

Successful Management Of Various Manifestations Of BCIS During Cemented Hemiarthroplasty Surgery

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ABSTRACT

Bone Cement Implantation Syndrome (BCIS) is a known but potentially life-threatening complication occurring during cemented arthroplasty procedures. An observational study of 80 patients was conducted for 6 months from July 2025 to December 2025. This case series presents four patients who developed varying manifestations of BCIS during cemented total knee replacement, cemented total hip replacement, and cemented hemiarthroplasty. The patients, aged 50 to 90 years, had diverse clinical backgrounds, including hypertension, diabetes Mellitus, hypothyroidism, and hypertrophic obstructive cardiomyopathy (HOCM). While all patients had normal preoperative laboratory parameters and electrocardiograms (ECG), the below mentioned patients exhibited distinct intraoperative responses post-cementation. In the first case, a 48-year-old female developed hypotension (80/50 mmHg) and bradycardia (50 bpm), which was managed with intravenous fluids and vasopressors. The second case, 70-year-old male presented with acute confusion and oxygen desaturation (85%), requiring oxygen therapy and postoperative monitoring. The third case, 55-year-old female experienced hypotension (90/50 mmHg), tachycardia (110 bpm), and desaturation (98% to 88%), diagnosed as an anaphylactic reaction, successfully managed with antihistamines, fluids, and oxygen. The fourth case, most severe case involved 90-year-old female who developed cardiac arrest following cementation. She required Advanced Cardiac Life Support (ACLS) measures, intubation, noradrenaline support, and prolonged ICU care, but was successfully weaned off ventilation and mobilized. This case series highlights the spectrum of BCIS severity, the importance of intraoperative vigilance, and the critical role of immediate resuscitative measures in improving patient outcomes. Early recognition, multidisciplinary perioperative planning, and prompt intervention remain essential for managing BCIS effectively.

Keywords: Cemented Hemiarthroplasty, Bone Cement Implantation Syndrome, Hypotension, Anaphylaxis, Resuscitation.

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INTRODUCTION

Hemiarthroplasty and total joint replacement surgeries are commonly performed to treat joint diseases, particularly for elderly patients suffering from hip fractures or severe osteoarthritis of hip and knee joints. Cemented hemiarthroplasty is a widely used surgical procedure for managing fractures of the hip, such as those involving the femoral neck, particularly in

geriatric patients. This procedure involves the insertion of a prosthesis into the femoral head, followed by the use of bone cement to anchor the implant, ensuring immediate fixation. Although this procedure has a high success rate, it is not without its complications, particularly when patients are elderly or present with comorbid conditions. [1]

The surgical management of these patients requires precise planning and careful consideration of the anesthetic techniques, especially given the often fragile nature of their physiological reserves. One key aspect of the surgery is the administration of anesthesia, which can present several challenges, especially with the combined spinal and epidural anesthesia often used for these procedures. While regional anesthesia is generally preferred due to its lower complication rates, it also has its share of potential risks, including hypotension, bradycardia, and respiratory issues, particularly during the cementing phase of the surgery. [2]

Blood pressure instability is one of the most common complications observed during cemented hemiarthroplasty surgeries. The use of bone cement during the procedure can lead to the release of embolic particles, which may cause a variety of hemodynamic changes. Such changes can include a sudden drop in blood pressure, which can be exacerbated by the anesthetic agents and the patient's underlying medical conditions. This condition, termed "bone cement implantation syndrome" (BCIS), is a major cause of perioperative morbidity and mortality in patients undergoing joint replacement surgeries. [3]

BCIS is a complex phenomenon that includes a range of clinical manifestations such as hypotension, bradycardia, hypoxia, and in severe cases, cardiac arrest. It is believed to be caused by the release of embolic material, such as fat, cement particles, or air, during the pressurization phase of cementing. The embolic material may reach the pulmonary or systemic circulation, causing a sudden drop in cardiac output, thereby precipitating a series of acute cardiovascular events. However, the exact pathophysiology of BCIS remains poorly understood, and there is ongoing research to determine the most effective preventive and therapeutic measures. [4]

