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Original Research Paper

Orthopaedics

ROLE OF BONE CEMENT IN DEVELOPMENT OF HYPOXIA AND HYPOTENSION INTRAOPERATIVELY IN PATIENTS OF CEMENTED TOTAL HIP ARTHROPLASTY AND CEMENTED BIPOLAR HEMIARTHROPLASTY

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KEYWORDS :

INTRODUCTION

Elderly people who stumble on the floor or experience trauma often suffer from hip fractures. Nowadays, hip replacements for these fractures, AVN, and hip osteoarthritis are relatively prevalent (Primary or Secondary). One potentially fatal side effect of orthopaedic surgery requiring pressured bone cement following cemented hemiarthroplasty as well as total hip and knee replacement surgery is the bone cement implantation syndrome (BCIS)1. Hypoxia, systemic hypotension, pulmonary hypertension, arrhythmias, loss of consciousness, and cardiac arrest are the defining features of this syndrome. [3]

It often happens during one of the five phases of surgery: joint reduction, acetabular or femoral cement implantation, prosthesis placement, or femoral reaming. It can also be noticed in the postoperative period in a lesser form, producing hypoxia and disorientation, and it is a significant cause of intraoperative and postoperative mortality and morbidity in patients having cemented hip arthroplasty. [4]

Components Of Bone Cement-

The two-component systems that make up PMMA bone cements are typically delivered as a powder and a liquid. In order to initiate the polymerization reaction, which creates the polymethylmethacrylate (PMMA) cement, these two ingredients are combined in a ratio of around 2:1. 5 The presence of methyl methacrylate at the product's surface has been connected to the potential blood pressure decrease that might result from the early insertion of bone cement. [6]. Methyl methacrylate's hypotensive effects will be enhanced if the patient is suffering from hypovolaemia.

Bone cement phase [5]:

Mixing Phase -

The mixing phase is the amount of time needed to completely combine the powder and liquid. The benzoyl peroxide is released into the mixture when the monomer begins to break down the polymer powder.

Waiting Phase/Dough Time-

The cement reaches an appropriate viscosity for handling during this phase, which normally lasts a few minutes (i.e, can be handled without sticking to gloves). Throughout the majority of this stage, the cement is a sticky dough. Dough time is the period of time from the start of mixing to the moment when surgical gloves can be used to handle the cement without them sticking. For most bone cements, dough time is 2-3 minutes after beginning to mix under usual circumstances (23°C–25°C, 65% relative humidity). Before this time, the bone cement may be placed into a syringe, cartridge, or injection gun for aided application when the ingredients have been well mixed.

Working Phase/Working Time:

The working phase is the time frame in which the prosthesis may be inserted and the cement can be worked with. The viscosity of the cement increases throughout the working phase, and heat is generated by the cement. Before the working period is through, the implant must be placed. Working time is the period of time, usually between 5-8 minutes, between the dough and setting periods. This duration is increased by 1 to 1.5 minutes when mechanical introduction equipment like syringes and cartridges are used.

Setting Phase/Setting Time:

During this stage, the temperature reaches its highest point and the cement totally hardens and sets. When the cement cools to body temperature, both thermal and volumetric shrinkage continue to occur. The operation room temperature, the patient's body temperature, and the cement temperature all have an impact on how quickly a filling hardens. It is the period of time, generally 8 to 10 minutes, from the start of mixing until the exothermic reaction warms the cement to a temperature that is precisely halfway between the ambient and maximum temperatures (i.e., 50% of its maximum value).

The pathogenesis of BCIS is unknown, however it has been suggested that allergy, inflammatory, thermic, and complement activation7 might cause BCIS1. Studies using perioperative ultrasound imaging and invasive hemodynamic monitoring have identified subclinical pulmonary emboli and hemodynamic abnormalities that are not seen with routine intra- and postoperative monitoring [8].

Pathophysiology of BCIS[9]

Intra-medullary pressure rise caused by cementing and inserting a prosthesis

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causes pulmonary embolisation by forcing medullary material into the circulation.

↓

causes pulmonary embolisation by forcing medullary material into the circulation.

↓

the right ventricular (RV) afterload is increased

↓

Finally, systemic hypotension and RV failure.

