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Bullet in the Right Ventricular Wall: Integrated CT, TTE, and Intraoperative 3D TEE in Safe Surgical Extraction

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ABSTRACT

Background: Penetrating cardiac injuries caused by bullets are rare, but potentially fatal that requires accurate diagnosis and precise management. An intracardiac bullet poses a significant problem due to high mortality rates and a wide range of immediate and long-term complications. The right ventricle is the most commonly affected cardiac chamber due to its anterior anatomical position. Multimodal imaging such as computed tomography (CT), transthoracic echocardiography (TTE), and transesophageal echocardiography (TEE) play a vital role in the diagnosis and surgical management of such cases.

Case Presentation: A male air rifle technician came to the emergency room with a penetrating right chest injury without loss of consciousness or significant respiratory symptoms. Preoperative computed tomography identified a tubular, metallic-density foreign body near the right ventricle; blooming artifact limited precise chamber identification. Transthoracic echocardiography revealed a hyperechoic mass at the right ventricular septal wall with normal cardiac structure and function. During surgery, manual exploration failed to locate the bullet, but intraoperative three-dimensional TEE precisely visualized and guided safe removal of the bullet embedded in the posterior RV wall. The patient remained hemodynamically and respiratory stable in postoperative care.

Conclusion: This case highlights the critical role of integrated multimodal imaging involving CT, TTE, and intraoperative TEE in accurately diagnosing and managing retained intracardiac bullets. Such integration optimizes surgical planning, minimizes intraoperative uncertainty, and improves patient safety and outcomes in complex cardiac trauma.

KEYWORDS: Intracardiac bullet, multimodal imaging, cardiac trauma, transesophageal echocardiography, transthoracic echocardiography, computed tomography.

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INTRODUCTION

Penetrating cardiac injuries caused by an intracardiac bullets are rare, but potentially fatal that requires accurate daignosis and precise management. The right ventricle is the most commonly affected cardiac chamber due to its anterior anatomical position (Nguyen et al., 2022). Management strategies vary depending on the hemodynamic stability of the patient and the bullet's location. Surgical extraction is often recommended to prevent complications, such as embolization, infection, arrhythmia, or structural damage (Memmedov et al., 2023).

Initial imaging with computed tomography (CT) is important for defining the trajectory of the projectile and identifying associated thoracic injuries. However, CT often suffers from metallic artifacts ("blooming") that limit the exact localization of bullets within complex cardiac anatomy (Nguyen et al., 2022). Transthoracic echocardiography (TTE) improves cardiac assessment by visualizing intracardiac masses and cardiac function. TTE may be limited by acoustic window availability due to chest tubes, pulmonary contusions, or patient positioning in trauma settings (Memmedov et al., 2023).

Transesophageal echocardiography (TEE) has emerged as the gold standard for intraoperative evaluation of intracardiac foreign bodies due to its ability to provide high-resolution, multiplanar and three-dimensional imaging of cardiac structures in real-time. TEE allows the precise localization of retained bullets relative to critical anatomic landmarks, guiding surgical approach and minimizing unnecessary myocardial dissection, and thus improving patient safety and surgical outcomes (Abbasciano et al., 2025).

This report demonstrates the integrated use of computed tomography (CT), transthoracic echocardiography (TTE), and intraoperative transesophageal echocardiography (TEE) for the diagnosis and management of a right ventricular intracardiac bullet. This multimodal imaging integration optimizes surgical planning, reduces intraoperative uncertainty, and enhances patient safety and outcomes.

CASE PRESENTATION

A 35-year-old male air-rifle technician presented to the emergency room after sustaining a gunshot wound to the right chest

during a repair procedure. He reported a localized chest pain but denying shortness of breath and had no loss of consciousness. The incident happened at 13.30 on 25 November 2024 in Purwokerto. He was then admitted to the RSUD Serengat in Purwokerto on same day at 13.45. Initial assessment revealed that his airway was patent, and breathing was stable with a respiratory rate of 18/min and SpO_2 of 98% on 3 L/min nasal cannula. Blood pressure was 130/80 mmHg with heart rate of 93/min. Thorax X-ray revealed a small opaceous object inside his heart in the right ventricle with no pleural nor pericardial effusion. He was assessed as a gunshot wound victim with intracardiac corpus alienum. He was injected with 3x30 mg of ketorolac and 3x500 mg of tranexamic acid as early relief. On the same day at 23.15, he was referred to RSDS for further treatment.

