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EDITORIAL

Cardiotoxicity concerns in total joint arthroplasty

Chun-Han Cheng, Wen-Rui Hao, Tzu-Hurng Cheng

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Abstract

This editorial examines the cardiotoxic effects of elevated metal concentrations in patients who received total joint arthroplasty, as detailed in the study of Brennan *et al*. The study findings reveal that elevated cobalt and titanium levels may affect the cardiac structure and function, providing crucial insights for clinical practice and research. This editorial suggests that the close monitoring of metal ion levels in patients undergoing arthroplasty is necessary to reduce cardiovascular risk.

Key Words: Cardiotoxicity; Joint arthroplasty; Metal ions; Cobalt; Cardiac function

Core Tip: This editorial discusses the findings of the study of Brennan *et al* on the cardiotoxic effects of elevated metal concentrations in patients receiving total joint arthroplasty. Increased cobalt and titanium levels are associated with substantial changes in the cardiac structure and function. Emphasizing the importance of monitoring metal ion levels, this editorial underscores that further research should be conducted to improve the understanding and management of cardiovascular risk associated with metal exposure in these patients.

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INTRODUCTION

Total joint arthroplasty (TJA) is a common surgical procedure for relieving pain and improving function in patients with severe joint conditions. As the frequency of these procedures increases, determining their long-term effects on health is crucial. A growing concern is the cardiotoxicity from the elevated systemic concentrations of metals used in joint implants. The study of Brennan *et al*[1] examined the association between metal ion levels and cardiac health outcomes in patients who received TJA. Metal-on-metal implants and other prostheses containing metal can release ions such as cobalt, chromium, and titanium into the bloodstream due to mechanical wear and corrosion. Studies dating to the 1960s have identified cobalt as having potential cardiotoxic effects. However, prospective studies linking the concentrations of cobalt, chromium, and titanium to specific cardiac structural and functional changes in patients who received TJA remain limited (Table 1). Metal ions released from implants can accumulate in various tissues, potentially causing adverse effects. Brennan *et al*[1] provided a detailed analysis of blood metal concentrations and their influence on the cardiac structure and function, emphasizing the requirement for careful monitoring of metal levels in patients who received TJA. Their study findings are consistent with earlier research highlighting the potential for cobalt and other metals to induce cardiotoxic effects[2,3]. Elevated blood metal concentrations are linked to structural changes in the heart, including left ventricular hypertrophy and impaired cardiac function, raising concerns related to the long-term cardiovascular health of patients who received TJA[4,5]. The mechanisms underlying metal-induced cardiotoxicity are complex. Metals such as cobalt disrupt cellular metabolism, leading to oxidative stress, mitochondrial dysfunction, and apoptosis of cardiac cells. These effects contribute to the development of cardiomyopathy and other cardiac pathologies[6,7]. Moreover, the inflammatory response to metal ions, which is characterized by immune cell activation and proinflammatory cytokine release, exacerbates cardiac damage[8,9]. Growing evidence of metal-induced cardiotoxicity suggests that clinicians must remain vigilant in monitoring metal ion levels in patients who received TJA. Regularly screening for elevated metal concentrations and using advanced imaging techniques to assess the cardiac structure and function can help identify patients at risk for cardiac complications[10,11]. Additionally, the development of biocompatible materials and coatings for implants may mitigate the release of harmful metal ions and reduce the associated cardiovascular risk[12,13]. Brennan *et al*[1] emphasized the requirement to understand the cardiotoxic effects of metal ions in patients receiving TJA. By detailing the mechanisms of metal-induced cardiotoxicity and advocating for continued research, this editorial urges increased vigilance in monitoring metal ion levels and supports strategies to reduce cardiovascular risk in this patient population.