Table 1[10] ASA Grading

ASA PS Classification	Definition	Adult Examples, Including, but not Limited to:
ASA I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use
ASA II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 < BMI < 40), well-controlled DM/HTN, mild lung disease

ASA III	A patient with severe systemic disease	Substantive functional limitations; One or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.
ASA IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes	

Donaldson et al. (2009) [1] defined a severity classification of BCIS (Grade 1, 2, and 3)

- Grade 1: Moderate hypoxia (SpO2 94%) or hypotension (fall in SBP > 20%).
- Grade 2: severe hypoxia (SpO2 88%), hypotension (fall in SBP > 40%), or sudden loss of consciousness.
- A circulatory failure in Grade 3 necessitates CPR.

Old age, male sex, osteoporosis, use of diuretics, poor physical reserve, impaired cardiopulmonary function, pre-existing pulmonary hypertension, high ASA score 10, congestive heart failure, and chronic obstructive pulmonary disease are some of the patient-related risk factors linked to bone cement implantation syndrome.

MATERIAL AND METHODS

A Total number of 102 patients were selected (those who needed to be operate for cemented Total Hip Replacement and Cemented Bipolar Hemi Arthroplasty) after the Approval of institutional ethical review committee.

Inclusion Criteria

Patients having femoral neck fracture and intertrochanteric fractures planned for cemented hemiarthroplasty and cemented Total Hip Arthroplasty surgery.

Exclusion Criteria

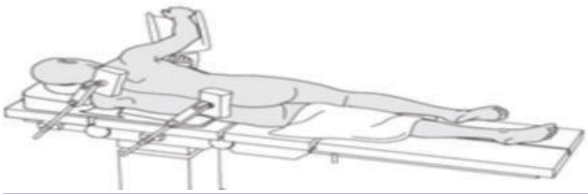
Patients with Suspected Pathological fracture, Patients with failed internal fixation > 1 time and When surgery performed was > 1 during the study period and those with history of hypersensitivity to antibiotics or other drugs.

All patients were thoroughly investigated and evaluated by clinical and radiological means . All patients included in the study were subjected to the investigations and pre Anaesthetic check up for fitness and were described surgical procedure, after surgical fitness was obtained. Written informed consent was also obtained for all patients for all such patients.

All procedures were performed in Jay Arogya Group of Hospital, G.R. Medical college, Gwalior. The patients were treated with Hip Arthroplasty or Cemented Bipolar Hemiarthroplasty under regional or general Anaesthesia under guidance of Anaesthesiologist.

Operative Procedure

In this study Patient was positioned lateral decubitus on the radiolucent table and we used Posterior Approach for both Total and Hemi Arthroplasty under spinal anaesthesia. All the parameters were monitored before and after spinal anaesthesia and patient was hemodynamically stabilized before starting the procedure.



Following the insertion of the acetabular cup in a total hip replacement, the femoral canal was prepared in accordance with guidelines. In each case, the femoral canal was thoroughly lavaged following head removal, followed by progressive rasping of the canal, drying of the canal, removal of debris, and application of cement restrictor. With the use of a cement gun, the prepared cement was retrogradely introduced into the femoral canal (during the working phase) over a suction catheter to remove any trapped air. The appropriate-sized Femoral stem component or Bipolar prosthesis was implanted after the cement had been introduced and was pressurised by the hand.

The arterial oxygen saturation, mean arterial blood pressure, systolic blood pressure, diastolic blood pressure, and heart rate of each patient were examined in their anaesthetic records. On a regular basis, these variables were recorded. The cementation procedure was noted on the anaesthetic sheet for patients who underwent cemented hemiarthroplasty and cemented total hip replacement.

Four times these variables were collected:
(a) Just before the start of anaesthesia
(b) Every five minutes for a total of 15 minutes prior to the insertion of bone cement.
(c) Every 5 minutes, starting at least 20 minutes after the prosthesis and cement are placed
(d) 3 hourly checks upon arrival at the post-anesthesia recovery facility for up to 24 hours

The degree of hypoxia/hypotension was determined by recording the vitals (Sytolic blood pressure) after prosthesis placement and comparing it to pre-insertion readings.