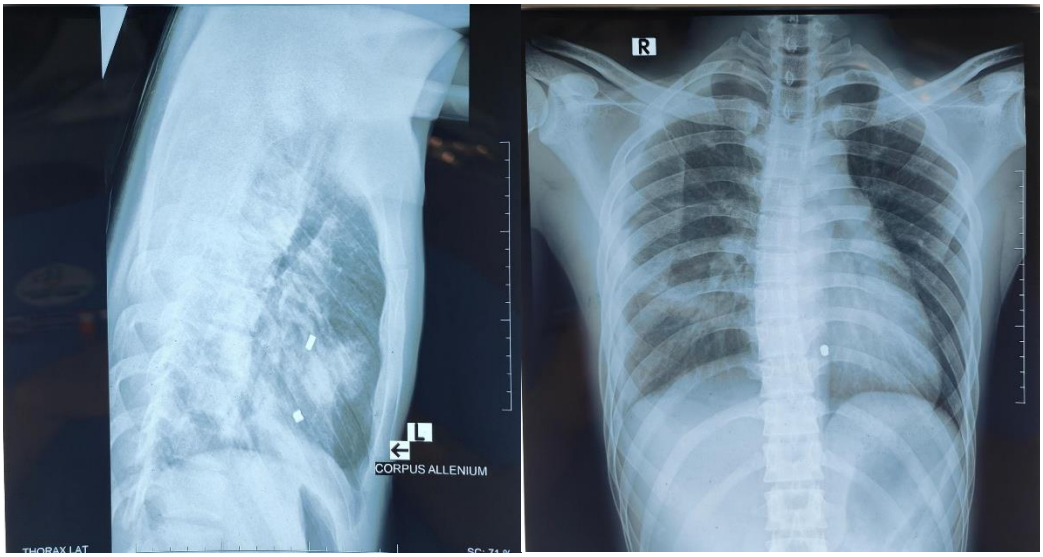

Figure 1. Chest X-ray of RSUD Serengat

Primary survey in the RSDS Emergency Room showed a clear airway and stable cervical spine. The patient had diminished movement and decreased breath sounds on the right chest due to a penetrating wound, with stable breathing (RR 20–22/min, SpO2 98% on oxygen) and circulation (BP 126/81 mmHg, HR 86 bpm). A 28 Fr chest tube drained 500 cc of haemorrhagic fluid, with chest X-ray confirming right hemothorax and pulmonary contusion without pneumothorax.

Figure 2. Clinical Picture of Thorax

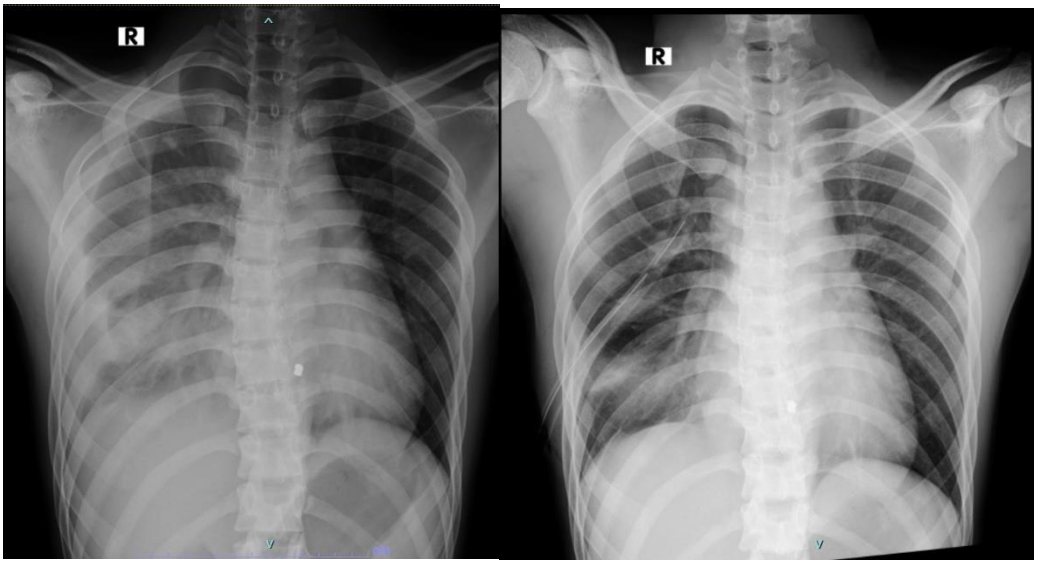

Figure 3. Hemothorax Pre (Left) and Post Chest Tube Insertion (Right)

