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Research Article

Perioperative Cardiovascular Complications and Their Medicolegal Implications in Patients with Metabolic Syndrome Undergoing Elective Hip or Knee Arthroplasty: A Prospective Cohort Study

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ABSTRACT
Background: Patients with metabolic syndrome (MetS) have an increased cardiovascular risk at elective joint arthroplasty. Completeness of the clinical documentation at the time of surgery is also pertinent to later medicolegal evaluation.
Objective: To evaluate the incidence and correlates of 30-day cardiovascular complications and assess perioperative documentation practices among patients with metabolic syndrome undergoing elective hip or knee arthroplasty.
Methods: This prospective cohort study included 130 adults aged ≥45 years undergoing elective THA or TKA between January 2025 and January 2026. Clinical data were collected at Nawaz Sharif Medical College, Aziz Bhatti Shaheed Teaching Hospital, Gujrat, Pakistan, with medicolegal evaluation conducted in collaboration with King Edward Medical University, Lahore, and M. Islam Medical and Dental College, Gujranwala, Pakistan. Participants were stratified by metabolic syndrome burden (three versus four or five components). Cardiovascular complications were assessed within 30 postoperative days, and associated factors were identified using multivariable logistic regression. Medicolegal evaluation examined cardiovascular risk assessment, informed consent, postoperative monitoring, and adverse event documentation and communication.
Results: Cardiovascular complications occurred in 18 patients (13.8%). The incidence was higher among patients with four or five metabolic syndrome components than among those with three components (22.4% vs 6.9%; risk ratio 3.23; 95% CI 1.22–8.53; p=0.020). Myocardial injury without infarction (6.2%) and new-onset atrial fibrillation (3.8%) were the most frequent outcomes; 11 of 18 complications (61.1%) were identified within 48 hours. Five patients (3.8%) experienced major cardiovascular events, and no cardiovascular deaths occurred. Greater metabolic burden (adjusted odds ratio [aOR] 3.22; 95% CI 1.04–10.01) and reduced renal function (aOR 3.82; 95% CI 1.26–11.57) were associated with the primary outcome. Individualized risk disclosure was documented for 72.3% of patients, and communication within 24 hours was documented for 72.2% of patients with complications.
Conclusion: Greater metabolic syndrome burden and preoperative renal impairment were associated with 30-day cardiovascular complications. These findings underscore the importance of individualized preoperative risk assessment, early postoperative surveillance, informed consent, and comprehensive clinical documentation.

Keywords: Metabolic Syndrome, Total Hip Arthroplasty, Total Knee Arthroplasty, Cardiovascular Complications, Perioperative Risk, Informed Consent, Medicolegal Documentation.

INTRODUCTION

Total hip and knee arthroplasty are well-defined surgical procedures for end-stage degenerative joint diseases that result in significant improvements in pain, function, and health-related quality of life[1]. Despite the great advances achieved in surgery, anesthesia, and postoperative care, cardiovascular complications continue to be a major factor influencing postoperative morbidity, length of stay, and clinical outcomes[2]. The high burden of cardiometabolic disease among candidates for elective joint replacement adds complexity to the preoperative risk assessment and perioperative management. The metabolic syndrome is especially pertinent as it constitutes a cluster of interrelated cardiovascular risk factors that can combine to affect surgical outcomes. Understanding of these abnormalities is helpful in the pre-operative assessment and post-operative monitoring[3].

Metabolic syndrome is characterized by a combination of central obesity, hypertension, impaired glucose regulation, hypertriglyceridemia, and low levels of high-density lipoprotein (HDL) cholesterol[4]. These abnormalities cause endothelial dysfunction, chronic low-grade inflammation, insulin resistance, abnormal vascular responsiveness, and an increase of atherosclerotic disease[5]. The heart can be further vulnerable due to physiological changes and sympathetic activation, hemodynamic instability, inflammatory response, and changes in myocardial oxygen supply and demand which occur during major orthopedic surgery[6]. Cumulative effects of several metabolic abnormalities may therefore be particularly relevant in patients undergoing hip or knee arthroplasty, who frequently have multiple metabolic abnormalities and advanced age, reduced functional capacity, and underlying cardiovascular disease.