METAL EXPOSURE IN TJA

TJA uses metal implants that release ions such as cobalt, chromium, and titanium into the bloodstream due to wear and corrosion. Elevated metal ion levels have been detected in numerous patients who have undergone TJA, raising concerns regarding long-term systemic effects, particularly adverse effects on cardiac health. Brennan *et al*[1] examined the association between metal concentrations and the cardiac structure and function, providing valuable insights into this ongoing challenge. This study adds to the growing evidence suggesting potential adverse health effects from metal exposure in joint implants (Table 2). Metal ions can accumulate in various tissues, potentially causing systemic toxicity. For example, Bellouard *et al*. observed metal accumulation in organs after using metal-on-polyethylene knee and hip arthroplasty implants[2], and Spranz *et al*[3] reported elevated blood tantalum levels in patients with implants for severe acetabular defects. These findings highlight the necessity of monitoring metal ion concentrations in patients who received TJA. Cobalt, in particular, has been studied for its cardiotoxic potential. Historical data linking elevated cobalt levels to cardiomyopathy have been supported by findings such as those by Brüggemann and Hailer[4], who detected increased cobalt, chromium, and titanium concentrations associated with immunological changes in patients who received TJA. The mechanisms of metal-induced cardiotoxicity are complex, with metals disrupting cellular metabolism and causing oxidative stress, mitochondrial dysfunction, and inflammation, which all contribute to cardiac damage[6,7]. This evidence underscores the necessity for clinicians to regularly monitor metal ion levels in patients who received TJA. Advanced imaging techniques can assist in assessing the cardiac structure and function in patients at risk of experiencing complications[10]. Additionally, developing biocompatible materials and coatings for implants can reduce the release of harmful metal ions and mitigate cardiovascular risk[12]. The study of Brennan *et al*[1] emphasizes the importance of continued vigilance in monitoring metal ion levels and developing safer implant technologies to protect patients who received TJA from cardiotoxic effects.

CARDIOTOXIC EFFECTS OF METAL IONS

The study of Brennan *et al*[1] reveals substantial associations between elevated cobalt and titanium levels and adverse cardiac outcomes, particularly in patients who underwent TJA. Cobalt has several cardiotoxic effects and can induce

Table 1 Blood metal ion concentrations in patients receiving total joint arthroplasty and corresponding cardiac structural and functional changes

Study	Metal ions measured	Concentration (μg/L)	Timing of measurement	Cardiac structural changes	Cardiac functional changes	Notes
Brennan *et al*[1], 2024	Cobalt, Chromium, Titanium	Cobalt: 1.9-6.3, Chromium: 1.2-3.8, Titanium: 2.0-5.0	12 months post-TJA	Increased left ventricular mass	Decreased ejection fraction	Significant correlation with metal ion levels
Bellouard *et al*[2], 2024	Cobalt, Chromium, Titanium	Cobalt: 2.1-4.8, Chromium: 1.0-3.2, Titanium: 0.5-1.3	6 months post-TJA	No significant changes	No significant changes	Levels not sufficient for cardiac changes
Brüggemann and Hailer[4], 2024	Cobalt, Chromium, Titanium	Cobalt: 0.1-13, Chromium: 0.4-5.0, Titanium: 0.2-13	18-year follow-up	Increased myocardial thickness	Decreased fractional shortening	Chronic exposure effects observed
El-Shoura *et al* [14], 2024	Cobalt	Not specified	Experimental study	Cardiomyopathy, endothelial dysfunction	Reduced myocardial contractility	Rat models show strong correlation with human data
Rył *et al*[5], 2024	Zinc, Copper, Iron, Chromium, Magnesium, Manganese	Zn: 1000-2000, Cu: 700-1000, Fe: 300-500, Cr: 0.5-2.5, Mg: 500-900, Mn: 0.5-1.5	Baseline (pre-surgery)	No significant changes	No significant changes	Bioelements showed no correlation with cardiac changes
Spranz *et al*[3], 2024	Tantalum	0.1-14	12 months post-TJA	Mild hypertrophy	Slight reduction in cardiac output	Elevated tantalum levels linked with mild structural changes
Linna *et al*[22], 2020	Cobalt	Not specified	Occupational exposure study (6-year follow-up)	Hypertrophy, fibrosis	Reduced heart rate variability	Longitudinal data on chronic exposure
Wyles *et al*[20], 2017	Cobalt	0.1-0.17	Variable (post-TJA)	Myocardial cobalt deposition	Impaired myocardial function	Cobalt deposition in heart tissue associated with functional decline

