International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

Bone Cement Implantation Syndrome during Cemented Hemiarthroplasty Surgery: A Case Report

Dary Gunawan[1], Anak Agung Ngurah Ronny Kesuma[2], I Komang Mahendra Laksana M[3]

[1]Intern of Orthopedic and Traumatology Department in Wangaya Regional Hospital, Denpasar, Bali, Indonesia
gunawandary[at]gmail.com

[2, 3]Orthopaedic Surgeon of Orthopedic and Traumatology Department in Wangaya Regional Hospital, Denpasar, Bali, Indonesia

Abstract: ***Introduction: The increase of life expectancy makes the elderly population increase. This is also related to the degeneration of bones and joints and the increasing number of patients requiring arthroplasty, as well as morbidity and mortality. Cemented arthroplasty is still an option in this treatment. However, in practice a "cement reaction" or Bone Cement Implantation Syndrome (BCIS) can occur. BCIS can present with symptoms such as hypoxia, hypotension or both, and decreased consciousness or even worse cardiac arrest. Case description: This case report describes an 83 year old woman who underwent a cemented hemiarthroplasty bipolar surgery. During the operation, the patient is in a stable condition until the moment cement was inserted, the patient's hemodynamics gradually become unstable. Handling was done quickly and precisely, thereafter, hemodynamic stability was achieved. Discussion: Several risk factors that play a role in the occurrence of BCIS such as history of cardiovascular disease and pulmonary disease, advanced age, osteoporosis, fracture type, metastatic bone disease, femoral canal diameter of more than 21mm, previously non-instrumented femoral canal, and patent foramen ovale. The use of appropriate inotropes, vasopressors, and surgical techniques can reduce the risk of BCIS. Conclusions: Appropriate management and collaboration between the surgeon and anesthesiologist can prevent worsening of BCIS. Administration of high levels of oxygen fractions, as well as inotropes and vasopressors are useful for preventing intravascular volume depletion.***

Keywords: cemented arthroplasty, fracture, cement reaction

1. Introduction

As life expectancy increases, the number of diseases associated with degeneration of bones and joints is also increasing. This occurs mainly in the elderly population and associated with an increasing number of arthroplasty surgeries. Hines said that nearly 11 million elderly in the United States are expected to undergo hip or knee arthroplasty by 2030.(1) Meanwhile, around the world, the number of people with hip fractures in 2000 was 1.6 million and it is estimated to reach 6 million in 2050. (2)

The increasing number of these events carries the risk of increasing the morbidity and mortality of patients by up to 25%. Cemented arthroplasty is believed to be a proven option to reduce this incidence rate and has been shown to provide good results in greater anchoring and lesser periprosthetic fractures. This action is also said to reduce the time of surgery and bleeding during surgery. Unfortunately, this action can also be fatal due to the occurrence of a "cement reaction" or also known as Bone Cement Implantation Syndrome (BCIS). (3, 4)

BCIS is a deadly emergency condition commonly experienced by patients undergoing cemented hemiarthroplasty surgery. (1) Donaldson et al stated that the symptoms of BCIS include the occurrence of hypoxia, hypotension or even both and even more severe symptoms such as decreased consciousness that occurs at cementation, insertion of prosthesis, reduction and release of torniquet when the patient had surgery. (5)

Until now, the number of BCIS incidents has increased along with old age and comorbidities suffered. Although several guidelines have been made to reduce the incidence of BCIS, the number is still quite significant, reaching 28%, where several independent predictors such as the American Society of Anesthesiologists (ASA) grade 3-4, chronic obstructive pulmonary disease and the use of preoperative drugs such as diuretics or warfarin can cause severe BCIS.(6)