According to the standards established by Donaldson et al.[1], each patient was further categorised as having Grade 0, no hypotension/hypoxia, or Grade 1, 2, or 3 hypotension/hypoxia.

For 24 hours following the operation, all patients remained under constant observation.

3 months follow up by MINI MENTAL STATUS EXAMINATION[11] to evaluate for INCIDENCE of BCIS and MORTALITY due to BCIS.

In spite of the fact that no patients in our study had Donaldson[1] grade III Bone cement Implantation Syndrome, a protocol was established for any patients developing BCIS during cementation intra-operatively to be intubated and ventilated with 100% oxygen, along with cardiopulmonary resuscitation (CPR) and administration of cardiac massage, CPR, crystalloid, vasopressors like adrenaline and atropine, and supportive treatment to revive the patient. Patients with BCIS were kept under close surveillance in the ICU during the postoperative period. Although the technique of cementing and the kind of cement (low vs. high viscosity) play important roles in the development of BCIS, evaluation is difficult due to high intraoperative variability across surgeons.

POSTOP PROTOCOL:

All patients were monitored post operatively every hour for first 3 hours followed by 6 hourly monitoring for next 24 hours followed by 12 hourly monitoring for next 3-5 days till patient stay at hospital

Patient was followed up for mini mental status[11] examination on day 1,

Day 7, 1 month and after 3 months.

RESULT

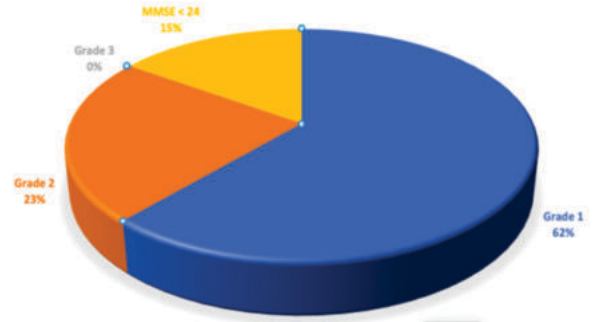
In our study total 102 patients treated for Cemented THA and Cemented Bipolar Hemiarthroplasty during last 2 years were

included. Out of these 11 patient had BCIS (as per Donaldson criteria[1]) and 2 patients had altered Mini Mental Status Examination during 3 months follow up time.

Most patients were in age group of 50-75 years (Mean age 62 years) with male pre dominance of 64.7%. 66.7% patients were operated for Cemented Bipolar Hemiarthroplasty and 33.3% patients were operated for Cemented Total Hip Arthroplasty.

Grade (Donaldson)	Cemented bipolar hemiarthroplasty	Cemented THR	Total
Grade 1	05	03	08
Grade 2	02	01	03
Grade 3	00	00	00
MMSE < 24	00	02	02

In our study, cumulative Incidence of BCIS was 12.74% out of which 7.8% were having Grade 1 and 2.9% were having grade 2 as per Donaldsons Criteria, while 1.9% were diagnosed as BCIS post operative follow up with MMSE.



Early postoperative mortality (<48 hours) was 0% in cemented total hip Arthroplasty and cemented bipolar hemiarthroplasty

Mortality	Cemented bipolar hemiarthroplasty	Cemented THR	Total
Within 48 hours	00	00	00
At 1 month	02	02	04
At 3 months	04	02	06

DISCUSSION

For fractures, AVN, and hip arthritis, cemented hemi and total arthroplasty are now regularly performed procedures. The risk of death from the potentially lethal cementation complication known as bone cement implantation syndrome (BCIS) is greatly underreported and underestimated[12]. Milder forms of BCIS are not recognised at all or are not routinely collected or reported, and there are not many case series or formal trials published on this issue. One might assume that the moderate hypoxia or hypotension in this particular group of cases was either brought on by mild pulmonary embolization, which had no significant clinical impact, or by hypovolemia, atelectasis-induced intrapulmonary shunting, or both, both of which are easily treated and had negligible clinical impact.