The incidence of BCIS varies widely across studies, with some reports indicating that up to 30% of patients undergoing cemented hip arthroplasty experience some form of BCIS. The mortality rate associated with severe BCIS is estimated to be around 10%. Several risk factors have been identified, including advanced age, obesity, preexisting cardiac conditions, and the use of high-pressure cementing techniques. Additionally, regional anesthesia, while generally safe, may exacerbate the hemodynamic instability seen in BCIS due to its effects on sympathetic and vascular tone. [5]

In addition to hemodynamic instability, other complications that may arise during cemented hemiarthroplasty include pulmonary complications

such as desaturation and respiratory distress. The elderly population, in particular, is at a higher risk of these complications due to their reduced pulmonary reserve. Factors such as pre-existing lung disease, poor nutritional status, and impaired ventilatory response to anesthesia can further increase the likelihood of respiratory complications during and after surgery. [6]

Acute anaphylactic reactions are another potential complication during cemented hemiarthroplasty, albeit rare. These reactions may be triggered by medications used during surgery, including antibiotics, muscle relaxants, or local anesthetics. The symptoms of anaphylaxis may overlap with those of BCIS, making it challenging to distinguish between the two. Prompt recognition and treatment are essential to ensure favorable patient outcomes. [7]

The management of these complications requires a multi-disciplinary approach involving the surgical team, anesthesiologists, and intensive care specialists. Effective management strategies include the use of hemodynamic support, such as fluid resuscitation and vasopressors, as well as advanced airway management in cases of respiratory distress. In addition, monitoring techniques such as continuous pulse oximetry, capnography, and invasive blood pressure monitoring are essential to detect and treat complications promptly. [8,9]

Despite the knowledge of these risks and complications, there is a lack of standardized protocols for the management of BCIS and related events during cemented hemiarthroplasty. Many clinical decisions, including the timing of interventions and the choice of medications, are made on a case-by-case basis. As a result, there is considerable variation in the management approaches across hospitals and surgical teams. [10]

This case report aims to highlight the successful management of various manifestations of BCIS during cemented hemiarthroplasty surgeries. By presenting four cases of patients who underwent cemented hemiarthroplasty, this report will explore the clinical challenges posed by BCIS and provide insight into the effective interventions that can be used to address these complications. The objective of this study is to improve awareness of BCIS and its management, with the ultimate goal of improving patient outcomes in patients undergoing cemented joint replacement surgeries.

CASE PRESENTATION

Case 1:

A 48-year-old woman with no known comorbidities presented with grade 4 osteoarthritis of the right knee and was scheduled for total knee replacement. Her

preoperative laboratory parameters and electrocardiogram (ECG) were within normal limits. She was administered combined spinal-epidural anesthesia and remained hemodynamically stable as the surgery commenced. Continuous monitoring was done throughout the procedure. Following the insertion of the prosthesis, cementing was performed. However, within three minutes, the patient experienced a sudden drop in blood pressure to 80/50 mmHg and bradycardia with a heart rate of 50 bpm. Immediate resuscitative measures were initiated, including the administration of 100% oxygen and intravenous fluids. Ephedrine was given in incremental doses intravenously. The patient remained conscious, oriented, and obeying commands throughout the episode. With adequate resuscitation, her hemodynamic parameters stabilized, and she was closely monitored postoperatively for 24 hours without any further complications.

