Case Series

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Bone Cement Implantation Syndrome- A Case Series

Anaesthesia Section

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ABSTRACT

In Bone Cement Implantation Syndrome (BCIS) there occurs hypoxia, hypotension, and loss of consciousness at around the time the bone is cemented. Hip arthroplasty has become a frequent intervention with the increase in aging population. Hereby, the authors discussed five cases (three male and two female patients), all aged 58 years and above. Few patients found to have co-morbid medical conditions in the Preanaesthetic Clinic (PAC). All the patients developed adverse responses after the bone cementing procedure. One of the patients presented for PAC and was scheduled for right-sided knee arthroplasty. The generalised signs observed amongst these patients were hypoxia, hypotension, unexpected loss of consciousness, cardiovascular collapse, either intraoperatively or postoperatively, and were of varying severity. Patients were accordingly managed medically and were also given Cardiopulmonary Resuscitation (CPR), whenever required. Two patients could not be revived while three got discharged in good condition. The incidence of morbidity and mortality due to BCIS can be reduced by carefully identifying high-risk patients.

Keywords: Cardiac arrest, Cemented arthroplasty, Hip surgeries

INTRODUCTION

The Bone Cement Implantation Syndrome (BCIS) is a common and possibly fatal intraoperative complication in individuals undergoing cemented hip arthroplasty [1]. The syndrome is most common with cemented hemiarthroplasty, complete hip and knee replacements. It is characterised by several clinical features that may include hypoxia, hypotension, cardiac arrhythmias, increased Pulmonary Vascular Resistance (PVR), and cardiac arrest that can occur during the time of femoral reaming, cementation, prosthesis insertion, reduction of the joint, or during the time of tourniquet deflation in a patient undergoing cemented bone surgery [2].

CASE SERIES

Case 1

A 76-year-old female patient presented to the Preanesthetic Clinic (PAC) for right-sided hemiarthroplasty, and the preanaesthetic check-up was unremarkable. She had a history of systemic hypertension for the past 15 years, and she had been taking tablet telmisartan 40 mg OD. Twenty years ago, she underwent a vaginal hysterectomy, which was uneventful.

The laboratory investigations were within normal limits. Spinal anaesthesia was given with 12 mg of 0.5% bupivacaine Heavy (H) and 15 μg of fentanyl. Two hours after spinal anaesthesia, during cementing, the patient had disorientation and Oxygen Saturation (SpO_2) dropped to 85%. Using a non rebreathing mask, the patient was treated with 100% oxygen supplementation. The patient had bradycardia of 34 beats per minute and Blood Pressure (BP) of 104/68 mmHg and was treated with intravenous (i.v.) injection of atropine 0.6 mg. Surgeons were asked to stop the procedure. The Electrocardiography (ECG) showed a flat line, the pulses were not palpable, the blood pressure was not recordable, and the patient did not respond to commands. Cardiopulmonary Resuscitation (CPR) was initiated and continued as per the Advanced Cardiovascular Life Support (ACLS) guidelines [3]. The patient was revived and the sinus rhythm reverted after 7 minutes of CPR, BP was 89/67 mmHg, and heart rate was 110/min. The patient was started on noradrenaline and dopamine infusions and shifted to the Intensive Care Unit (ICU). The patient had developed pulseless ventricular tachycardia in the ICU after 6 hours. Cardioversion was attempted but the patient could not be revived.

Case 2

A 90-year-old male patient presented to the PAC for right-sided hemiarthroplasty. He was a chronic smoker, otherwise, the PAC was unremarkable. The patient had an episode of the cerebrovascular event five years back with hemiparesis on the right side which recovered completely. The patient was on tablet atorvastatin 20 mg OD and tablet aspirin 75 mg OD after the CVA.

The laboratory investigations were within normal limits. The echocardiogram revealed severe Pulmonary Artery Hypertension (PAH), aortic sclerosis, and an ejection fraction of 55%. Spinal anaesthesia was given with 10 mg of 0.5% bupivacaine (H) and 15 μg of fentanyl. After 5 minutes of the start of the cementation procedure, the patient developed progressive bradycardia and cardiac arrest.

Adrenaline 1 mg i.v. was administered, and CPR was begun.The patient was intubated with a size 8 cuffed endotracheal tube. After 9 minutes of CPR, the patient reverted to sinus rhythm. The BP was 74/52 mmHg and the heart rate was 134/min. The patient was started on vasopressors with noradrenaline infusion and shifted to the ICU for further management. After 4 hours, the patient died.