Thorax X-ray of RSDS

Subsequently, the patient remained stable with a slight increase in respiratory rate to 22/min and SpO2 of 98% on reduced oxygen supplementation. Breath sounds were symmetrical with positive chest tube undulations. Circulation remained stable (BP 102/62 mmHg, HR 78 bpm), and neurological status was intact (GCS 15). Initial laboratory examination revealed mild leukocytosis (15,150) with normal hematology, coagulation, and electrolyte panels. Arterial blood gas analysis showed mild respiratory acidosis (pH 7.34, pCO_2 48), excellent oxygenation (pO_2 138, SaO_2 99%, PF ratio 460). A second chest x-ray was performed, which showed a hemothorax in his right hemithorax with a 28 Fr chest tube in place in his right hemithorax.

A chest CT scan without contrast confirmed a tubular metallic foreign body, approximately 0.5 x 0.5 x 0.78 cm in size, located near the right ventricle, about 4 cm from the heart inlet and 4.4 cm behind the sternum. The scan also revealed a blood-density lesion tracking through the right middle lung lobe for about 7.68 cm from the lateral thoracic wall to the right heart border. Additionally, air density was noted in the anterior pleural space indicating pneumo-hemothorax, with mixed blood and fluid densities in the right pleural cavity where a chest tube was inserted.

Figure 4. Sagital (Top), Coronal (Middle), and Axial (Bottom) Non-contrast

Thorax CT-Scan

A TTE examination was then performed. A subsequent transthoracic echocardiogram (TTE) showed normal ventricular and ventricular function, mild pericardial effusion, intact septa, and a hyperechoic mass (0.6×0.6 cm) located in the right ventricular septal wall, without signs of vegetation or thrombus. A small pericardial effusion was detected without right atrial or ventricular collapse. Hemodynamic monitoring showed a normal cardiac index (3.1 L/min/m²) and cardiac output (5.2 L/min), with a mean pulmonary artery pressure (18.3 mmHg) and pulmonary vascular resistance (112.1) within normal limits. After all examinations had been completed, the patient was immediately transferred to the operating room for bullet removal.