Other risk factors such as male gender and elderly, congestive heart failure, and other cardiovascular diseases, pre-existing lung disease besides COPD, osteoporosis and cancer are also said to play a role in the incidence of BCIS.(7) Olsen et al, in their study found that the highest number of BCIS patients with grade 1 was 21%, followed by grades 2 and 3 with 5.7% and 1.7% and perioperative patient mortality as much as 2%.(8) However, orthopedic surgeons prefer to use cement especially in elderly patients in order to reduce the re-surgery ratio due to stem loosening and migration.(3,9)

Until now, the pathophysiology of BCIS itself is still not fully explained. However, several studies mention several possibilities due to anaphylaxis, pulmonary embolism, complement activation, histamine release resulting in increased pulmonary vascular resistance and potentially ventilation/ perfusion mismatches resulting in acute hypoxia, right ventricular failure, and cardiogenic shock.(9)

This study provides a case report of a patient with BCIS intraoperatively and its management.

2. Case History

An 83 year old female patient, Indonesian citizen and is a retirement, escorted by her family to the emergency room with the main complaint of pain in her right thigh after fell in her house.

Before the fall, the patient had a complaining history of pain in the right leg and walking with a walking stick since ±6 months ago. The complaint was said to be caused by bone loss with a history of taking calcium supplements from a doctor and a history of controlled hypertension using medication.

On the examination of the limbs, the patient's right thigh was found swollen, in an external position of rotation and could not be moved, with good sensory and distal range of motion within normal limits.

The radiological image in (**Figure 1 A**) shows closed right column femoral fracture and osteopenia. The patient was planned to undergo cemented hemiarthroplasty bipolar fixation surgery.

On preoperative examination, the patient was well conscious, blood pressure 136/80 mmHg, respiration 18-20 beats per minute, heart rate 97 beats per minute and 97% room air oxygen saturation. The patient's body weight was 80kg with 160cm height (BMI 31.25kg / m2). Physical examination was found to be within normal limits, with laboratory results showing hemoglobin levels 9.5 g/ dL, hematocrite 28.3%, red blood cells 2.82 10^6/ uL, leukocytes 12.59 10^3/ uL, potassium 3.1 mmol/ L, with other tests in normal limits including an electrocardiogram. Chest X-Ray shows traces of pulmonary inflammation and aortosclerosis. Patients were assessed by the American Society of Anasthesiologists (ASA) classification grade 3.

Prior to surgery, patients were given analgesic ketorolac and omeprazole injection, KCl in NaCl 0.9% until the potassium was corrected to 3.5 mmol/ L. The patient was also given ceftriaxone injection for prophylaxis.

The patient was given ondancetron, diphenhydramine, midazolam, ketamine premedication, continued with L3-L4 space sub-arachnoid block and epidural regional anesthesia with a 27 G needle and 10 mg Marcaine. After 10 minutes the patient was placed in the right lateral position and followed by strict vital sign monitoring.

The patient was performed a cemented hemiarthroplasty using high viscosity cement mixed with gentamicin. During surgery, the patient's vital condition was generally stable up to ±2 minutes after the insertion of cement, the patient's blood pressure decreased to 90/60 mmHg, with the SpO_2 and ECG images on the monitor still within normal limits. Before inserting the cement, the femoral canal was washed, brushed, dried, and depressurized using suction.

When there is a drop in blood pressure, the operator temporarily stops the operation and the anesthesiologist injected a 0.2 mL Norepinephrine Bitartrate Monohydrate (Vascon) using the syringe pump. After ±15 minutes of monitoring and evaluation of the patient's hemodynamics, the patient's blood pressure became 110/70 mmHg and gradually increased to 140/70 mmHg.

The vascon was stopped and the operation was resumed. The development of the patient's vital sign can be seen in (**Figure 2**). Thereafter, the operation went smoothly while still paying close attention to the patient's vital sign. The radiological results of hemiarthroplasty surgery can be seen in (**Figure 1 B**).