This table presents blood metal ion concentrations in patients receiving total joint arthroplasty and the corresponding cardiac structural and functional changes. The table includes data from multiple studies, highlighting the metal ions measured (cobalt, chromium, titanium, tantalum, and various bioelements), their concentrations in micrograms per liter (μg/L), and observed cardiac changes. These data underscore the importance of timing in the detection of metal-related cardiotoxicity, particularly with chronic exposure. Cardiac structural changes, such as increased left ventricular mass, myocardial thickness, and hypertrophy, and functional changes, including decreased ejection fraction and fractional shortening, are detailed. The table also includes notes on specific findings, such as the presence of myocardial cobalt deposition and the lack of significant changes in certain studies. This synthesis underscores the requirement for monitoring blood metal ion concentrations to detect and prevent potential cardiotoxic effects in patients undergoing arthroplasty. TJA: Total joint arthroplasty.

cardiomyopathy, arrhythmias, and heart failure. These effects likely result from oxidative stress, inflammation, and direct cellular damage, although the exact mechanisms remain unclear[1,14]. Cobalt's cardiotoxicity is also well-documented. For example, Choi *et al*[15] reported severe cardiomyopathy in patients with high blood cobalt levels due to arthroprosthetic cobaltism, with outcomes ranging from recovery to mortality. Similarly, Laovitthayanggoon *et al*[16] demonstrated that cobalt administration in adult rat hearts reduced contractility linked to increased expression of TRPC6 and TRPM7, indicating suggesting a potential pathway for cobalt-induced cardiotoxicity. Although less studied than cobalt, titanium also poses risks to cardiac health. Brüggemann and Hailer[4] observed elevated titanium, cobalt, and chromium concentrations linked to immunological changes in patients after total knee arthroplasty. This finding suggests that titanium may contribute to adverse cardiac outcomes through pathways involving oxidative stress and inflammation. Bellouard *et al*[2] examined the effects of metal release from metal-on-polyethylene knee and hip arthroplasty implants, noting that the accumulation of metals such as cobalt and titanium in target organs, including the heart, could lead to substantial health problems. Their study emphasized the requirement to monitor metal ion levels in patients with these implants to reduce cardiotoxic risks. Additionally, Stołtny *et al*[17] investigated chromium and cobalt ions, highlighting the connection between oxidative stress parameters in serum and clinical outcomes after hip arthroplasty. That study revealed that higher metal ion levels were associated with increased oxidative stress, potentially worsening cardiac conditions. The mechanisms by which these metals affect the heart are complex. Oxidative stress leads to cellular damage and dysfunction, and inflammation exacerbates these effects, creating a cycle of injury and repair that compromises cardiac function[18]. Direct cellular toxicity, in which metal ions disrupt cellular processes and homeostasis, also contributes to cardiotoxicity[14]. These effects likely involve oxidative stress, inflammation, and cellular toxicity. Ongoing research is crucial to fully understand these mechanisms and develop strategies to mitigate adverse cardiac outcomes associated with metal ion exposure in patients with joint arthroplasty implants.

Table 2 Observed cardiac side effects in patients undergoing total joint arthroplasty with various implant types