Case 3

A 80-year-old male patient presented to the PAC for right-sided hemiarthroplasty. The preanaesthetic check-up was unremarkable. The laboratory investigations were within normal limits. Spinal anaesthesia was given with 10 mg of 0.5% bupivacaine (H) and 15 μg of fentanyl. Two hours after beginning the surgery, during cementation, the patient developed itching and rashes over the arms and chest after cementation, which were treated with 8 mg of dexamethasone and 10 mg of Pheniramine i.v. The patient developed hypotension (80/50 mmHg) and bradycardia with a Heart Rate (HR) of 38 beats per minute.

Atropine 0.6 mg i.v. was administered, and intravenous fluid was rushed in. After 2 minutes, the patient developed atrial fibrillation, and cardioversion was done. After the patient reverted to sinus rhythm, a cardiology consultation was done and an amiodarone infusion was started. The patient was shifted to the ICU for monitoring and was discharged after 2 days.

Case 4

A 75-year-old female patient presented to the PAC for right-sided knee arthroplasty. The preanaesthetic check-up revealed marked thoracic

kyphoscoliosis. Her haemoglobin was 8 mg/dL during the general examination, and she had received two units of blood transfusion. The cardiac evaluation was unremarkable, with a Left Ventricle Ejection Fraction (LVEF) of 58%. Spinal anaesthesia was given with 10 mg of 0.5% bupivacaine (H) and 15 μg of fentanyl. After 2 hours of surgery, immediately after tourniquet deflation, the patient developed an episode of absent seizure with a vacant look and loss of responsiveness. The blood pressure was 70/40 mmHg and the heart rate was 56/min.

The patient was oxygenated with 100% oxygen via a non rebreathing mask and the airway was maintained. Intravenous fluids were rushed in and an injection of ephedrine 6 mg i.v. was administrated. A 1 mg injection of midazolam was administered. The patient regained consciousness within 1 minute and the procedure continued. The rest of the surgery went smoothly. Following surgery, the patient was transferred to the ICU, and a neurology consultation was sought. After three days, the patient was discharged in good condition.

Case 5

A 58-year-old male patient was posted for left hemiarthroplasty. He was a known case of type 2 diabetes mellitus and was on 500 mg of the tablet metformin. Preoperative investigations were unremarkable. The patient was given spinal anaesthesia with 12 mg of 0.5% bupivacaine (H) and 15 μg of fentanyl. The intraoperative period was uneventful. Six hours postoperatively, the patient developed chest discomfort and sweating. An urgent ECG was done, which revealed an evolving inferior wall myocardial infarction.

Tablet aspirin 300 mg, tablet clopidogrel 150 mg, tablet isosorbide dinitrate 5 mg sublingual, and tablet atorvastatin 20 mg were used to treat the patient after cardiac consultation. The patient was stabilised and shifted for coronary angiography, which was found to be normal. After five days, the patient was discharged in good condition under the observation of a cardiologist.

DISCUSSION

Bone cement is an acrylic material that is used to hold implants in place or to fill joint cavities and serves as a filler rather than an adhesive. The components include a polymer component (white powder) and benzoyl peroxide, as well as Polymethylmethacrylate (PMMA) monomer, a colourless flammable liquid, barium sulphate, which is added to make the cement radioopaque [4].

Although there is no commonly accepted definition for bone cement implantation syndrome, it is increasingly recognised as a distinct condition. The symptoms might range from a moderate form of transitory hypoxia to a catastrophic one that results in death [2]. The severity classification of BCIS is as given in [Table/Fig-1] [2].

Grading	Symptoms and severity
Grade 1	Moderate hypoxia (SpO_2 <94%) or hypotension {fall in Systolic Blood Pressure (SBP) >20%}
Grade 2	Severe hypoxia (SpO_2 <88%) or hypotension (fall in SBP >40%) or unexpected loss of consciousness.
Grade 3	Cardiovascular collapse requiring CPR.

[Table/Fig-1]: Classification of BCIS [2].
SpO_2: Saturation of Peripheral Oxygen; CPR: Cardiopulmonary Resuscitation; SBP: Systolic blood pressure

In a retrospective study comprising 1016 patients, Olsen F et al., identified the incidence of grade I BCIS to be around 21%, grade II to be 5.1%, and grade III to be around 1.7% [5]. According to the available literature, for every one patient reported, 13 other patients remain unreported [5].

The aetiology and pathophysiology of BCIS are not completely understood. Early theories focused on circulating PMMA monomers [1,2,4,5]. However, new evidence suggests that an embolus-mediated model is more likely. Additional hypothesis proposed include histamine release, complement activation, and multimodal possibilities [6-8].