After one day in the Intensive Ward, the patient was then transferred to a Regular Ward and returned home after receiving physiotherapy exercises with education not to do internal and external rotation, excessive flexion-extension and adduction. The patient went home after being able to self-mobilize using a walker and was informed to return one week later at the orthopedic surgery clinic.

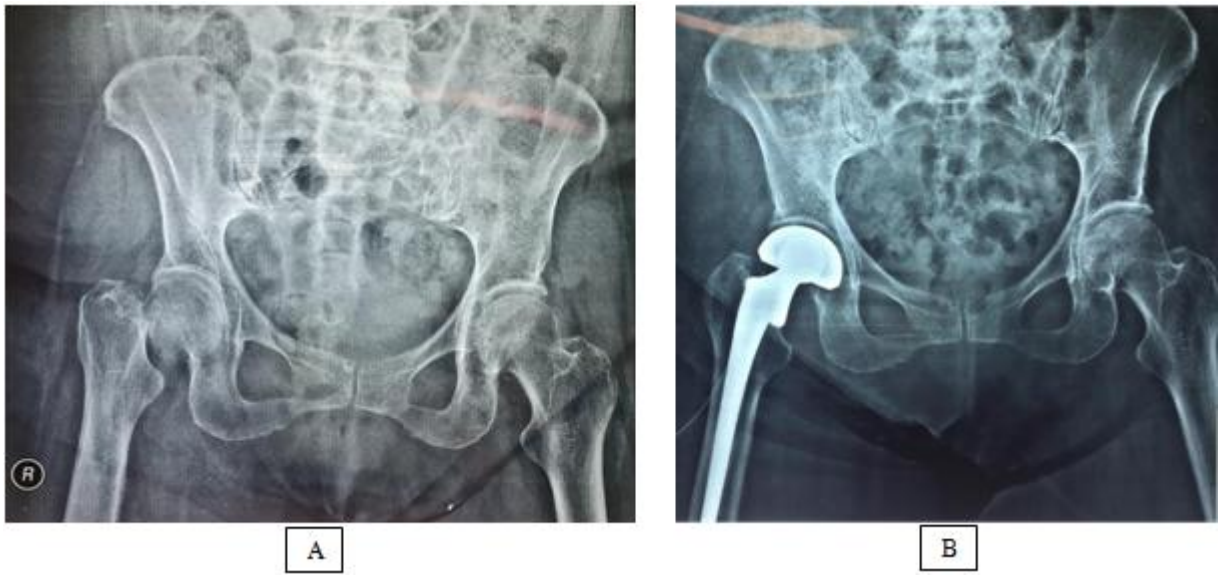
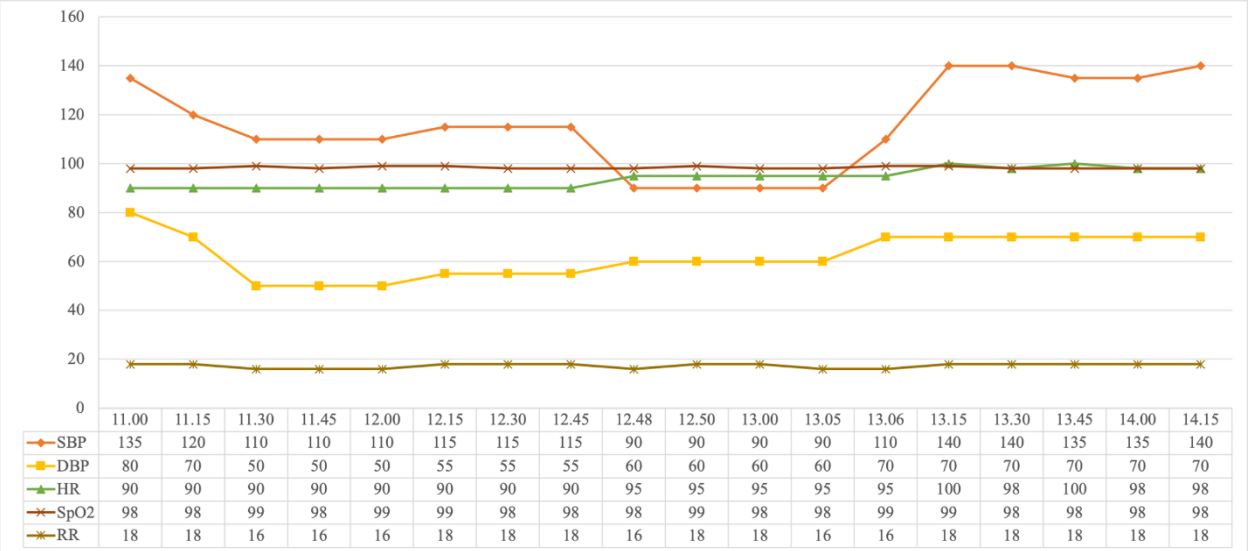