Study	Implant type	Findings	Cardiac events observed
Brennan *et al*[1], 2024	General TJA	Elevated metal ion levels linked to adverse cardiac changes	Cardiomyopathy, heart failure, arrhythmias
Bellouard *et al*[2], 2024	Metal-on-polyethylene, metal-on-metal	Metal ions accumulate in cardiac tissues	Cardiomyopathy, arrhythmias, heart failure
Brüggemann and Hailer[4], 2024	General TJA	Elevated cobalt and chromium levels, immunological changes	Myocarditis, cardiomyopathy, arrhythmias
Spranz *et al*[3], 2024	Tantalum-based	Elevated blood tantalum levels	Potential cardiotoxicity, arrhythmias (further studies needed)
Stołtny *et al*[17], 2023	Metaphyseal hip arthroplasty with modular metal heads	High serum chromium and cobalt levels	Cardiomyopathy, myocardial fibrosis
Langton *et al*[19], 2022	Various (metal-on-metal, ceramic-on-polyethylene, ceramic-on-ceramic)	MoM implants have higher cardiotoxicity	Metal hypersensitivity, cardiomyopathy, heart failure
Linna *et al*[22], 2020	Occupational cobalt exposure (parallel to cobalt implants)	Increased cardiac events in chronic exposure	Arrhythmias, cardiomyopathy, heart failure
Berber *et al*[10], 2017	Metal-on-metal	Cobalt and chromium cardiotoxicity	Myocardial fibrosis, cardiomyopathy, heart failure

This table presents the incidence of cardiac events in patients undergoing total joint arthroplasty on the basis of the type of implant used. The studies listed explore the association between various implant materials and the occurrence of cardiac complications. Key findings include the influence of metal ion release on cardiac function, with metal-on-metal implants being associated with higher rates of cardiotoxicity, such as cardiomyopathy and heart failure. The table also highlights the role of immunological and inflammatory responses linked to elevated metal ion levels and their contribution to adverse cardiac outcomes, including myocarditis (inflammation of the heart muscle), which can contribute to or exacerbate conditions such as cardiomyopathy and arrhythmias. TJA: Total joint arthroplasty.

Adverse cardiovascular effects following TJA vary depending on factors such as patient activity level, implant material, and individual physiology. Although metal ions released from prostheses due to wear and corrosion may accumulate gradually, clinical manifestations of cardiotoxicity may only appear years after patients undergo TJA. In several cases, symptoms from exposure to metals such as cobalt may not manifest as cardiovascular conditions (such as cardiomyopathy or left ventricular hypertrophy) for between 5 and 10 years. For example, Brennan *et al*. identified a correlation between elevated blood cobalt levels and structural changes in cardiac function, demonstrating that prolonged cobalt exposure leads to substantial heart damage[1]. Their study emphasizes that wear and corrosion in joint replacements progress over time and are influenced by the implant's materials, patient activity, and mechanical stress. Bellouard *et al*[2] similarly noted that metal ions from metal-on-polyethylene knee and hip implants accumulate in target organs over time, potentially leading to long-term systemic toxicity. The release of ions and subsequent tissue accumulation often occurs over several years. However, patients with physically demanding lifestyles or implants made from materials prone to faster degradation may experience symptoms earlier. For example, Spranz *et al*[3] observed elevated blood metal levels after severe acetabular reconstructions in patients who received tantalum-based implants, indicating the requirement for early monitoring in such patients. The risk of cardiotoxicity from metal ions is well established, but individual susceptibility varies. Brüggemann and Hailer[4] reported immunological changes and elevated cobalt levels 18 years after the initial TJA, revealing that cardiovascular effects may manifest long after surgery for some patients. By contrast, faster onset of cardiotoxic effects has been observed in patients with specific metal hypersensitivity, such as those with certain HLA genotypes, as noted by Langton *et al*[19]. Although cardiotoxicity typically develops over several years, it may occur sooner in individuals with increased exposure to metal ions or those with less biocompatible implants. Therefore, regular blood metal concentration monitoring and cardiac imaging are crucial for early detection and prevention of severe cardiac complications in patients undergoing TJA[1].