Case 2:

A 70-year-old male with a history of hypertension, well-controlled with Amlodipine 5 mg once daily for the past 10 years, presented with a fracture of the neck of the femur on the left side and was scheduled for cemented hemiarthroplasty. His preoperative laboratory parameters and electrocardiogram (ECG) were within normal limits. He was administered combined spinal-epidural anesthesia, under which he remained hemodynamically stable. The surgery commenced, and following the insertion of the prosthesis, bone cementing was performed. Approximately five minutes post-cementation, the patient began speaking irrelevantly and desaturated to 85% SpO₂. Surgery was immediately stopped, and resuscitation measures were initiated, including 100% oxygen administration. A cardiovascular examination was normal, and the patient remained hemodynamically stable. After 10 minutes, the patient regained consciousness but remained disoriented. He was shifted postoperatively to the surgical intensive care unit (ICU) for further monitoring. Over the next 24 hours, the patient regained full consciousness and orientation but continued to require oxygen therapy (3-5 L/min via face mask). Serial arterial blood gas (ABG) analyses were normal. Postoperative management included deep breathing exercises, incentive spirometry, and adequate epidural analgesia, which contributed to improved lung function. The recovery was uneventful, and the patient stabilized without further complications.

Case 3:

A 55-year-old female patient with left hip osteoarthritis was scheduled for cemented total hip replacement. She had a history of hypothyroidism,

diagnosed four years ago, and was on Tab. Thyronorm 25 mcg. Preoperative laboratory parameters and electrocardiogram (ECG) were within normal limits. The patient received combined spinal-epidural anesthesia and remained hemodynamically stable as surgery commenced. During bone cementing, the patient developed itching, acute hypotension (BP 90/50 mmHg), tachycardia (HR 110 bpm), and a drop in oxygen saturation from 98% to 88%. Despite the desaturation, there were no signs of respiratory distress, and a physical examination showed no breathing difficulties. ECG remained normal, ruling out a pulmonary embolism. The clinical picture suggested an acute anaphylactic reaction, which was promptly managed with 100% oxygen administration, rapid intravenous fluid resuscitation, and antihistamine therapy (Injection Pheniramine). The patient stabilized within 15 minutes, with no loss of consciousness, angioedema, or urticarial rash. The surgical procedure was successfully completed, and the patient was shifted to the intensive care unit (ICU) for 24-hour postoperative monitoring. The postoperative course remained uneventful, with no further complications.

Case 4:

A 90-year-old elderly female presented with a basicervical neck of femur fracture on the right side following a self-fall and was scheduled for cemented bipolar hemiarthroplasty. She had a history of hypertension diagnosed three months ago, controlled with Tab. Metoprolol XL 25 mg, and pre-existing hypertrophic obstructive cardiomyopathy (HOCM) with an ejection fraction (EF) of 58% and METS <4. The patient also experienced breathlessness one day after the fall. On general examination, she was conscious and oriented, with a blood pressure of 130/70 mmHg, heart rate of 88 bpm, and SpO₂ of 98% with 5 L of oxygen but only 80% on room air. Bilateral wheezing was present on auscultation, though cardiac evaluation was normal. Preoperative airway assessment revealed Mallampati grade 4, partially edentulous status, and loose teeth in the left upper and lower second premolars. Laboratory investigations showed hemoglobin of 11.7 g/dL and sodium of 130 mmol/L, while ECG showed T wave inversion in V₁, V₅, and V₆ with normal sinus rhythm. 2D echocardiography revealed HOCM with asymmetric septal hypertrophy, a left outflow tract (LOVT) gradient of 108 mmHg at rest, grade 1 left ventricular diastolic dysfunction (LVDD), and mild to moderate tricuspid regurgitation (TR).

Considering the high-risk nature of the case, written informed consent was obtained, and the patient was classified as ASA 3. Preoperative preparation included

Tab. Rantac 150 mg, Tab. Anxit 0.5 mg, and 8 hours of nil per oral (NPO) status. Her antihypertensive was switched to Tab. Cilnidipine 10 mg OD, which was continued on the day of surgery. Preoperative nebulization with Duolin and Budesonide was administered. On the day of surgery, the pre-anesthetic checkup was reviewed, the workstation was checked, and emergency drugs, as well as cross-matched blood products, were kept ready.

