

Bone Cement Implantation Syndrome During Cemented Shoulder Arthroplasty

Laura Lombardi-Karl, MD and Anthony Brown, MBChB, FFA (SA)

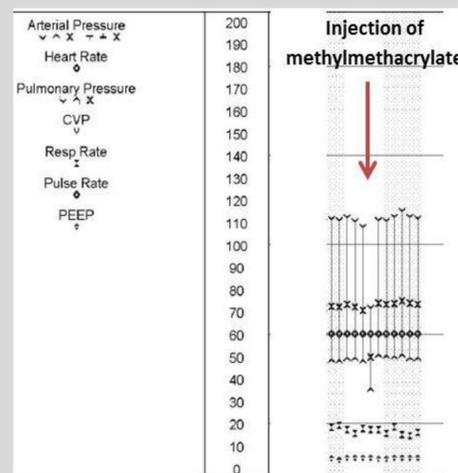
Patient History

- 76 year-old woman with left shoulder osteoarthritis presented for a left total shoulder replacement
- Medical history:
 - Cardiac amyloid with left ventricular ejection fraction of 20%
 - Moderate mitral and aortic regurgitation
 - Bradycardia requiring a pacemaker (PPM)
 - Ventricular tachycardia requiring an implantable cardio-defibrillator (ICD)

Perioperative Course

- Surgery was performed under regional (single shot interscalene block) and general anesthesia in the beach chair position
- An arterial line and defibrillator pads were placed preoperatively
- PPM programmed to VOO at 60 beats per minute
- The operative course was uneventful until seconds after insertion of methylmethacrylate (MMA) bone cement:

- Blood pressure → nadir 50/25, MAP 36
- SpO2 98% → 91%
- ETCO₂ 40 → 34



Immediate Management:

- Surgeon alerted
- FiO₂ increased 100%
- Hypotension was addressed by reversing the beach chair position, administration of fluid, and phenylephrine boluses (total 320mcg)
- SpO₂ and blood pressure normalized within minutes and she remained stable for the duration of the surgery
- The underlying cause of this episode was suspected to be bone cement implantation syndrome (BCIS)

Bone Cement Implantation Syndrome (BCIS)

- BCIS is a rare and potentially fatal complication occurring in patients undergoing cemented arthroplasty with MMA. It is primarily associated with cemented arthroplasty of the hip but has been observed with cemented knee and spine procedures. There are rare case reports of BCIS during shoulder arthroplasty
- Characterized by hypotension, bradycardia, arrhythmias, hypoxia, and increased pulmonary vascular resistance (PVR). Awake patients may experience dyspnea and altered sensorium
- Occurs during cementation, prosthesis insertion, joint reduction, or tourniquet deflation

Pathophysiology

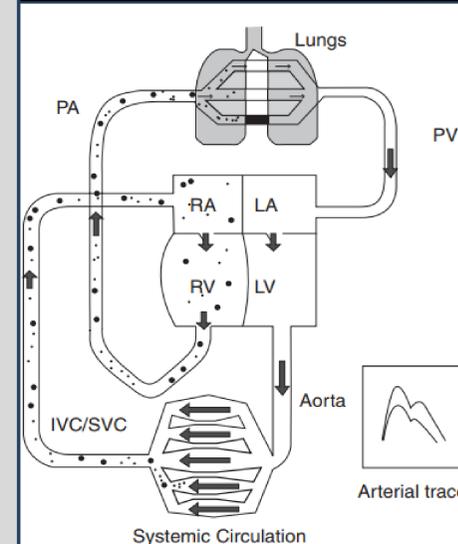
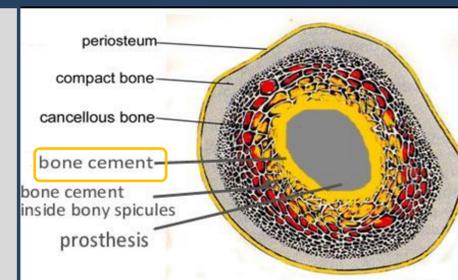
Inciting Event: Cement Insertion

- Cement undergoes an exothermic reaction and expands in the space between bone and prosthesis causing intramedullary hypertension
- Subsequent embolization of marrow, fat, cement particles, air, bone particles and aggregates of platelets and fibrin.
- MMA can cause cardiopulmonary changes secondary to vasodilation

Etiology and pathophysiology:

Two models have been described: Embolic and Monomer-mediated.

- The presence of embolic material in circulation may cause obstruction to forward flow, histamine release and endogenous cannabinoid mediated vasodilation
- Cement can cause an increase in PVR; pulmonary hypertension (pHTN) contributes to right ventricular (RV) failure and hypoxia
- The thin walled RV dilates, shifts the intraventricular septum to the left, decreases left ventricular (LV) filling, causing decreased cardiac output (CO) and hypotension
- Hypotension reduces coronary perfusion pressures (CPP); reduced right coronary flow and increased right ventricular end-diastolic pressure (RVEDP) contributes to ischemia
- MMA monomer may cause vasodilation



Acute pHTN and secondary RV failure

BCIS Risk Assessment

Patient Risk Factors	Surgical Risk Factors
<ul style="list-style-type: none"> Increasing age Cardiopulmonary disease <ul style="list-style-type: none"> Impaired cardiopulmonary function, pHTN, and RV dysfunction are susceptible to effects of increased PVR Osteoporosis, bony metastases Poor pre-existing physical reserve 	<ul style="list-style-type: none"> Pathological fractures <ul style="list-style-type: none"> Abnormal vascular channels Long stem prosthesis Undisturbed medullary canal <ul style="list-style-type: none"> More potentially embolic material

Proceed with cemented vs. uncemented arthroplasty

Intraoperative Roles

Anesthesiology Team	Surgical Team
<ul style="list-style-type: none"> Vigilant hemodynamic monitoring during cement insertion <ul style="list-style-type: none"> Arterial line or non-invasive blood pressure cuff on "stat" mode (if indicated) Optimize hemodynamics, oxygenation, and volume status <ul style="list-style-type: none"> 100% FiO₂ Blood pressure within 20% baseline Vasopressors available or given prophylactically 	<ul style="list-style-type: none"> Inform anesthesia team prior to cement application Wash and dry femoral canal Avoid excessive pressurization Apply cement retrograde with intramedullary vent

• "Cement Curfew": Pre-assignment of individual roles in the event of BCIS

BCIS suspected

Management: Early and Aggressive Resuscitation

- Cardiovascular collapse should be treated in line with RV failure
- Main priority is to maintain coronary perfusion pressure and cardiac output:
 - Vasopressors (phenylephrine) facilitate peripheral vasoconstriction and increased myocardial perfusion
 - Inotropes (dobutamine, epinephrine) support ventricular contractility
 - Pulmonary vasodilators reduce PVR and RV afterload
 - IV fluids maintain RV preload
 - Pacing (as in this case) prevents bradycardia and facilitates cardiac output
- Consider additional hemodynamic monitoring:
 - TEE may help assess RV function
 - PA catheter may help monitor CO and guide resuscitation
 - Central access facilitates vasopressor and inotrope administration

Conclusions

- BCIS can occur in cemented arthroplasty of the shoulder. Patients with significant cardiac dysfunction can recover from BCIS, provided that it is rapidly recognized and treated.

Classification of BCIS Severity

	SpO ₂	Blood Pressure	Consciousness	Incidence
Grade 1	SpO ₂ <94%	>20% fall SBP	Alert	20%
Grade 2	SpO ₂ <88%	>40% fall SBP	Loss of consciousness	3%
Grade 3	Cardiopulmonary resuscitation required			1%

References

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