The emboli model suggests that because of the high intramedullary pressures (> 300 mmHg) that occur at cementation and prosthesis insertion, emboli are formed. The exothermic reaction of the cement expands the space between prosthesis and bone, thus trapping air and debris, which is forced into the circulation [6,7]. Haemodynamically, emboli travel to the lungs, heart, and cerebral and coronary circulations, thus explaining the hypoxia, Right Ventricular (RV) dysfunction, and hypotension of BCIS [6,7]. Increased pulmonary vascular resistance may result from the mediators released from the emboli. Mediators like 6-keto prostaglandin F1 and tissue thromboplastin may bring about reduction in the Systemic Vascular Resistance (SVR). An increased PVR in the presence of decreased RV preload results in a marked decrease in Cardiac Output (CO), which worsens the hypotension. The increase in PVR and the ventilation-perfusion mismatch establishes hypoxaemia [8].

There are four important factors to consider for BCIS: the patient, the surgeon, the anaesthesiologist, and the theatre team involved in the surgery [5,6]. Patient-related risk factors predisposing to BCIS include old age, American Society of Anaesthesiology (ASA) grade III and above, poor physical reserve, preexisting Pulmonary Arterial Hypertension (PAH) (Chronic Obstructive Pulmonary Disease), medications such as diuretics, Angiotensin Converting Enzyme (ACE) inhibitors, warfarin, etc., osteoporosis, bone metastases, and total hip replacement. Similarly, some surgical factors, like revision surgery, long stem hip arthroplasty, cementing with a gun and high viscosity cement have a higher incidence of BCIS [9].

Several surgical measures can be taken to reduce the risk of BCIS. Though uncemented arthroplasty avoids BCIS, cemented arthroplasty leads to less residual pain, better mobility, and a reduced need for revision surgery [10]. Perioperative mortality is significantly higher in cemented hip hemiarthroplasty compared with uncemented techniques, but they have a more favorable outcome [7-10].

Therefore, using low-viscosity cement, a short stem prosthesis, lavaging the intramedullary canal before insertion of the prosthesis, achieving haemostasis before implanting the prosthetic joint, and venting the medulla can reduce the patient's risk of BCIS [4,5]. Venting the bone allows the air to escape from the end of the cement plug, thus, diminishing the risk of an air embolus. While mixing the cement, using a bone-vacuum cementing technique, reduces its porosity and thus the embolic load of both mechanical and mediator-driven particles, thereby decreasing the incidence of BCIS [4-6,11]. Using a pulse lavage system to implant the bone cement retrogradely helps to compartmentalise the bone marrow contents, generating a consistent lower intramedullary pressure and reducing the risk of BCIS. Adequate preoptimisation of the patients and continuous communication with the orthopaedician and, the patient is necessary [11]. Careful monitoring and keeping a high index of suspicion to detect BCIS during cementing or prosthesis insertion can go a long way towards decreasing morbidity and mortality [11].

It is important to identify high-risk groups like patients who have cardiovascular compromise and who might require high-level haemodynamic monitoring with Central Venous Pressure (CVP) monitoring and an arterial line [12]. BCIS can be detected early with Transesophageal Echocardiogram (TEE) Doppler. Maintenance of arterial pressure during surgery and adequate circulating volume before cement insertion is very important [12]. In the anaesthetised patient, a drop in end-tidal carbon dioxide concentration may be the first symptom of clinically significant BCIS and should alert the anaesthesiologist. Dyspnoea and altered sensorium are early signs of BCIS in an awake patient undergoing regional anaesthesia. If BCIS is suspected, the inspired oxygen concentration should be raised to 100% and supplementary oxygen should be continued into the postoperative period [12]. Aggressive resuscitation with intravenous fluids has been recommended. Although Central Venous Pressure

(CVP) monitoring does not accurately reflect Positive Airway Pressure (PAP), a central venous catheter may be indicated for the administration of inotropic drugs [12,13]. Haemodynamic instability should be treated with sympathetic alpha-1 agonists in the context of right heart dysfunction and vasodilatation [13].

Although cemented procedures are generally very effective, there are specific groups of patients who are particularly at risk of developing BCIS. Adequate communication with the surgeon about the type of prosthesis, generous intravascular fluid replacement, and increased vigilance during high-risk periods can all aid in the prevention and early detection of BCIS [14]. The authors suggest that cemented arthroplasty should be avoided in patients who are at high-risk of BCIS unless there are overriding orthopaedic considerations.

CONCLUSION(S)

In cemented arthroplasties, it is important to consider certain preoperative optimisations like increasing inhaled oxygen concentration, using inotropes and vasopressors, and avoiding intravascular volume depletion during surgery. Elderly patients may have co-existing morbidities that enhance the risk of acquiring BCIS. BCIS is a significant cause of intraoperative mortality and morbidity in patients undergoing cemented hip arthroplasty.

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