Baseline intraoperative monitoring recorded BP of 110/80 mmHg, PR of 96 bpm, and SpO₂ of 97% with 5 L of oxygen (84% on room air). Two IV lines (20G and 18G) were secured, and ASA standard monitoring was applied. A sole epidural anesthesia technique was planned, the epidural catheter was secured at L2-L3, Test dose with 1.5% lignocaine and 1:200000 adrenaline 3ml was given, isobaric Ropivacaine 0.5% with fentanyl (20 mcg), Sensory blockade reached T10, and the patient was stable as surgery commenced.

After the bipolar prosthesis was inserted, bone cementing was performed, following which the patient deteriorated hemodynamically, with a BP drop to 80/48 mmHg, SpO₂ desaturation to 81%, and subsequently became unresponsive. The surgery was immediately halted, and the wound was packed. Oxygen flow was increased to 10 L/min, and bag-mask ventilation was initiated. However, the patient continued to desaturate to 60%, followed by cardiac arrest with no cardiac activity. Cardiopulmonary resuscitation (CPR) was initiated as per ACLS protocol, with Inj. Atropine 0.6 mg and Inj. Adrenaline 1 mg administered, and CPR was continued. Inj. Hydrocortisone 200 mg was also administered. The patient was immediately intubated with a 6.5 mm oral endotracheal tube (ETT) and was ventilated with oxygen and air.

After two cycles of CPR over 10 minutes, return of spontaneous circulation (ROSC) was achieved, but the patient remained hemodynamically unstable. Noradrenaline infusion (0.16 mg/cc at 5 mL/hr) was started, and SpO₂ improved to 94% on controlled ventilation, with a heart rate of 100 bpm. The surgery was completed under general anaesthesia with intermittent muscle relaxant and the patient was shifted to the surgical ICU (SICU) with BP of 106/74 mmHg on inotropic support, receiving volume-controlled ventilation (TV: 325 mL, RR: 14 cpm, PEEP: 5 cmH₂O). Postoperative ABG and ECG were normal.

Over the following postoperative period, the patient regained consciousness and was started on Inj. Methylprednisolone 40 mg BD and Inj. Furosemide 40 mg OD. She continued nebulization with Salbutamol

and Budesonide. Epidural analgesia with Ropivacaine 0.065% was provided, and RT feeds (200 mL of clear liquid every 4 hours) were initiated. The patient was hemodynamically stable, and inotropic support was tapered and discontinued by postoperative day (POD) 2. The epidural catheter was removed aseptically, but weaning trials were unsuccessful until POD 5. Serial ABGs remained normal, and the patient was successfully extubated on POD 6 after spontaneous breathing trials. She was able to maintain SpO₂ between 89-93% on room air and 97-98% with 4 L oxygen, with normal vesicular breath sounds on auscultation. Post-extubation, the patient was started on chest physiotherapy, and oral feeding was reintroduced. She was monitored in the SICU until POD 7, after which she was shifted to the ward and was gradually mobilized.

DISCUSSION

Bone Cement Implantation Syndrome (BCIS) remains a significant intraoperative challenge in cemented hemiarthroplasty, particularly among elderly patients with multiple comorbidities. In our case, a 48-year-old woman undergoing cemented total knee replacement (TKR) developed BCIS with hypotension (80/50 mmHg) and bradycardia (50 bpm) post-cementation, which was successfully managed with oxygen therapy and ephedrine administration. A recent study by Sullivan et al. (2024) [10] reported a case of BCIS during revision TKR, where a patient suffered bradycardia and hypotension following cement application, progressing to pulseless electrical activity (PEA) arrest and mortality despite aggressive resuscitation. This highlights the variability in BCIS severity and outcomes. The mortality rate associated with severe BCIS is estimated at 6% of affected patients according to Rassir et al. (2020). Hypotension is a key manifestation of BCIS, occurring in 28% of TKA cases, as reported by Rassir et al. (2020) [11]. Our case aligns with the findings of Sahi et al. (2023) [12], where BCIS-related hypotension and hypoxia were common intraoperative complications in cemented TKR and hip arthroplasty. Our successful management with incremental vasopressors and vigilant monitoring reinforces the importance of early intervention. The role of anesthesia in BCIS severity is also crucial. Rao et al. (2021) [13] found that neuraxial anesthesia significantly reduces BCIS risk compared to general anesthesia, with a 71% BCIS incidence under general anesthesia versus 27% with neuraxial techniques. Our case, performed under combined spinal-epidural anesthesia, aligns with this protective effect, possibly contributing to the patient's rapid recovery.