Figure 1: X-Ray Pelvis AP (A) Pre-Operative showing Closedright Column Femoral Fracture. (B) Post-Operative Cemented Hemiarthroplasty Bipolar Right Femur



	11.00	11.15	11.30	11.45	12.00	12.15	12.30	12.45	12.48	12.50	13.00	13.05	13.06	13.15	13.30	13.45	14.00	14.15
SBP	135	120	110	110	110	115	115	115	90	90	90	90	110	140	140	135	135	140
DBP	80	70	50	50	50	55	55	55	60	60	60	60	70	70	70	70	70	70
HR	90	90	90	90	90	90	90	90	95	95	95	95	95	100	98	100	98	98
SpO2	98	98	99	98	99	99	98	98	98	99	98	98	99	99	98	98	98	98
RR	18	18	16	16	16	18	18	18	16	18	18	16	16	18	18	18	18	18

Figure 2: Graphic showing Patient's Monitoring during Operation

3. Discussion

BCIS is a perioperative emergency condition most often experienced by patients who undergo cemented surgery, especially in hip replacement surgery. This syndrome is characterized by hypoxia, hypotension, and/ or both accompanied by decreased of consciousness. BCIS itself occurs during the process of inserting cement, prosthesis, joint reduction and sometimes when removing the tourniquet. With the degree of severity of BCIS itself consists of 3 degrees. The degree of severity of BCIS can be seen in (Table 1).(5) Recently, the mechanism of BCIS is still unclear, however, there are several pathophysiological mechanisms were postulated such as histamine release hypothesis, monomer-mediated and embolus-mediated models, where embolic models are more widely accepted.(7)

Table 1: Classification of Bone Cement Implantation Syndrome Severity.(5)

Severity	*Hypoxia*	*Hypotension*	*Consciousness*
Grade 1	Moderate Hypoxia (SpO_2<94%)	Fall in Systolic Blood Pressure (SBP) >20%	No loss of consciousness
Grade 2	Severe Hypoxia (SpO2 <88%)	Fall in SBP >40%	Unexpected loss of consciousness
Grade 3	Cardiovascular collapse requiring CPR		

The embolus-mediated hypothesis states that increased intramedullary pressure can cause the expulsion of intramedullary contents to enter the bloodstream, causing embolism in the cardiopulmonary system. Hypoxia occurs when the embolism enters the lungs, whereas hypotension occurs when the embolism enters the right ventricle due to an increase in pulmonary vascular resistance (PVR). The increased PVR will cause the right ventricle to fill rapidly, while the pericardium is unable to accommodate this rapid filling. This results in the septum being pushed, thereby reducing the functional size of the left ventricle and causing a decrease in cardiac output.(5,7) The sudden increase in PVR is transient and will return to baseline within 24-48 hours if the patient responds to resuscitative and supportive measures. (10)

