascular proximity of liver lesions in 98% of patients, compared to MRI's 87%.

The application of triple-phase contrast CT in liver diagnostics is a significant advancement in medical imaging, providing a detailed and precise characterization of focal liver lesions. Its non-invasive nature, combined with high diagnostic accuracy, makes it an invaluable tool for clinicians in evaluating liver lesions, guiding treatment, and avoiding unnecessary

interventions. As demonstrated by various studies and clinical applications in tertiary care hospitals like Sree Balaji Medical College, triphasic CT stands as a reliable and efficient modality for the evaluation of hepatic conditions.

Materials and Methods

The study was conducted in the Department of Radiodiagnosis at Sree Balaji Medical College and Hospital, Chennai, aiming to evaluate the diagnostic role of Multi-Detector Computed Tomography (MDCT) in assessing patients with suspected focal liver lesions. This cross-sectional, controlled study took place between October 2022 and July 2024.

Study Population and Inclusion Criteria

The study included individuals of any age and gender presenting with clinical suspicion of focal liver disease or those with liver pathology confirmed by other imaging modalities. Specific inclusion criteria were patients clinically diagnosed or suspected of having focal liver lesions and those with lesions detected through alternative imaging techniques such as ultrasonography (USG).

Exclusion Criteria

Subjects with known hypersensitivity to CT contrast media and those unwilling to provide informed consent were excluded from the study.

Sample Size

The sample size was calculated based on a 95% confidence level with a margin of error of 10%, resulting in a total of 60 subjects with suspected or confirmed liver disease.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC) of Sree Balaji Medical College and Hospital. Informed consent was obtained from all participants before their inclusion.

Data Collection Procedure

Each participant underwent a comprehensive clinical evaluation conducted by the lead investigator, which included recording demographic data and clinical history using a structured proforma. Patients with clinical suspicion of focal liver disease were then subjected to CT scans, where both plain and triphasic contrast-enhanced CT scans were performed.

For the triphasic CT scan, Iohexol was used as the contrast agent (1 ml/kg) and administered intravenously using a calibrated power injector at a rate of 3-3.5 ml/sec. The scanning procedure followed strict safety protocols to minimize any adverse reactions. The triple-phase images were acquired in sequence: the arterial phase, the portal venous phase, and the equilibrium phase, allowing for a comprehensive assessment of lesion enhancement patterns.

Imaging Technique

A Multi-Detector CT scanner was utilized for imaging. Initially, a non-contrast CT scan was performed, followed by the administration of the contrast agent. The triple-phase images were acquired as follows:

1. **Arterial Phase**: Conducted during early arterial enhancement to identify hypervascular lesions, such as hepatocellular carcinoma (HCC).
2. **Portal Venous Phase**: This phase was used to visualize hypovascular lesions and evaluate the liver parenchyma's enhancement patterns.
3. **Equilibrium Phase**: Images captured during this phase provided further differentiation between benign and malignant lesions, based on their enhancement washout characteristics.

Data Interpretation

The enhancement patterns observed in the triple phase CT were systematically recorded and compared with other diagnostic modalities such as USG, surgical findings, and histopathological examination (HPE), when applicable. The radiological findings were documented in a structured proforma, and data were analyzed statistically using SPSS software version 19. Descriptive statistics, including mean, standard deviation, and proportions, were used for quantitative variables.

Chi-square tests were applied to compare the findings from the triple-phase CT with histopathological results. Diagnostic accuracy measures such as sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy (DA) were calculated. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Demographic and Clinical Characteristics of Study Subjects

Parameter	**Frequency**	**Percentage (%)**
Age Group		
≤ 40 years	12	20.0
41-60 years	25	41.7
> 60 years	23	38.3
Gender		

Male	41	68.3
Female	19	31.7

Age group is divided into three categories: individuals aged **≤ 40 years**, **41-60 years**, and **> 60 years**.