Earlier studies have shown the correlation between metabolic syndrome and poor postoperative outcomes after total joint arthroplasty. Gandhi et al. found that patients with metabolic syndrome had a higher risk for cardiovascular complications after joint replacement[7], and a follow-up systematic review and meta-analysis found a higher rate of all postoperative complications in patients with metabolic syndrome[8]. In a prospective cohort study, 2,901 patients undergoing hip or knee arthroplasty showed that metabolic syndrome was linked to prolonged length of hospital stay and 90-day readmission more recently[9]. However, the definitions of cardiovascular outcome, duration of follow-up, and evaluation of metabolic abnormalities have varied among available studies. It is therefore important that the increasing burden of metabolic syndrome is associated with specific perioperative cardiovascular events and that this relationship needs to be further explored[10].

Perioperative cardiovascular complications include myocardial injury, AMI, clinically important arrhythmias, acute heart failure, cerebrovascular events, and cardiovascular death[11]. Of particular concern is the occurrence of myocardial injury after noncardiac surgery, where clinically important elevations in cardiac troponin can occur in the absence of typical ischemic symptoms, and therefore, recognition and management may be delayed[12]. Current cardiovascular guidelines focus on personalized risk stratification based on clinical features, capacity, and validated cardiovascular risk scores, as well as targeted biomarker assessment[13]. Using traditional clinical measures as a risk assessment tool may not fully capture the combination of multiple metabolic abnormalities. More insight into the link between the severity of metabolic syndrome and the development of postoperative cardiovascular disease may thus help to better distinguish high-risk patients and develop better perioperative surveillance strategies[14].

In addition to their clinical importance, perioperative cardiovascular complications also have important medicolegal implications, especially in elective surgical practice[15]. Risk assessment and disclosure, informed consent, postoperative monitoring, and response to clinical deterioration are all important components of perioperative care[16]. When treating patients with metabolic syndrome, health care providers must be especially diligent in openly communicating with the patient about risks and recording clinical decision-making. Preoperative counseling, postoperative monitoring or communication may not be completed after adverse events, which may make it difficult to rule out or assess professional responsibilities or standard of care later[17]. A poor outcome does not necessarily equate to negligence; a medicolegal conclusion requires evidence of causation, clinical context, and the standard of care[18].

The negative impact of metabolic syndrome in orthopedic surgery has become a growing focus, but evidence to link peri-operative

cardiac events with systematic review of medicolegal documentation practices is limited[19]. The link between cumulative metabolic abnormalities, postoperative cardiovascular issues, individualized informed consent and clinical accountability is an area that needs to be further explored[20]. The objective of the current study was to evaluate the prevalence, spectrum of clinical presentation and risk factors for perioperative cardiovascular events in patients with metabolic syndrome who underwent elective hip or knee arthroplasty. A secondary aim was to review cardiac risk assessment and informed consent, post-operative monitoring and communication following adverse events in relation to clinical governance and medicolegal review documentation.

MATERIALS AND METHODS

Study Design and Setting:

The study was a prospective observational cohort study that spanned the period from January 2025 to January 2026. Clinical data were obtained from the Nawaz Sharif Medical College, Aziz Bhatti Shaheed Teaching Hospital, Gujrat, Pakistan, in conjunction with a medicolegal evaluation by the Department of Forensic Medicine, King Edward Medical University, Lahore and the Department of Forensic Medicine and Toxicology, M. Islam Medical and Dental College, Gujranwala, Pakistan. The cardiovascular outcomes and the perioperative documentation in patients with metabolic syndrome who underwent elective primary hip or knee arthroplasty were evaluated. Reporting was guided by the STROBE statement for observational studies[11].

Study Population and Eligibility Criteria: The cohort included 130 adults 45 years and older with metabolic syndrome diagnosed by the presence of at least three of the five criteria, and who had elective primary THA or TKA. Those in need of surgical postponement due to acute coronary syndrome, decompensated heart failure, uncontrolled arrhythmias, emergency surgery, or revision surgery for arthritis were excluded. Follow-up was up to 30 days after surgery.