The clinical pattern of BCIS often appears during the process of prosthesis placement and bone cementation. The pathophysiology of BCIS is unclear, but it may be brought on by pulmonary embolisation, complement activation, and histamine release. These three factors work in concert to increase pulmonary vascular resistance, which, if it is severe enough, may result in hypoxia, right ventricular failure, and cardiogenic arrest[9]. In a recent intraoperative study, it was demonstrated that cemented hemiarthroplasty in patients with femoral neck fracture does, in fact, result in pronounced pulmonary vasoconstriction, RV function impairment, and abnormalities in pulmonary ventilation and perfusion early after cementation and prosthesis insertion.

Donaldson[1] proposed a severity classification for BCIS, grading it into three categories based on SpO2 and systolic blood pressure decline: grade 1 is defined as moderate hypoxia (SpO2 94%), grade 2 is defined as severe hypoxia (SpO2 88%), and grade 3 is defined as cardiovascular collapse requiring cardiopulmonary resuscitation. In our study, there were eight patients with Donaldson1 grade I, three patients with grade II, and none with grade III.

Prevalence is found to be advanced in cases who have ASA score> 3 and other co morbid conditions in our studies which is similar with Weingärtner K[13] et all who in their studies linked High ASA as revelatory threat factor for development of BCIS. The diagnosis of BCIS can be verified by Histological examination of various organs, which was done by R J Byrick et all[14] and have set up that Hypoxia and Hypotension along with dropped mental function are identical to diagnose BCIS. The degree of cardiovascular impairment is not always inversely correlated with the magnitude of the embolic burden due to variations in patient risk factors, susceptibility, and response, as well as mediator-based effects of BCIS. [15,16]. There is a wide range of clinical presentations as a result, ranging from temporary hypoxia, hypotension, or disorientation to fulminant cardiovascular alterations that may lead to arrhythmias, shock, or cardiac arrest. Fall in end tidal CO2 concentration with dyspnea or altered sensorium is the initial symptom of clinically relevant BCIS, which is then followed by hypoxia and hypotension[17].

Transoesophageal echocardiography, intraoperative pulmonary artery catheter placement, and other invasive hemodynamic monitoring techniques can identify imminent BCIS earlier than conventional hemodynamic monitoring, although they are not often utilised and were not employed by us either. The literature search did not turn up any references to the use of steroids or antihistamines as preventative measures for cement embolism therapy.[18]

BCIS prevention is preferable, and we may lower the risk of BCIS by a number of intraoperative surgical methods, such as medullary lavage, adequate hemostasis prior to cement insertion, avoid excessive cement pressurisation, use low toxicity monomeric cement, shorten the length of the prosthesis, vacuum cement mixing, retrograde application with cement gun and a suction catheter, intramedullary plug, and venting the medulla1,[20]. vacuum mixing and venting a hole was not done by us, rest all the other modern cementing techniques to minimize BCIS in all our case of cemented Arthroplasty.

The National Patient Safety Agency (NPSA) 2009 released multidisciplinary clinical guidelines for both anaesthetists and surgeons on the use of bone cement during hip arthroplasty that emphasises the collaborative decision-making and thorough intra operative monitoring notably in high risk patients. Also, all hip fracture operations should be performed by skilled anaesthetists and surgeons, ideally on scheduled lists, with full participation from the anaesthesia team in preoperative planning to allow for appropriate

evaluation and pre-optimization. Each member should be knowledgeable about the BCIS and have a specific role to play in patient resuscitation if a severe response or cardiopulmonary arrest (BCIS Grade III) happens. [19,20]

CONCLUSION:

BCIS is a rare, avoidable complication of cemented arthroplasty that can cause hypoxia, systemic hypotension, pulmonary hypertension, arrhythmias, loss of consciousness, and cardiac arrest. severe BCIS significantly affects both early and late mortality. High ASA scores, COPD, drugs containing diuretics, and warfarin are independent preoperative danger factors for the development of BCIS. As a result of our findings, it is essential for a successful outcome that these cases be discussed in an interdisciplinary forum prior to surgery, with a focus on threat identification and an intraoperative surgical plan to reduce the risk for BCIS. This should also include constant monitoring both during and after the surgery, as well as surgical technique modification using modern cementing techniques and the appropriate supportive measures in accordance with BLS and ACLS guidelines.

Conflict Of Interest-

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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