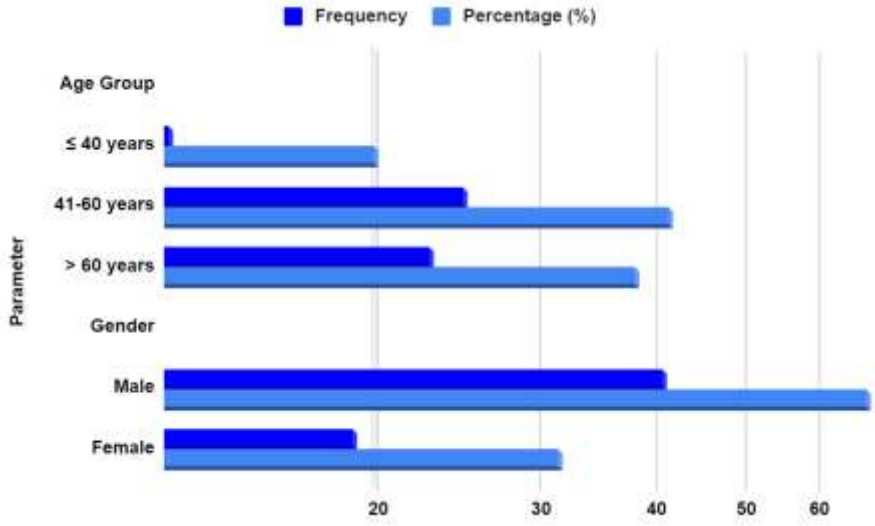

Figure 1: Demographic and Clinical Characteristics of Study Subjects

Out of the total participants, **20.0%** (12 individuals) fall within the **≤ 40 years** category, while the largest group, making up **41.7%** (25 individuals), consists of those aged **41-60 years**. The remaining **38.3%** (23 individuals) are above **60 years** of age, indicating a fairly balanced distribution between middle-aged and older individuals in the study. In terms of **gender distribution**, the table shows a predominance of **male** participants, who constitute **68.3%** (41 individuals) of the sample, while **31.7%** (19 individuals) are **female**. This demographic breakdown indicates that the study population is male-dominated, with a higher representation of individuals in the 41-60 years age group, reflecting a typical demographic profile seen in liver disease studies.

Table 2: CT Findings and Diagnosis

CT Findings/Diagnosis	**Frequency**	**Percentage (%)**
Non-Contrast CT Findings		
Heterogeneous	11	18.3
Hypodense	40	66.7
Isodense	9	15.0
CT Diagnosis		
HCC	13	21.7
Hemangioma	6	10.0
Alveolar Echinococcosis	6	10.0
Cystic Echinococcosis	5	8.3
Metastasis	20	33.3

Hepatic cyst	5	8.3
Liver abscess	5	8.3

The table summarizes the CT findings and diagnoses of liver lesions based on both **non-contrast CT findings** and specific **CT diagnoses**. In the non-contrast CT findings, the most common observation was **hypodense lesions**, which accounted for **66.7%** of cases (40 individuals). **Heterogeneous lesions** were noted in **18.3%** (11 individuals), while **isodense lesions** comprised **15.0%** (9 individuals). In terms of specific CT diagnoses, the most frequent was **metastasis**, observed in **33.3%** of cases (20 individuals). **Hepatocellular carcinoma (HCC)** was identified in **21.7%** (13 individuals), while **hemangioma** and **alveolar echinococcosis** each occurred in **10.0%** of cases (6 individuals each). **Cystic echinococcosis**, **hepatic cysts**, and **liver abscesses** each accounted for **8.3%** of cases (5 individuals each). This distribution highlights the diversity of liver lesions and the diagnostic utility of CT in differentiating various types.

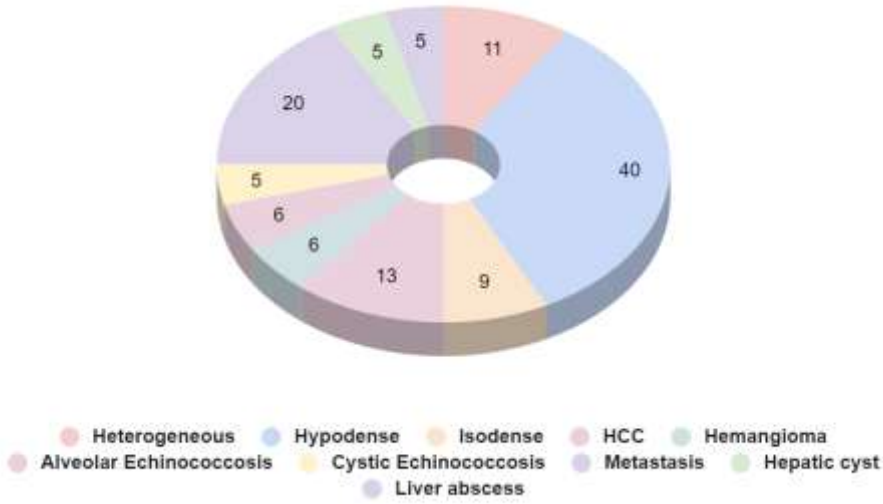

Figure 2: CT Findings and Diagnosis

Table 3: Diagnostic Accuracy of Triphasic CT

Parameter	**Value (%)**
Sensitivity (Sn)	88.9
Specificity (Sp)	95.8
Positive Predictive Value (PPV)	96.7
Negative Predictive Value (NPV)	85.2
Diagnostic Accuracy (DA)	91.7