Our case highlights a 70-year-old male with a history of well-controlled hypertension who developed BCIS grade 1 (transient hypoxia and confusion) after cementation, which was successfully managed with oxygen therapy and postoperative supportive care. Recent studies report BCIS incidence ranging from 26% to 37% in cemented hemiarthroplasty cases, with varying severity (Weingärtner et al., 2021, Rassir et al., 2020) [14,11]. In a study by Yuenyongviwat et al. (2024) [15], BCIS grade 1 was observed in only 4.18% of patients, with no instances of severe BCIS, supporting the generally favorable outcomes seen in our case. Our patient developed desaturation (85% SpO₂) and confusion without hemodynamic compromise, similar to reports by Gunawan et al. (2021) [16], where prompt oxygen therapy led to successful recovery. In contrast, severe BCIS cases often present with cardiac arrest or hemodynamic collapse, as observed in Dradjat et al. (2020) [17]. The use of neuraxial anesthesia in our case likely played a protective role, as Zastrow et al. (2024) reported a lower BCIS incidence with neuraxial anesthesia (19%) compared to general anesthesia (55%) [18]. This supports the importance of anesthetic choice in mitigating BCIS risks.

In our case, a 55-year-old female undergoing cemented total hip replacement (THR) developed itching, acute hypotension (90/50 mmHg), tachycardia (110 bpm), and desaturation (88% SpO₂) post-cementation. Given the absence of respiratory distress and ECG abnormalities, a differential diagnosis of an anaphylactic reaction was made and successfully managed with oxygen therapy, fluid resuscitation, and antihistamines. A recent study by Sahi et al. (2023) [12] reported that BCIS occurred in 26% of cemented hip arthroplasty cases, with hypotension and hypoxia being the most common manifestations. Our patient's presentation aligns with Grade 1 BCIS, characterized by transient hypoxia and hypotension. The study also emphasizes the importance of early intervention, with successful outcomes in 92% of patients receiving immediate resuscitation. In contrast, Weingärtner et al. (2021) [14] found that 37% of BCIS cases in cemented hip arthroplasty had severe cardiovascular complications, with a 15.6% in-hospital mortality rate. This highlights the spectrum of BCIS severity, where prompt management, as demonstrated in our case, is crucial for patient stabilization. While anaphylaxis is not commonly associated with BCIS, Zhou et al. (2021) reported a similar case where a patient undergoing cemented THR developed acute hypotension and hypoxia post-cementation, requiring intensive cardiovascular support [19]. Our case deviates from the typical BCIS course due to the absence of loss of consciousness and the rapid

response to antihistamine therapy, supporting the likelihood of an allergic response to bone cement components rather than embolic-mediated BCIS.