Embolism is thought to occur due to increased intramedullary pressure that occurs during the cementation process and insertion prosthesis. The extent of embolic occurrence is said to be related to intramedullary pressure, with peak and mean intramedullary pressures significantly higher at cementation with prostheses insertion. This was found in unvented femurs, the peak and mean pressure during prosthesis insertion could reach 4931 and 3140 mmHg, compared to cementation only where the peak and mean reached 608 and 127 mmHg. In the process, cement undergoes exothermic reaction and expands in the space between the bone and prosthesis. Pressure causes the trapping air and medullary contents are pushed into the bloodstream, causing embolism. (5, 11)

Although this embolic model is more widely known, embolization does not explain the whole BCIS phenomenon that occurs. This is because embolization is not always associated with hemodynamic changes and correlates poorly with the extent of hypoxia and hypotension. This mechanism is also closely related to the pre-existing condition of the patient before surgery. (9)

In addition to several risk factors as mentioned in the introduction, such as male gender, old age, underlying cardiovascular disease, osteoporosis, cancer, pre-existing lung disease (6,7) fracture diagnosis that indicates performing surgery such as intertochanteric surgery, or those associated with malignancy, metastatic bone disease, femoral canal diameter greater than 21mm, previously non-instrumented femoral canal and patent foramen ovale (paradoxical embolus) were also identified as risk factors for BCIS.(10)

Patients undergoing surgery with a non-instrumented femoral canal may have a higher risk of developing BCIS because of the following two possible mechanisms: First, there is more potential embolic material in the non-instrumented femur; Second, when the canal has been instrumented and cemented, the inner surface of the femur will become smooth and sclerotic, this causes the surface to become less permeable. (9) The patient in the case was having several risk factors and comorbidities such as old

age, column femur fracture and osteoporosis (involving irregular and porous bony surfaces) and a history of pulmonary inflammation on chest x-ray findings. Another risk factors in the patient include non-instrumented femur.
Clinical manifestations that can be experienced by a patient suffering from BCIS can vary depending on the degree of severity, as an indication, the patient may be suspected of having the syndrome if experiencing any of the following symptoms: acute drop in end-tidal carbon dioxide, hypoxia, hypotension, hypothermia, unexplained loss of consciousness, pulmonary hypertension, increased central venous pressure, pulmonary edema, bronchospasm or bronchoconstriction, cardiac dysryhtmia, thrombocytopenia and finally cardiac arrest.(1) In the case, the patient was having a sudden drop of blood pressure reflecting the symptoms of developing BCIS. Therefore, the patient was diagnosed with BCIS grade I.

Because there is no guideline that patently describes the management of BCIS, the current treatment is only based on a case report and some literature that states the treatment includes: securing airway and giving 100% oxygen fraction, cardiopulmonary resuscitation according to Advanced Cardiac Life Support (ACLS) protocol in patients with severe BCIS, stopping all kinds of sedative drugs used in surgery such as continuous injection of propofol and/ or nitrous oxide inhalation, intravenous fluid resuscitation and administration of inotropes to maintain right ventricular preload which can be continued during surgery until the patient is transferred to the ICU if required to maintain hemodynamic stability. (1, 9)

The sudden drop of blood pressure could be maintained by given of norepinephrine bitartrate monohydrate and the stable hemodynamic was achieved.

Several surgical techniques can be attempted to reduce the risk of BCIS by Lavage of the femoral canal before cement insertion, high pressure, high-volume, pulsatile lavage, brushing and drying intramedullary canal before cementation, reducing pressure using intramedullary canal suction, using bone-vacuum technique (mixing cement in a vacuum and using a retrograde cement introduction).(1,9,12) In the case, before cementing the surgeon washed the femoral canal, brushed, dried and also depressurized the intramedullary canal using suction.

Although the patient in this case was accompanied by several comorbidities and risk factors, worsening could be prevented by good collaboration between the surgeon and the anesthesiologist on duty so that no undesirable events occurred.