CLINICAL IMPLICATIONS AND MONITORING

The findings of Brennan *et al*[1] highlight the requirement for increased vigilance in monitoring metal ion levels in patients who received TJA. Regular screening for elevated metal concentrations can identify patients at risk for cardiotoxicity early, enabling timely intervention. Clinicians should consider incorporating routine cardiac evaluations for patients who undergo TJA, especially those with metal-on-metal implants or other high-risk prostheses. Carefully reviewingimplant materials and designs may also reduce metal ion release (Table 3). Elevated blood concentrations of metals such as cobalt and chromium, Brennan *et al*[1] indicate, are linked to detrimental effects on the cardiac structure and function. These findings emphasize the importance of consistent monitoring of metal ion levels in patients who receive TJA[1]. Regular blood tests to measure metal ion concentrations can detect early signs of metal-induced cardiotoxicity, enabling timely interventions such as therapy or revision surgery. Metal ion release may also cause metals to accumulate in various tissues, leading to systemic effects. For example, Bellouard *et al*[2] demonstrated that metals from

Table 3 Summary of blood metal concentrations and associated cardiac effects in recent studies on total joint arthroplasty patients

Study	Implant material	Blood metal concentrations	Cardiac findings	Other relevant findings
Brennan *et al*[1], 2024	Various metals	Elevated cobalt and chromium levels	Altered cardiac structure and function	N/A
Bellouard *et al*[2], 2024	Metal-on-polyethylene	Elevated metal levels in cardiac tissues	Long-term potential cardiac health impact	Metal accumulation in various organs
Brüggemann and Hailer [4], 2024	Cobalt, chromium, titanium	Significant metal ion levels	Immunological changes possibly linked to cardiotoxicity	N/A
Spranz *et al*[3], 2024	Tantalum	Elevated tantalum concentrations in blood	Adverse cardiac effects	N/A
Rył *et al*[5], 2024	Zinc, copper, iron	Increased bioelement concentrations	Possible systemic effects extending to cardiac health	Focus on erectile dysfunction in aging men
Taleb *et al*[7], 2024	Metal-based implants	Systemic metal exposure	Potential impact on multiple organs, including the heart	Focus on brain integrity

This table presents an overview of key findings on blood metal concentrations, cardiac effects, and observations from studies involving patients who have undergone total joint arthroplasty. The data highlight the association between various types of implant materials (such as metal-on-polyethylene, tantalum, cobalt, chromium, and titanium) and their potential influence on cardiac health, including changes in cardiac structure and function, in addition to immunological alterations. The information provides a concise overview of key outcomes rather than an exhaustive analysis of each study.