Our case highlights a 90-year-old high-risk female with pre-existing hypertrophic obstructive cardiomyopathy (HOCM) and respiratory compromise who developed BCIS following cementation, leading to cardiac arrest, requiring aggressive resuscitation and prolonged ventilatory support. A recent study by Gunawan et al. (2021) identified advanced age, pre-existing cardiovascular disease, and pulmonary pathology as primary risk factors for BCIS [16]. Their case of an 83-year-old undergoing cemented hemiarthroplasty similarly experienced sudden hemodynamic deterioration post-cementation, requiring immediate intervention. The incidence of BCIS in elderly patients is estimated at 26-31%, with severe BCIS (Grade 3) occurring in 6% of cases (Rassir et al., 2020) [11]. Zastrow et al. (2024) [18] analyzed anesthetic factors in BCIS development and found that neuraxial anesthesia significantly reduces the risk compared to general anesthesia, with BCIS incidence only 19% in neuraxial anesthesia compared to 55% in general anesthesia. Our patient received sole epidural anesthesia, which may have mitigated the severity of BCIS but did not prevent it entirely due to her high-risk profile. The use of vasopressors, high-flow oxygen, and fluid resuscitation remains critical in BCIS management. In cases of cardiac arrest due to BCIS, Ifran et al. (2020) reported a mortality rate of 0.5-1.7%, emphasizing the importance of preoperative optimization, intraoperative vigilance, and post-resuscitation support. Our case highlights successful resuscitation despite cardiac arrest, prolonged ventilation, and a challenging postoperative course, with eventual full recovery.

CONCLUSION

Bone Cement Implantation Syndrome (BCIS) manifests in varying severities, from mild transient hypotension and hypoxia to severe cardiovascular collapse and cardiac arrest. Our four cases highlight the diverse clinical presentations and management strategies necessary for successful outcomes. Mild cases (Case 1 and Case 2) involving a 48-year-old female and a 70-year-old male demonstrated transient hypotension, bradycardia, and hypoxia post-cementation, which were effectively managed with oxygen therapy, fluid resuscitation, and vasopressor support, leading to uneventful recoveries. Case 3, a 55-year-old female undergoing total hip replacement, presented with itching, acute hypotension, tachycardia, and desaturation, which responded rapidly to antihistamines, suggesting a possible

hypersensitivity reaction rather than classic BCIS, reinforcing the importance of differential diagnosis. In contrast, Case 4, a 90-year-old female with hypertrophic obstructive cardiomyopathy (HOCM), suffered severe BCIS with cardiac arrest, requiring ACLS and prolonged ventilatory support; however, with aggressive resuscitation and ICU management, she achieved full recovery. These cases emphasize the need for thorough preoperative risk assessment, as studies suggest that neuraxial anesthesia may reduce BCIS severity compared to general anesthesia. Early recognition, intraoperative vigilance, and prompt resuscitative measures, including oxygen supplementation, fluid optimization, and vasopressor administration, are critical in improving outcomes. Severe BCIS remains life-threatening, but with timely ACLS intervention and ICU support, survival is possible. Given the unpredictable nature of BCIS, future research should focus on refining risk stratification tools, optimizing intraoperative management, and exploring alternatives to cemented prostheses to enhance patient safety in orthopedic surgery.