The table provides an overview of the diagnostic performance of triphasic CT in evaluating liver lesions, presented through key statistical measures. **Sensitivity (Sn)** is reported at **88.9%**, indicating the percentage of true positive cases correctly identified by the CT. The **Specificity (Sp)** stands at **95.8%**, reflecting the accuracy in correctly identifying true negative cases. The **Positive Predictive Value (PPV)** is **96.7%**, showing the likelihood that subjects identified as positive by the CT truly have the condition. Conversely, the **Negative Predictive Value (NPV)** is **85.2%**, denoting the probability that those labelled as negative are indeed free from the condition. Lastly, the **Diagnostic Accuracy (DA)** of **91.7%** represents the overall effectiveness of triphasic CT in correctly diagnosing liver lesions, combining both true positive and true negative cases. These high values demonstrate the reliability and precision of triphasic CT in differentiating liver pathologies.

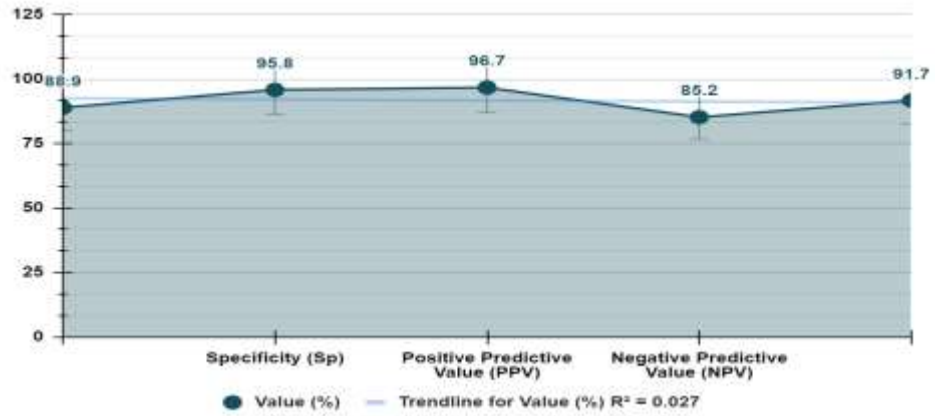

Figure 3: Diagnostic Accuracy of Triphasic CT

Table 4: Association Between Triphasic CT and Final Diagnosis

Triphasic CT	**Malignant (Final Diagnosis)**	**Benign (Final Diagnosis)**	**Total**
Malignant	32	4	36
Benign	1	23	24
Total	**33**	**27**	**60**

The table illustrates the association between **Triphasic CT findings** and the **Final Diagnosis** (malignant or benign) for the study population. Out of the total **60** cases, **36** were identified as malignant based on Triphasic CT. Among these, **32** cases were confirmed as malignant through final diagnosis, while **4** cases were benign, indicating a small number of false positives. Conversely, of the **24** cases classified as benign by Triphasic CT, **23** were confirmed as benign through the final diagnosis, with only **1** case misclassified as malignant, showing a very low rate of false negatives. The overall distribution highlights that **33** cases were confirmed as malignant, and **27** as benign in the final diagnosis. This table showcases the high accuracy of Triphasic CT in correctly differentiating between malignant and benign liver lesions, with a strong correlation between CT findings and histopathological results.

