

Bone cement implantation syndrome

Identifying and caring for patients with surgical complications related to bone cement

General overview

Bone cement implantation syndrome (BCIS) is a rare and potentially fatal perioperative complication of cemented bone surgery.¹ This poorly understood cause of intraoperative mortality and morbidity primarily occurs with patients undergoing hip replacement.² This clinical resource will focus on the history of bone cement utilization, its clinical applications in hip replacement, the potential complication of bone cement implantation syndrome and recommended evidence-based clinical practices to improve patient outcomes.

Bone cement

Bone cement, or polymethylmethacrylate (PMMA), is a synthetic resin that was developed in 1928 and originally marketed as Plexiglass. Due to its biocompatibility, it was initially used as a component in numerous clinical products such as intraocular lenses and dentures, and as a composite material for dental fillings.¹ Broken down into its primary components, PMMA consists of a liquid monomer (methylmethacrylate) and a white powdered polymer component. When combined, these components initiate a polymerization process that converts the mixture first into a soft, viscous pourable liquid. As it continues to polymerize, the liquid solidifies into a cement-like substance. PMMA also contains barium sulfate, which makes it radiopaque (visible on X-ray).³

Table 1. Components of bone cement

Powder	Liquid
Polymer: polymethylmethacrylate/copolymer (PMMA)	Monomer: methylmethacrylate (MMA)
Initiator: benzoyl peroxide (BPO)	Accelerator: N, N-dimethyl para-toluidine (DMPT)/dimethyl para-totuidine (DMpt)
Radio-opacifier: barium sulphate (BaSO ₄)/zirconia (ZrO ₂)	Stabilizer: Hydroquinone
Antibiotics (e.g. gentamycin)	

Bone cement was used as a fixation element by an orthopedic surgeon credited for pioneering the total hip arthroplasty during a femoral implant in 1958. Subsequently, in the 1970s, the U.S. Food and Drug Administration (FDA) approved bone cement for use in hip and knee procedures.⁴

Bone cement implantation syndrome (BCIS)

While there is currently no widely accepted definition of bone cement implantation syndrome, it is an established condition that can range in severity from mild to severe. Severity of BCIS has been classified into three grades:³

Grade 1: Moderate hypoxia (SpO₂<94%) or hypotension [fall in systolic blood pressure (SBP) >20%]

Grade 2: Severe hypoxia (SpO₂<88%) or hypotension (fall in SBP >40%) or unexpected loss of consciousness

Grade 3: Cardiovascular collapse requiring cardiopulmonary resuscitation (CPR)

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Clinical presentation

A mild event of BCIS may consist of transient oxygen desaturation (low-circulating oxygen) or mild hypotension, while severe instances of BCIS may result in cardiac dysrhythmias or cardiac arrest. Increased postoperative mortality rates, as high as 16-fold compared to non-cemented procedure, have been seen following cemented hemiarthroplasty (hip surgery) for femoral neck fractures.¹

The primary cause of BCIS is directly related to the insertion of bone cement into the femoral canal during cemented arthroplasty procedures.⁶

During surgery, when material is inserted into a femoral canal, the pressure inside that cavity (known as intramedullary pressure) may become excessive, creating a potential for fat molecules to be driven into the vascular circulation.² These molecules (fat emboli) can be carried via blood circulation to the right atrium and ventricle of the heart, blocking the pulmonary vasculature and causing pulmonary vascular resistance (PVR).⁷ PVR can lead to a cascade of sequelae, including rapid overfilling of the heart right ventricle with blood returning from the venous circulation. If the heart muscle fails to accommodate this rapid filling, the ventricular septum will shift, reducing the size of the left ventricle and causing a decrease in cardiac output. The negative impact of decreased cardiac output is ischemia, which is a lack of oxygen to the heart muscle.⁸

Risk factors

Preoperative patient-related risks that can contribute to the onset of BCIS include (but are not limited to):

- Being an older adult or being male
- Using warfarin (blood thinner)
- Having any of the following:
 - Impaired cardiopulmonary function
 - Preexisting pulmonary hypertension
 - Chronic obstructive pulmonary disease
 - Osteoporosis
 - Revision surgery
 - Naturally occurring hip fractures or pathological fractures³

Preventive interventions

Caring for patients with the potential for BCIS is multidisciplinary. While surgeons and anesthesia staff follow protocols essential for the reduction and management of BCIS, it is imperative that operating room (O.R.) staff be educated and prepared to respond should an intraoperative event occur. Being familiar with the risk factors and preventive interventions can facilitate the early recognition of the signs and symptoms of BCIS.^{6,8,9}

During cementation, the surgical teams' responsibilities should include:

- RN circulator: "Pause" to verbally confirm that O.R. personnel are aware that cementation is about to occur
- Scrub person: Assist the surgeon in preparing, washing and drying the femoral canal (pressurized lavage system)
- Surgeon: Avoid excessive pressurization when applying cement in a retrograde fashion
- RN circulator and scrub person: Know why the surgeon is washing the femoral canal, using a cement gun and avoiding excessive pressure when inserting a prosthesis. Be prepared to assist with resuscitation efforts if they become necessary

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Occupational hazards

The use of bone cement can present hazards to surgical team members. Adherence to bone cement package instructions for use is crucial to avoid these potential hazards.

The product's package insert will contain a warning that operating room personnel should exercise caution when mixing the two components of bone cement. If you wear contact lenses, you should not be near or participate in mixing the cement.^{1,10}

Industry and professional resources

Health care providers are significant participants as well as educators in the ongoing effort to prevent the risk of BCIS.

The following resources offer information and guidelines for health care professionals:

- U.S. Food and Drug Administration (FDA)
[Special Controls Guidance Document: PMMA Bone Cement](#)
- American Society for Testing and Materials (ASTM International)
[ASTM F451-16 Standard Specification for Acrylic Bone Cement](#)

Vizient-contracted resources

Vizient provides access to the following orthopedic bone cement product and supply agreements:

Manufacturer	Contract no.	Expiration Date
Howmedica Osteonics Corp	MS9942	9/30/2026
Zimmer Inc.	MS9943	9/30/2026
Encore Medical	MS9941	9/30/2026

References

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5. Gomez P, Morcuende J. [A historical and economic perspective on Sir John Charnley, Chas F. Thachray Limited, and the early arthroplasty industry](#). *Iowa Orthop J*. 2005;25:30-37. Accessed July 8, 2019.
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7. Barbosa V, Carneiro S, Barros J, Rebelo T. **Bone cement implantation syndrome: An unavoidable catastrophe? Case Reports International website**. Published 2016. Accessed June 27, 2023.
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9. Burlingame B. **Bone cement implantation syndrome**. *AORN J*. 2009; Accessed July 8, 2019.
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