REFERENCES

1. Dradjat RS, Pradana AS, Putra DP, Pandiangan RA, Cendikiawan F, Mustamsir E. Successful management of severe manifestation bone cemented implantation syndrome during hemiarthroplasty surgery in patient with multiple comorbidities: A case report. *International Journal of Surgery Case Reports*. 2021 Jan 1;78:331-5.
2. Dhillon M, Garg SK, Jindal R, Anand L, Gupta S. What is the Incidence of Bone Cement Implantation Syndrome in Elderly patients Undergoing Cemented Stem Hemiarthroplasty? An Evaluation of 40 Patients. *Indian Journal of Orthopaedics*. 2024 Dec 12:1-7.
3. Bonfait H, Delaunay C, De Thomasson E, Tracol P, Werther JR. Bone cement implantation syndrome in hip arthroplasty: Frequency, severity and prevention. *Orthopaedics & Traumatology: Surgery & Research*. 2022 Apr 1;108(2):103139.
4. Jain S, Pal A, Jain M, Ajmera A. Incidence and risk for Cement Implantation Syndrome after hemiarthroplasty. *Orthopaedic Journal of MP Chapter*. 2019 Dec 31;25(2):77-81.
5. Bhadani JS, Kumar I, Ahmed W, Kumar S, Kumar A. Hemodynamic Effects of Bone Cement Implantation in Hip Arthroplasty: Insights from a Prospective Study in Eastern India. *Journal of Orthopaedic Case Reports*. 2024 Aug;14(8):212.
6. Fu M, Shen J, Ren Z, Lv Y, Wang J, Jiang W. A systematic review and meta-analysis of cemented and uncemented bipolar hemiarthroplasty for the treatment of femoral neck fractures in elderly patients over 60 years old. *Frontiers in Medicine*. 2023 Feb 2;10:1085485.
7. Rao SS, Suresh KV, Margalit A, Morris CD, Levin AS. Regional or neuraxial anesthesia may help mitigate the effects of bone cement implantation syndrome in patients undergoing cemented hip and knee arthroplasty for Oncologic indications. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*. 2022 Feb 1;30(3):e375-83.
8. Bökeler U, Bühler A, Eschbach D, Ilies C, Liener U, Knauf T. The influence of a modified 3rd generation cementation technique and vacuum mixing of bone cement on the bone cement implantation syndrome (BCIS) in geriatric patients with cemented Hemiarthroplasty for femoral neck fractures. *Medicina*. 2022 Nov 3;58(11):1587.
9. Patil SS, Kotwani M, Lele SS, Dhamangaonkar AC. Comparison of haemodynamic parameters in two different geriatric age groups undergoing cemented bipolar hemiarthroplasty. *International Journal of Research in Medical Sciences*. 2019 Dec;7(12):4656.
10. Sullivan C, Russo CM, Wilson L, Dennig S, Coleman P. Total Knee Arthroplasty Revision in the Setting of Periprosthetic Joint Infection Resulting in Bone Cement Implantation Syndrome (BCIS), Pulseless Electrical Activity (PEA) Arrest, and Intraoperative Death: A Case Report and Literature Review. *Cureus*. 2024 Apr;16(4).
11. Rassir R, Schuiling M, Sierevelt I, van der Hoeven CW, Nolte P. What are the frequency, related mortality, and factors associated with bone cement implantation syndrome in arthroplasty surgery? *Clin Orthop Relat Res*. 2020.
12. Sahi G, Sameer G, Vikas S, Aman S. Role of bone cement in development of hypoxia and hypotension intraoperatively in patients of cemented total hip arthroplasty and cemented bipolar hemiarthroplasty. *Glob J Res Anal*. 2023.

13. Rao SS, Morris CD, Levin A. The effect of anesthetic regimen on bone cement implantation syndrome in cemented hemiarthroplasty for hip fracture. *J Am Acad Orthop Surg.* 2024.
14. Weingärtner M, Zacharowski K, Meybohm P. Bone cement implantation syndrome in cemented hip arthroplasty: Incidence, pathophysiology, and prevention. *Anaesthesist.* 2021;70(9):673-683.
15. Yuenyongviwat V, Janejaturanon J, Hongnaparak T, Iamthanaporn K. Comparative assessment of bone cement implantation syndrome in cemented bipolar hemiarthroplasty: Impact in patients with and without preexisting heart disease. *Orthop Rev.* 2024;16(122320).
16. Gunawan D, Kesuma AANR, Laksana IKM. Bone cement implantation syndrome during cemented hemiarthroplasty surgery: A case report. 2021.
17. Dradjat F, Pradana A. Successful management of severe manifestation bone cement implantation syndrome during cemented arthroplasty: A case report. 2020.
18. Zastrow R, Rao SS, Morris CD, Levin A. The effect of anesthetic regimen on bone cement implantation syndrome in cemented hemiarthroplasty for hip fracture. *J Am Acad Orthop Surg.* 2024.
19. Zhou W, Zhang WJ, Zhao GQ, Li K. Bone cement implantation syndrome during hip replacement in a patient with pemphigus and Parkinson's disease: A case report. *World J Clin Cases.* 2021;9(14):3342-3349.