4. Conclusions

Bone Cement Implantation Syndrome (BCIS) is a rare complication that can occur in mild to severe conditions and can cause death. Understanding of this syndrome needs to be known more deeply both by the operator and by everyone who works perioperatively. The first line of treatment for BCIS is to maintain the patient's hemodynamics and stop surgery during resuscitation measures to reduce intravascular volume depletion. Good and appropriate cooperation can prevent unwanted events and of course reduce the risk of BCIS.

5. Acknowledgments

The Authors are responsible for this study and also reports there is no conflicts of interest in this work.

6. Declarations

Conflict of Interest: The author reports no conflicts of interest in this work.

Funding Source: None

Author Contribution: All authors contribute in concepting, designing, conduct the study, prepare the manuscript and agree for this final version of manuscript to be submitted to this journal.

References

[1] Hines CB, Yoder AC. Bone cement implantation syndrome: Key concepts for perioperative nurses. AORN J. 2019;109(2):203–16.
[2] Barışhan FC, Akesen B, Atıcı T, Durak K, Bilgen MS. Comparison of hemiarthroplasty and total hip arthroplasty in elderly patients with displaced femoral neck fractures. J Int Med Res. 2018;46(7):2717–30.
[3] Prashanth YS, Niranjan M. Comparative study of surgical management of fracture neck of femur with cemented versus uncemented bipolar hemiarthroplasty. J Clin Diagnostic Res. 2017;11(2):RC17–21.
[4] Tsai MC, Ng YY, Chen WM, Tsai SW, Wu SC. The effects of cement fixation on survival in elderly patients with hip hemiarthroplasty: A nationwide cohort study. BMC Musculoskelet Disord. 2019;20(1):1–8.
[5] Donaldson AJ, Thomson HE, Harper NJ, Kenny NW. Bone cement implantation syndrome. Br J Anaesth [Internet]. 2009;102(1):12–22. Available from: http://dx.doi.org/10.1093/bja/aen328
[6] Kaufmann KB, Baar W, Rexer J, Loeffler T, Heinrich S, Konstantinidis L, et al. Evaluation of hemodynamic goal-directed therapy to reduce the incidence of bone cement implantation syndrome in patients undergoing cemented hip arthroplasty - a randomized parallel-arm trial. BMC Anesthesiol. 2018;18(1):1–9.
[7] Schwarzkopf E. Occurrence, Risk Factors, and Outcomes of Bone Cement Implantation Syndrome after Hemi and Total Hip Arthroplasty in Cancer Patients. J Surg Oncol 2019 Novemb ; 120(6) 1008–1015. 2019;
[8] Olsen F, Kotyra M, Houltz E, Ricksten SE. Bone cement implantation syndrome in cemented hemiarthroplasty for femoral neck fracture: Incidence, risk factors, and effect on outcome. Br J Anaesth. 2014;113(5):800–6.
[9] Dradjat RS, Pradana AS, Putra DP, Hexa 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. Int

J Surg Case Rep [Internet]. 2021;78:331–5. Available from: https://doi.org/10.1016/j.ijscr.2020.12.076

[10] Kalra A, Sharma A, Palaniswamy C, El-Oshar S, Desai P, Yazbeck M, et al. Diagnosis and management of bone cement implantation syndrome: Case report and brief review. Am J Ther. 2013;20(1):121–5.

[11] Yang T han, Yang R sen, Lin C peng, Tseng T hao. Bone Cement Implantation Syndrome in Bone Tumor Surgeries: Incidence, Risk Factors, and Clinical Experience. Orthop Surg. 2020;(April):1–7.

[12] So D, Yu C, Doane MA. Subscribe to ATOTW tutorials by visiting www.wfsahq.org/resources/anaesthesia-tutorial-of-the-week Bone Cement Implantation Syndrome. 2017;(Figure 1):1–6. Available from: www.wfsahq.org/resources/anaesthesia-tutorial-of-the-weekAccessed: February, 14th-2021.