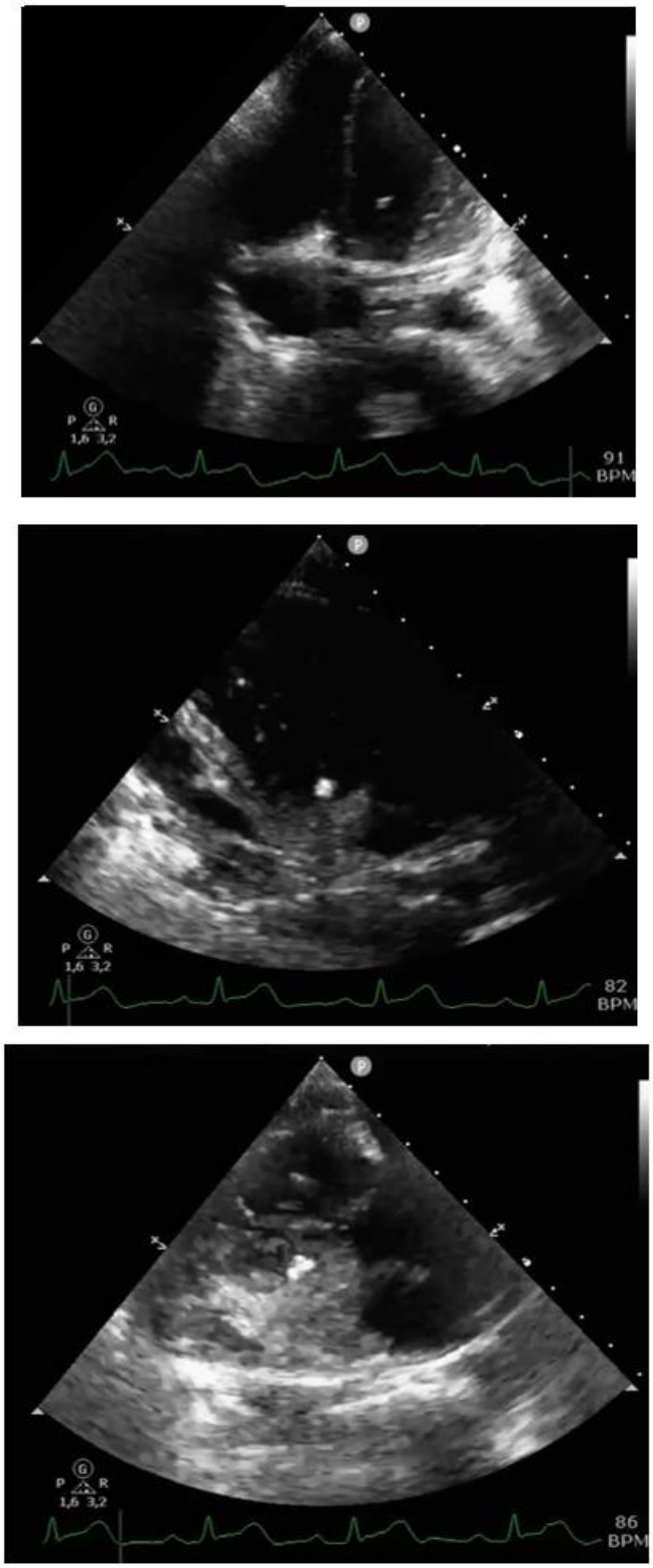

Figure 5. TTE A4 Chamber (Top), Plax RV Inflow (Middle), Modified PLAX (Bottom) showing the Bullet

The patient underwent a median sternotomy with cardiopulmonary bypass (CPB). Careful dissection and heparin administration were initiated. The bullet track was visualized to be extending from the right mediastinal pleura to the right atrium, involving the

right ventricular myocardium. Despite exploration via the right atrium, the intracardiac foreign body was not immediately visible, prompting the use of aortic cross-clamping and antegrade cardioplegia.

Intraoperative transesophageal echocardiography (TEE), performed by a cardiovascular anaesthesiologist, was critical in describing the precise location of the bullet. A 3x3x5 mm air rifle bullet was embedded in the posterior right ventricle near the tricuspid valve. Guided by real-time TEE imaging, the surgical team successfully extracted the bullet intact and minimizing myocardial trauma. Post-extraction TEE confirmed no residual foreign bodies, wall defects, or fistulas. The procedure concluded with myocardial rewarming, suturing, weaning from CPB, placement of chest drains, with meticulous reversal of anticoagulation, and closure.