Cardiovascular Assessment and Metabolic Syndrome:

Metabolic syndrome was determined based on the harmonized criteria, which identified at least three of five abnormalities: central obesity, elevated blood pressure, increased fasting glucose, hypertriglyceridemia, and reduced high-density lipoprotein cholesterol[1]. The participants were divided into two groups (three and ≥ four metabolic syndrome components). Demographic data, cardiovascular history, use of medications, blood pressure, electrocardiography, glycemic profile, lipid concentrations, renal function, and the concentration of N-terminal pro-B-type natriuretic peptide (NT-proBNP) were assessed as preoperative data. The Revised Cardiac Risk Index was documented as a risk factor preoperatively. Renal impairment was characterized by estimated GFR < 60 mL/min/1.73 m^2.

Post-operative Care and Assessment of Results Perioperative care was provided as per institutional orthopedic and anesthetic protocol. Perioperative management included haemodynamic monitoring, glycaemic monitoring, optimizing fluids, thromboprophylaxis, and mobilisation after surgery. The main result was a composite endpoint of myocardial injury, myocardial infarction, new-onset clinically significant atrial fibrillation, acute heart failure, ischemic stroke, or cardiovascular death in the first 30 postoperative days. Cardiovascular events were evaluated using clinical examination, electrocardiogram, cardiac troponin measurements, and other investigations as deemed necessary. The classification of the diagnosis was made according to the known cardiovascular diagnostic criteria. Only the first qualifying cardiovascular event was used for the primary composite event in each patient. Medicolegal Documentation Assessment Perioperative records were reviewed for cardiovascular risk assessment, patient-specific informed consent, postoperative monitoring plan, prompt identification and management of complications, and communication with patient or family after adverse events. The event-related indicators were investigated for patients with cardiovascular complications. The completeness of the documentation was considered as a clinical quality indicator – missing documentation was not assumed as evidence that a clinical action had not occurred. Statistical Analysis Continuous variables were expressed as means with standard deviations, while categorical variables were presented as frequencies and percentages. Chi-square and Fisher's exact tests were used to compare groups as appropriate. The relative risks and 95% confidence intervals for cardiovascular complications were calculated based on the

number of metabolic syndrome components. Metabolic burden and age were also included in a multivariable logistic regression model, which assessed the association of these factors with the primary outcome (with necessarily cautious interpretation, due to the limited number of events), as was renal impairment. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were provided. The two-sided p-values < 0.05 were used to determine statistical significance.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable institutional and national research ethics guidelines. The relevant Institutional Review Board or Ethics Committee approved the study, if necessary. Informed consent was obtained. Throughout the research process, the privacy, confidentiality, and protection of the participants were respected. Research data were secured and only accessible to authorized personnel and used for approved research. All study procedures were conducted with due consideration for participant rights, safety, and welfare.

RESULTS

Baseline Demographic and Clinical Characteristics

A total of 130 patients with metabolic syndrome who underwent elective primary total hip or knee arthroplasty were included in the analysis. The mean age was 64.24±8.44 years, and 82 patients (63.1%) were female. 78 patients (60.0%) had total knee arthroplasty, and 52 (40.0%) had total hip arthroplasty. Of the seventy-two participants, 55.4% had three metabolic syndrome components, while 58 (44.6%) had four or five.

Preoperative renal impairment was found in 25 (19.2%) participants, and NT-proBNP concentrations≥300 pg/mL were found in 41 (31.5%). In comparison with those meeting three criteria, participants with four or five metabolic syndrome components were more likely to have renal impairment (27.6% versus 12.5%) and elevated NT-proBNP (43.1% versus 22.2%) and Revised Cardiac Risk Index scores ≥1 (41.4% versus 23.6%). Baseline demographic and clinical characteristics according to metabolic syndrome burden are presented in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics According To Metabolic Syndrome Burden (N=130).