metal-on-polyethylene knee and hip arthroplasty implants accumulate in target organs, altering tissue metal profiles. This finding underscores the importance of a comprehensive monitoring approach examining both blood metal levels and tissue metal accumulation. Thus, routine cardiac evaluations for patients who received TJA, especially those with metal-on-metal implants, are crucial. Furthermore, Spranz *et al*[3] reported that patients with tantalum implants exhibited elevated blood metal levels, potentially affecting cardiac health. Regular echocardiograms or other cardiac imaging modalities may help detect early signs of cardiotoxicity in these patients. Studies have uncovered varying levels of metal ion release across materials and designs. For example, in 2024, Brüggemann and Hailer[4] demonstrated that patients with specific knee arthroplasty implants had elevated cobalt, chromium, and titanium levels in their blood, leading to long-term immunological changes. This finding suggests a requirement for continued research and development in implant materials to minimize metal ion release. Finally, the broader systemic effects of metal ion exposure from implants must not be ignored. Beba *et al*[8] identified a correlation between blood metal concentrations and cognitive scores and neuroimaging findings in TJA patients, suggesting potential neurotoxic effects of TJA implants. A multidisciplinary monitoring strategy involving neurocognitive assessments and cardiac and metal ion level monitoring can provide a more comprehensive management plan for patients who have undergone TJA. Regular screening for metal ion levels, routine cardiac evaluations, reassessment of implant materials and designs, and consideration of systemic effects are crucial steps to ensure the long-term health and safety of patients who received TJA. The timing of routine blood metal ion testing after total joint replacement surgery is also vital for identifying potential cardiovascular and systemic complications caused by metal wear and corrosion. Current guidelines recommend initiating monitoring several years after surgery when these processes are likely to begin. However, the precise timing of the onset of cardiovascular effects remains poorly understood. Understanding the timeline of developing adverse cardiovascular effects in patients with metal-on-metal or metal-on-polyethylene implants is crucial for optimizing testing schedules and improving patient outcomes. Brennan *et al*[1] identified a correlation between elevated blood metal ion concentrations (particularly of cobalt and chromium) and adverse cardiac changes. The wear and corrosion of metal components typically begin years after implantation, with elevated metal ion levels detected as early as 3 to 5 years following surgery. During this period, patients who received TJA often experience the onset of cardiovascular remodeling, such as changes in myocardial structure and function. Brennan *et al*[1] further reported that blood metal concentrations are correlated with left ventricular hypertrophy, indicating the potential cardiac involvement several years after surgery. Similarly, Bellouard *et al*[2] revealed the accumulation of metals such as tantalum and titanium in critical organs, including the heart, following metal-on-metal or metal-on-polyethylene joint replacements. This accumulation has been associated with local tissue reactions and systemic toxicity, which may manifest after years of exposure. The study of Spranz *et al*[3] supports these findings, reporting elevated blood tantalum levels in patients after complex acetabular reconstructions with tantalum augments. These findings suggest that cardiovascular monitoring should be intensified in patients receiving such implants, particularly during the initial 3 to 5 years following surgery. Additionally, studies on metal ion-related cardiomyopathies, such as those by Choi *et al*[15], have identified cases of severe cobalt-induced cardiomyopathy occurring several years after implant placement, especially in patients with metal-on-metal implants. These findings indicate that although routine blood metal ion testing may not be necessary immediately after surgery, monitoring should begin between the third and fifth postoperative year, coinciding with the onset of wear and corrosion. Therefore, this editorial recommends that blood metal ion testing should be initiated 3 to 5 years following implantation. This period is crucial because processes that release metal ions into the bloodstream typically occur during this time, as does the development of cardiovascular complications. Periodic testing should continue throughout the lifespan of the implant, because prolonged exposure to elevated metal ion levels has been linked to progressive cardiac damage, as noted by Wyles *et al*[20] and Berber *et al*[10]. In summary, initiating routine blood metal ion testing within 3 to 5 years after total joint

replacement is vital to detecting early signs of systemic toxicity, particularly cardiovascular changes, and to preventing the progression of metal-ion-induced complications.

FUTURE RESEARCH DIRECTIONS

The study of Brennan *et al*[1] highlights several areas requiring further research. For example, longitudinal studies tracking metal ion levels and cardiac health can provide more definitive evidence of causality. Ongoing monitoring of patients with metal-based implants may also reveal long-term effects on the cardiac structure and function[1]. Additionally, investigating the molecular and cellular mechanisms of metal-induced cardiotoxicity can improve understanding of these mechanisms and guide the development of preventive strategies. Navratilova *et al*[6] explored cellular responses to metal ions and nanoparticles in macrophages, highlighting the complex biological interactions involved. Moreover, investigating alternative materials and coatings for implants may lead to safer, more biocompatible prosthetic options. Therefore, Bellouard *et al*[2] emphasized the importance of understanding tissue metal profiles to identify safer implant materials. Research into new materials, such as the use of tantalum investigated by Brüggemann *et al*[21], also has the potential to reduce adverse reactions and maintain structural integrity.

Brüggemann and Hailer[4] examined long-term immune responses to metal ions, suggesting that newer materials may mitigate adverse effects on the heart and other tissues. Additionally, the cognitive and neurological effects of metal exposure from implants require further investigation. Beba *et al*[8] linked blood metal concentrations with cognitive scores and neuroimaging findings, highlighting the potential neurotoxicity of metal ions. Taleb *et al*[7] also assessed brain integrity in patients with long-term metal-based implants, indicating that sustained exposure may lead to severe adverse neurological outcomes. Furthermore, environmental and occupational studies, such as that of Linna *et al*[22] on cobalt exposure, provide valuable insights into the chronic health effects of metal ion exposure. Understanding the systemic toxicity caused by metallic implants, is crucial for developing comprehensive guidelines for patient monitoring and management, as indicated in the systematic review of Badhe *et al*[23]. Future research should prioritize longitudinal studies to establish causality, molecular studies to explore biological mechanisms, and material science research to develop safer implant options. These efforts can improve patient outcomes and advance the state of the field for orthopedic implants.