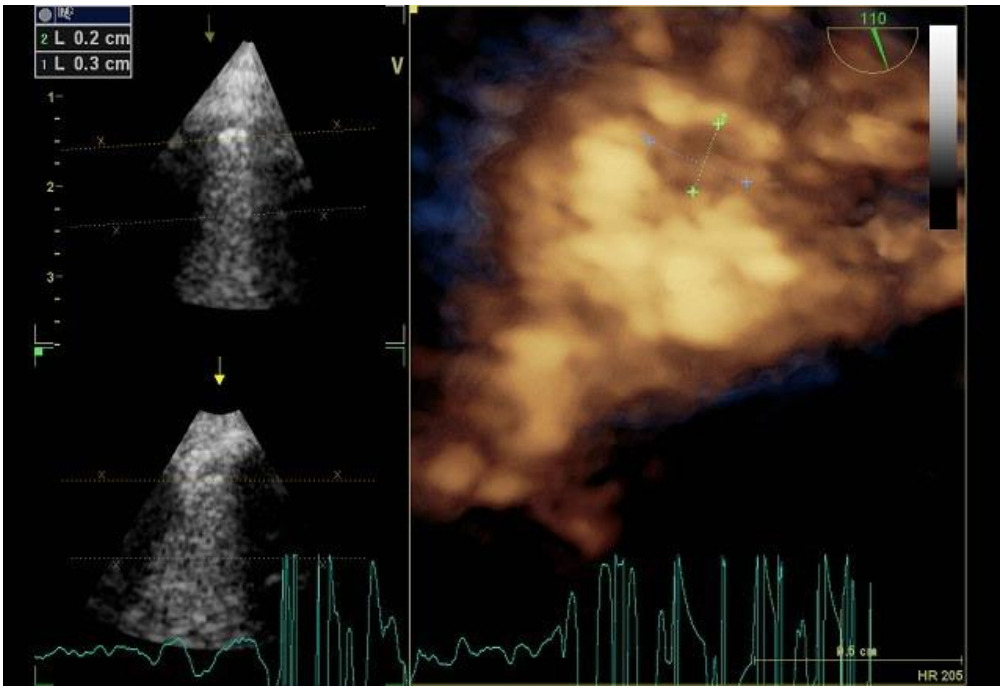

Figure 6. Intraoperative 2D & 3D TEE showing intracardiac bullet

In postoperative period, the patient was admitted to the intensive care unit for requiring ventilatory support via a pressure-support synchronized intermittent mandatory ventilation (PSIMV) mode with stable oxygenation. The chest tube remained in situ, demonstrating reduced drainage. Cardiovascular status was stable with low-dose norepinephrine infusion, maintaining warm peripheral perfusion (capillary refill time <2 seconds), a blood pressure of 135/77 mmHg, and a heart rate of 92 bpm. The patient was sedated to a RASS of -3 using dexmedetomidine and fentanyl. Renal, gastrointestinal, and musculoskeletal assessment were satisfactory, characterized by good urine output. normal bowel sounds, no limb oedema. The patient remains normothermic. Current pharmacologic management included ceftriaxone for antibiotic prophylaxis, intravenous fluids, vasopressors, analgesics, and other supportive drugs.

DISCUSSION

Intracardiac foreign bodies are rare but pose substantial dan fatal complications, such as cardiac tamponade, infection, arrhythmia, and embolism (De Jongste & Kok, 2023). Early recognition is vital. Chest X-ray provides preliminary localization but often lacks the precise spatial mapping. Computed tomography (CT) is used in this case for detailed anatomical mapping of the bullet location and trajectory, as well as the associated thoracic injuries (Yılmaz et al., 2024; Parikh et al., 2022). CT imaging also assists in detecting early complications such as hemothorax and pulmonary contusions, which can influence the urgency and the approach for those interventions (Gupta et al., 2021).

The decision-making for intracardiac foreign bodies interventions involves balancing the risks of retained objects morbidity against surgical complications. Conservative management is occasionally considered in asymptomatic, stable patients with small foreign bodies embedded securely and without signs of complications (Kumar & Talluri, 2024). In case of penetrating cardiac injury with evidence of myocardial involvement, surgical removal is generally advocated to prevent life-threatening sequelae such as perforation, endocarditis, or embolic events (Nakamura et al., 2023). The successful extraction with cardiopulmonary bypass in this case reflects the need for controlled operative environments in high-risk scenarios (Zhao et al., 2021; Davis et al., 2020).

Multidisciplinary approach involving trauma surgeons, cardiovascular anaesthesiologist with intraoperative TEE expertise, and intensivist reinforced the patient outcome optimization. Postoperative management including ventilatory support, hemodynamic monitoring, infection prophylaxis, and multi-organ function surveillance are aligned with the published trauma care protocols (O'Connor et al., 2023). The patient made a stable recovery without complications. This should highlight the efficacy of comprehensive perioperative care.

This case underlines the essential role of multimodal imaging in intracardiac foreign body interventions. Computed tomography (CT) and transthoracic echocardiography (TTE) provide crucial preoperative information, while intraoperative transesophageal echocardiography (TEE) offers unparalleled real-time guidance for successful surgical extraction.