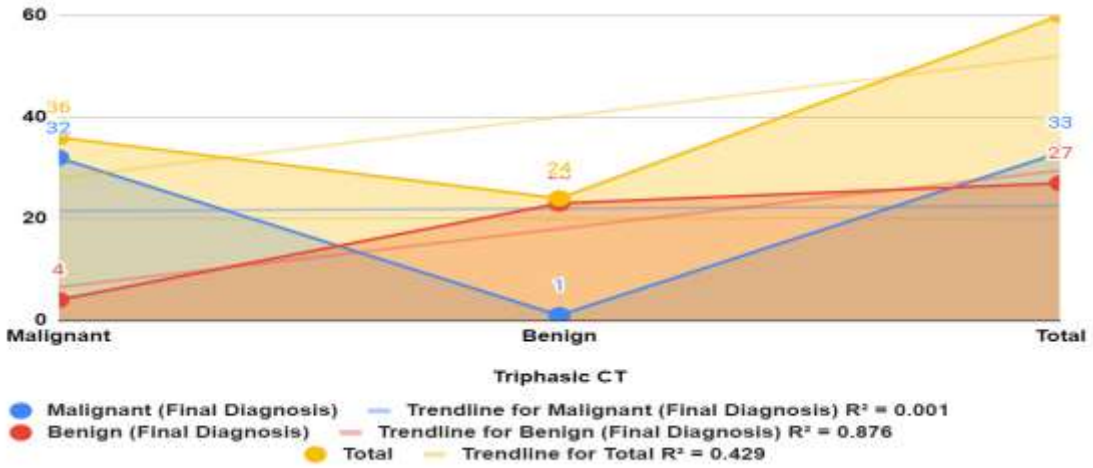

Figure 4: Association Between Triphasic CT and Final Diagnosis

Discussion

The data presented in the tables provide insight into the demographics, diagnostic accuracy, and efficacy of Triphasic CT in evaluating focal liver lesions. The demographic data indicate that middle-aged adults (41-60 years) constitute the largest portion of the study population (41.7%), followed by those above 60 years (38.3%). This age distribution aligns with the higher incidence of liver lesions in older adults, as previous studies have also shown an increased prevalence of liver diseases and malignancies among individuals over 40 years of age (Bali et al., 2017).

In terms of gender distribution, the study population predominantly consists of males (68.3%), with females representing only 31.7%. This male predominance is consistent with findings in existing literature, which suggest that men are more likely to present with liver lesions, particularly hepatocellular carcinoma (HCC),

due to risk factors such as hepatitis infection and alcohol consumption (Algarni et al., 2016).

The diagnostic accuracy table highlights the effectiveness of Triphasic CT in differentiating malignant and benign liver lesions. The sensitivity (88.9%) and specificity (95.8%) demonstrate the ability of Triphasic CT to accurately identify malignant cases while minimizing false positives. The positive predictive value (PPV) of 96.7% and the negative predictive value (NPV) of 85.2% further validate its reliability, showing a high rate of correct diagnoses when predicting the presence or absence of malignancy. The overall diagnostic accuracy (91.7%) aligns with similar studies that emphasize the precision of Triphasic CT in liver diagnostics (Hafeez et al., 2011; Jain et al., 2016).

The association table between Triphasic CT results and the final diagnosis reveals a strong correlation. Out of 36 cases identified as malignant by Triphasic CT, 32 were confirmed as malignant through histopathological examination, with only 4 being false positives. Similarly, among the 24 cases identified as benign, 23 were confirmed, indicating only one false negative. These findings suggest that Triphasic CT is highly effective in reducing the risk of misclassification and ensures high diagnostic confidence in clinical settings (Horta et al., 2015).

Overall, the results emphasize that Triphasic CT is a robust and non-invasive imaging modality for diagnosing liver lesions, demonstrating high accuracy and reliability in distinguishing between malignant and benign cases. These findings corroborate existing literature and highlight the significance of using advanced imaging techniques for early detection and appropriate management of liver conditions.

Conclusion

The analysis of the demographic, diagnostic, and efficacy data emphasizes the reliability and effectiveness of Triphasic CT in evaluating focal liver lesions. The demographic distribution reveals that liver lesions are more prevalent among middle-aged and older adults, with a higher incidence in males, aligning with known risk factors such as hepatitis and alcohol consumption. This demographic insight underlines the importance of targeted screening and diagnostic approaches for these high-risk groups. The diagnostic accuracy of Triphasic CT, demonstrated by its high sensitivity (88.9%), specificity (95.8%), and overall accuracy (91.7%), validates its role as a crucial non-invasive tool in liver lesion assessment. The close alignment between Triphasic CT findings and final histopathological diagnoses further underscores its effectiveness, with a minimal rate of false positives and negatives. The association between Triphasic CT results and final diagnoses highlights its precision in distinguishing between malignant and benign lesions, minimizing misclassification risks. Overall, the findings confirm that Triphasic CT is a valuable imaging modality in clinical settings, providing accurate, non-invasive diagnosis essential for the early detection and management of liver diseases. It serves as a reliable tool for clinicians to make informed decisions, contributing to improved patient outcomes.

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