Characteristic	Three components (n=72)	≥4 components (n=58)	Total (N=130)
Age, years, mean±SD	64.04±8.37	64.48±8.60	64.24±8.44
Female sex	44 (61.1)	38 (65.5)	82 (63.1)
Male sex	28 (38.9)	20 (34.5)	48 (36.9)
Total hip arthroplasty	29 (40.3)	23 (39.7)	52 (40.0)
Total knee arthroplasty	43 (59.7)	35 (60.3)	78 (60.0)
eGFR <60 mL/min/1.73 m²	9 (12.5)	16 (27.6)	25 (19.2)
NT-proBNP ≥300 pg/mL	16 (22.2)	25 (43.1)	41 (31.5)
Revised Cardiac Risk Index ≥1	17 (23.6)	24 (41.4)	41 (31.5)
Four metabolic syndrome components	0 (0.0)	41 (70.7)	41 (31.5)
Five metabolic syndrome components	0 (0.0)	17 (29.3)	17 (13.1)

Values are presented as n (%) unless otherwise specified. SD, standard deviation; eGFR, estimated glomerular filtration rate; NT-proBNP, N-terminal pro-B-type natriuretic peptide.

Incidence and Clinical Spectrum of Cardiovascular Complications

Within 30 postoperative days, 18 of 130 patients (13.8%; 95% CI 8.9–20.8%) experienced a cardiovascular complication. The incidence was significantly higher among participants with four or five metabolic syndrome components than among those with exactly three components (22.4% versus 6.9%; risk ratio 3.23, 95% CI 1.22–8.53; p=0.020). The absolute between-group difference was 15.5 percentage points. Cardiovascular complications occurred in seven patients undergoing hip arthroplasty (13.5%) and 11 undergoing knee arthroplasty (14.1%).

Myocardial injury without myocardial infarction was the most frequent complication, occurring in eight patients (6.2%), followed by new-onset atrial fibrillation in five (3.8%) and acute heart failure in three (2.3%). Myocardial infarction and ischemic stroke occurred in one patient each (0.8%). Major clinical cardiovascular events occurred in five patients (3.8%), with no cardiovascular deaths during the 30-day follow-up. The distribution of cardiovascular complications according to metabolic burden is presented in Table 2.

Table 2. Incidence and Distribution of Cardiovascular Complications within 30 Days of Arthroplasty.

Cardiovascular outcome	Three components (n=72)	≥4 components (n=58)	Total (N=130)
Any cardiovascular complication	5 (6.9)	13 (22.4)	18 (13.8)
Myocardial injury without MI	3 (4.2)	5 (8.6)	8 (6.2)
New-onset atrial fibrillation	1 (1.4)	4 (6.9)	5 (3.8)
Acute heart failure	1 (1.4)	2 (3.4)	3 (2.3)
Myocardial infarction	0 (0.0)	1 (1.7)	1 (0.8)
Ischemic stroke	0 (0.0)	1 (1.7)	1 (0.8)
Cardiovascular death	0 (0.0)	0 (0.0)	0 (0.0)
Major clinical cardiovascular events	1 (1.4)	4 (6.9)	5 (3.8)

Values are expressed as n (%). MI, myocardial infarction. Individual complications are classified according to the first qualifying event. Major clinical cardiovascular events comprise myocardial infarction, acute heart failure, ischemic stroke, and cardiovascular death. The between-group comparison for the primary composite outcome was performed using Fisher's exact test.

Of the 18 patients who developed cardiovascular complications, 11 (61.1%) experienced the first qualifying event within 48 postoperative hours, four (22.2%) between days 3 and 7, and three (16.7%) between days 8 and 30. Thus, 15 of the 18 complications (83.3%) occurred during the first postoperative week.

Factors Associated with Perioperative Cardiovascular Complications

In multivariable logistic regression, greater metabolic syndrome burden and preoperative renal impairment were associated with the primary cardiovascular outcome. Patients with four or five metabolic syndrome components had higher adjusted odds of cardiovascular complications than those with exactly three components (adjusted odds ratio [aOR] 3.22, 95% CI 1.04–10.01; p=0.043). Renal impairment was also associated with increased complication odds (aOR 3.82, 95% CI 1.26–11.57; p=0.018).

Increasing age demonstrated a positive but statistically nonsignificant association with the primary outcome (aOR 1.42 per 10-year increase, 95% CI 0.75–2.68; p=0.280). The adjusted estimates and corresponding confidence intervals are summarized in Table 3.

Table 3. Multivariable Logistic Regression Analysis of Predictors of Perioperative Cardiovascular Complications.