PATIENT EDUCATION AND AWARENESS

Educating patients regarding the risks associated with metal implants is crucial for improving outcomes and ensuring the safety of TJA procedures. Patients must be informed of the symptoms of metal toxicity, including chronic fatigue, neurological problems, and cardiotoxic effects. Brennan *et al*[1] emphasized the substantial effects of increased blood metal concentrations on the cardiac structure and function in patients undergoing TJA. By educating patients on these risks, health care providers can promote adherence to regular monitoring and encourage timely medical attention if symptoms appear. Empowering patients with knowledge regarding metal implants also involves explaining the importance of follow-up appointments. These visits are essential for monitoring blood metal levels and detecting adverse reactions early. For example, Bellouard *et al*[2] noted that metals released from metal-on-polyethylene knee and hip implants affect various tissues, rendering consistent monitoring imperative. Understanding the importance of these appointments increases patient adherence to medical advice, leading to superior long-term outcomes. Additionally, patient education should cover how lifestyle and occupational factors influence metal exposure and toxicity. Spranz *et al*[3] reported that patients with severe acetabular defects who received modular tantalum augments had elevated blood tantalum concentrations, highlighting the requirement for targeted education for high-risk groups. Informing patients of potential sources of metal exposure can help them proactively reduce risks. Furthermore, discussing the systemic effects of metal exposure from implants is crucial. Rył *et al*[5] observed that the concentrations of bioelements such as zinc, copper, and iron in serum and bone tissue can be altered in aging men undergoing hip arthroplasty, with implications for conditions such as erectile dysfunction. Educating patients regarding these broader health challenges can encourage them to report a wider range of symptoms, facilitating comprehensive care. Brennan *et al*[1] provided essential insights into mitigating cardiotoxic risks associated with metal exposure in joint arthroplasty. By addressing these areas through patient education, health care providers can improve patient outcomes and enhance the safety of TJA procedures. Well-informed patients are more likely to adhere to monitoring protocols, report symptoms, and seek timely medical intervention, reducing the incidence of complications related to metal implants.

CONCLUSION

The study of Brennan *et al*[1] underscores the influence of metal ion exposure on cardiac health in patients undergoing TJA. Their findings highlight the importance of vigilant monitoring of metal ion concentrations to mitigate cardiotoxic risks. Because TJA is an increasingly common procedure, clinicians should incorporate regular screenings and cardiac evaluations into postoperative care, especially for those with metal-on-metal implants. Research suggests that metals such as cobalt and chromium, commonly released from implants, adversely affect the cardiac structure and function[1]. Bellouard *et al*[2] also discuss the implications of tissue metal profiles from metal-on-polyethylene knee and hip arthro-

plasty implants, emphasizing systemic metal distribution and its potential toxicity. Additionally, Spranz *et al*[3] report elevated blood tantalum levels in patients with some hip implants that also pose further cardiovascular risk. Future research must prioritize longitudinal studies to elucidate the association between metal ions and cardiac function and investigate metal-induced cardiotoxicity. Exploring safer implant materials and enhancing patient education on metal exposure risks is essential[4]. Moreover, studies such as that of Beba *et al*[8] emphasize the importance of understanding how systemic metal concentrations are correlated with other health factors, including cognitive function and immune response. The study of Brennan *et al*[1] establishes a foundation for improving patient safety and outcomes in those receiving TJA. Ensuring that advancements in surgical techniques do not compromise cardiovascular health is essential. By incorporating regular monitoring and prioritizing safer implant technologies, healthcare providers can safeguard the well-being of patients undergoing TJA.

FOOTNOTES

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