Initial evaluation with Computed tomography (CT) is necessary for mapping the bullet trajectory and assessing collateral thoracic injuries (Nguyen et al., 2022). In this case, CT identified a metallic-density foreign body consistent with a bullet near the right ventricle along with the wound track, as well as a hemothorax in the right pleura. However, metallic "blooming" artifact complicated the precise mapping of intracardiac structures, a common issue seen in trauma imaging (Nguyen et al., 2022). Thus, CT effectively aids anatomical suspicion and guides surgical planning, while its limitations require confirmation from other imaging modalities.

Transthoracic echocardiography (TTE) is the standard bedside tool for cardiac functional assessment and mass localization (Cohen et al., 2022; Smith et al., 2019). In this case, TTE detected a hyperechoic mass at the right ventricular septal wall. Biventricular function was preserved, and potential life-threatening sequelae, such as tamponade or valvular disruption, had been excluded (Memmedov et al., 2023). Nevertheless, the accuracy of TTE can be compromised by poor optimal windows, especially in emergency trauma settings with chest tubes, pulmonary contusion, or challenging patient positioning (Memmedov et al., 2023).

Intraoperative transesophageal echocardiography (TEE), particularly with three-dimensional imaging capabilities, proved essential for this case. It provided detailed orientation and real-time multiplanar visualization of the intracardiac bullet, embedded in the posterior right ventricular wall near the tricuspid valve annulus. This imaging allowed the surgical team to precisely locate the foreign body, guiding a minimally invasive approach for safe extraction while preserving myocardial function (Abbasciano et al., 2025). The superior resolution and dynamic nature of TEE enables immediate detection of complications like residual foreign fragments, fistulas, pericardial effusions, or new valvular injury, thus improving safety and outcomes of the intraoperative and postoperative care (Cohen et al., 2022; Smith et al., 2019; Ghanaat et al., 2015). The use of TEE as an intraoperative imaging in this case had proved the best practice, as it was crucial for minimalizing myocardial trauma and preventing accidental injury during surgical exploration (Greenwood & Martinez, 2023).

The role of the anaesthesiologist extends beyond sedation and airway management, including expert use and interpretation of intraoperative TEE. In cardiac trauma surgery, anaesthesiologists with specialized training in cardiac imaging provide guidance to surgeons by continuously monitoring cardiac function and foreign body position. It allows surgeon to adjust surgical approach as necessary, and verify complete removal after extraction (Greenwood & Martinez, 2023; O'Connor et al., 2023). In this case, the anaesthesiologist's expertise in TEE was essential for successful localization and extraction of the air rifle bullet.

Imaging comparison between Computed tomography (CT), Transthoracic echocardiography (TTE), and intraoperative Transesophageal echocardiography (TEE) revealed the unique contributions of each modality for cardiac function assessment, preoperative mapping, and intraoperative navigation. Preoperative CT and TTE were consistent in identifying the likely presence of the bullet at the right ventricular septal wall. Intraoperative TEE provided the decisive location of the bullet in the posterior right ventricle wall approximately 0.8 cm from the tricuspid valve annulus. All of these imaging modalities were required for successful extraction. The use of three-dimensional TEE enabled accurate spatial mapping and real-time guidance that significantly improved the safety and efficiency of the surgical procedure.

CONCLUSION

This case demonstrates the crucial role of integrated multimodal imaging of computed tomography (CT), transthoracic echocardiography (TTE), and intraoperative transesophageal echocardiography (TEE) in the diagnosis and management of retained intracardiac bullets. Preoperative CT and TTE enabled initial localization and assessment of cardiac function, while intraoperative multiplanar and three-dimensional TEE provided precise spatial guidance for safe and successful extraction. The coordinated use of these modalities improved surgical planning, minimized intraoperative uncertainty, and enhanced patient safety and outcomes. This case highlights the necessity of a multidisciplinary and multimodal approach for accurate diagnosis, optimal treatment, and improved clinical results in complex cardiac trauma cases involving intracardiac foreign bodies.

Declarations

Ethical approval: Approval from the institutional ethics committee was obtained in accordance with institutional policies for publishing this case report.

Patient consent: Written informed consent was secured from the patient's legal guardian for the publication of this case report and related images. Reasonable measures were taken to ensure patient anonymity.

Authors' contributions: Both A.F.J. and T.A.H. equally participated in patient care, data acquisition, literature review, and manuscript drafting.

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Conflict of interest: The authors declare no conflicts of interest concerning this work.

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