Predictor	Adjusted OR	95% CI	p-value
≥4 metabolic syndrome components	3.22	1.04–10.01	**0.043**
Age, per 10-year increase	1.42	0.75–2.68	0.280
eGFR <60 mL/min/1.73 m²	3.82	1.26–11.57	**0.018**

OR, odds ratio; CI, confidence interval; eGFR, estimated glomerular filtration rate. All predictors were entered simultaneously into the regression model. Given the 18 observed cardiovascular events, adjusted effect estimates require cautious interpretation. Bold values indicate p<0.05.

Medicolegal Documentation and Clinical Accountability

Perioperative records showed variation in the documentation of cardiovascular risk assessment, informed consent, and postoperative management. Preoperative cardiovascular risk assessment was documented in 113 patients (86.9%), while patient-specific cardiovascular risk disclosure during informed consent was recorded in 94 (72.3%). A documented postoperative cardiovascular monitoring plan was available for 103 patients (79.2%).

Among the 18 patients who developed cardiovascular complications, timely clinical assessment and management were documented in 16 cases (88.9%). Communication with the patient or family within 24 hours of event recognition was recorded in 13 cases (72.2%). The corresponding documentation findings are summarized in Table 4.

Table 4. Perioperative Cardiovascular Documentation and Medicolegal Quality Indicators.

Documentation indicator	Relevant patients	Documented, n (%)
Preoperative cardiovascular risk assessment	130	113 (86.9)
Patient-specific cardiovascular risk disclosure during informed consent	130	94 (72.3)
Documented postoperative cardiovascular monitoring plan	130	103 (79.2)
Timely clinical assessment and management following a cardiovascular complication	18	16 (88.9)
Patient/family communication within 24 hours of event recognition	18	13 (72.2)

Percentages were calculated using the number of patients for whom each indicator was applicable. Event-related indicators were assessed among patients experiencing cardiovascular complications. Documentation indicators describe recorded clinical processes and do not constitute legal determinations of negligence.

Individualized cardiovascular risk disclosure was not documented for 36 patients (27.7%), and a postoperative monitoring plan was not documented for 27 (20.8%). Of the patients who had cardiovascular complications, communication within 24 hours was not documented in five cases (27.8%), and timely clinical assessment and management was not documented in two cases (11.1%). If there is no written entry, the clinical action cannot be determined.

DISCUSSION

Prospective cohort study to assess postoperative cardiovascular morbidity and medicolegal documentation in total hip and knee arthroplasty (THA) patients categorized as having metabolic syndrome (MS). Cardiovascular complications were seen in 13.8% of the participants, with a significant difference between the occurrence of these complications in patients with four or five metabolic syndrome components and in those who met all three metabolic syndrome criteria (22.4% versus 6.9%). These factors, including metabolic load and preoperative renal dysfunction, were still linked to cardiovascular complications after accounting for selected clinical factors. These observed correlations indicate that cumulative metabolic burden may be a factor to take into account in addition to the known clinical parameters in the assessment of perioperative cardiovascular risk[2–5].

The findings that metabolic syndrome burden is associated with cardiovascular complications are similar to previous studies with arthroplasty populations. Gandhi et al. found that patients with metabolic syndrome were at higher risk for cardiovascular events after total joint arthroplasty[2], and Cui et al. found that patients with metabolic syndrome had a greater risk for poor postoperative outcomes in their systematic review and meta-analysis[3]. In a more recent prospective cohort of 2,901 patients, Sørensen et al. found that patients with metabolic syndrome were more likely to be hospitalised longer and have 90-day readmission[4]. While there are several challenges to making direct comparisons of findings across the different studies, including the variability in study population, definition of the outcome, and length of follow-up, these data all suggest an important clinical role of cardiometabolic abnormalities in the assessment of perioperative risk[5]. The present results further support this evidence by

showing a spectrum of cardiovascular risk based on the presence of the different components of the metabolic syndrome among patients who already satisfy the diagnostic criteria[13,14].

The most common complications after surgery were myocardial injury, new-onset atrial fibrillation, and acute heart failure. These results may be due to the synergistic effect of the perioperative sympathetic activation, hemodynamic changes, inflammatory reactions, and myocardial oxygen supply-demand mismatch[15]. Metabolic syndrome may also contribute to the increased cardiovascular vulnerability by the presence of endothelial dysfunction, insulin resistance, and an increase in atherosclerotic disease[16]. Of particular note is the fact that 11 out of 18 (61.1%) cardiovascular complications occurred in the first 48 postoperative hours, emphasizing the need for extra care during the early post-operative period. Previous studies have found prognostic significance in elevated troponins even without typical ischemic symptoms, and this reappeared after surgery[6]. Modern-day peri-operative guidelines have permitted this kind of cardiac biomarker monitoring specifically, in carefully selected patients at higher cardiovascular risk to date, however[17].

There was a significant adjusted association between cardiovascular complications and preoperative renal impairment, but there was a positive but nonsignificant adjusted association between cardiovascular complications and increasing age. Renal function may play a role in cardiovascular vulnerability during the perioperative period, which leads to impaired control of fluid and vascular dysfunction and decreased tolerance for physiological changes[6]. These findings emphasize the importance of taking into account renal function, together with metabolic and known cardiovascular risk factors. However, the wide confidence intervals indicate that there is some imprecision in the effect estimates after adjustment, and hence the need for validation in larger prospective cohorts. Current cardiovascular guidelines focus on integrated risk assessment, based on functional capacity, clinical characteristics, and validated prediction tools, instead of individual metabolic parameters[8].

In addition to clinical outcomes, the perioperative document evaluation was assessed for its importance in the medicolegal assessment[9]. 86.9% of patients had cardiovascular risk assessment performed preoperatively, and 72.3% had cardiac risk disclosure during informed consent. This distinction highlights the importance of distinguishing documentation of clinical risk assessment from documentation of patient counseling[10]. In the case of elective arthroplasty, informed consent should include informed communication regarding the expected good, material complications, reasonable alternatives, and risks associated with individual comorbidities[18]. Previous orthopedic writing has revealed that there is a lack of uniformity in the documentation of consents and that structured communication is a key component in patient autonomy and professional accountability[19,20].

Documentation of patient/family communication was less complete following cardiovascular complications than documentation of clinical assessment and management. In patients with cardiovascular complications, timely clinical assessment and management were documented in 88.9%, and communication was documented within 24 hours in 72.2%. Recognizing adverse events and documenting them are an important part of the way in which continuity of care is reached, and also subsequent evaluation of professional conduct[9]. But partial documentation will not in itself prove that appropriate clinical actions were not taken. Likewise, if an adverse cardiovascular event occurred, it does not necessarily mean it was the result of medical negligence. When making a medicolegal assessment, it is important to take into account the standard of care, circumstances of clinical decisions, and evidence of any breach of standard of care and its relationship to patient harm[10]. In this context, these findings guide opportunities for improving documentation and communication and not about individual legal liability[5].

Strengths of the methodology are the prospective follow-up and the same definition of cardiovascular outcomes, the same classification of metabolic syndrome burden, and clinical documentation. However, there are several limitations that need to be taken into account when interpreting the results. The small sample size and number of cardiovascular events precluded the precision and complexity of adjusted analyses. Since this was an observational study, associations should not be viewed as causal, and residual confounding due to unmeasured cardiovascular characteristics is possible. In addition, the completeness of documentation does not always result in good verbal communication or clinical decision

making. Large multicentre studies with detailed cardiovascular phenotyping and standardized documentation assessment are justified to validate the reproducibility and clinical use of these associations[15-20].

CONCLUSION

In this prospective cohort of patients with metabolic syndrome undergoing elective primary hip or knee arthroplasty, greater metabolic burden and preoperative renal impairment were associated with cardiovascular complications during 30-day follow-up. Most of the events were new onset AF, with myocardial injury as the most common complication, occurring in the first postoperative week. The lack of documentation of individualized risk disclosure and communication after adverse events suggested opportunities for improvement in the documentation of adverse events. Patient safety and post-operative monitoring, individualized informed consent, and consistent documentation are relevant to integrated cardiovascular assessment.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Ft: Conceptualization and study design; **Th:** Data analysis and interpretation; **Src:** Data collection; **Sti:** Literature review and manuscript drafting; **Amh:** Critical revision and supervision. All authors reviewed and approved the final manuscript.

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