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Original

Hemodynamic changes and related factors in bone cement implantation syndrome in knee arthroplasty candidates

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Abstract

Introduction: Considering the importance of the anesthesia and surgery team's awareness of possible hemodynamic changes when using bone cement and preventing its risks, it is very important to know about this issue.

Objectives: This study aimed to identify and prevent the risks of possible hemodynamic changes and related factors when using bone cement in knee arthroplasty candidates.

Patient and Methods: This descriptive-analytical study of 63 knee arthroplasty candidates in Imam Reza and Shohada hospitals (affiliated with the Tabriz university of medical sciences) was conducted in 2020. The hemodynamic status (heart rate, blood pressure, and arterial oxygen saturation (SaO_2)) of all patients was recorded and changes were calculated three minutes before, during, and three minutes after using bone cement.

Results: The increase in diastolic ($P=0.221$) and systolic ($P=0.195$) blood pressure and heart rate ($P=0.125$) over time (before and after using bone cement) was statistically insignificant. However, the arterial oxygen saturation of patients remained constant ($P=0.999$).

Conclusion: The results showed that using bone cement causes minor changes in (systolic and diastolic) blood pressure and heart rate.

Keywords: Bone cement, Hemodynamic changes, Knee arthroplasty, Orthopedics

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Introduction

Often seen in hip and knee arthroplasty surgeries, bone cement implantation syndrome (BCIS) may threaten orthopedic surgery candidates (1). It can cause complications such as hypoxia, hypotension, arrhythmia, increased pulmonary vascular resistance, bradycardia, and pre- and post-operative embolism (2, 3).

To prevent its complications and reduce plasma histamine release, 30 mg of intravenous diphenhydramine is usually administered 1 hour before using bone cement (4, 5). Prodrugs such as diuretics or warfarin and aspirin are used for severe BCIS in chronic obstructive pulmonary disease patients (6, 7).

The shortcomings of previous studies include aspirin use, which cannot be used in all surgeries such as neurosurgery and severe trauma, and the failure to consider pathological bone diseases, underlying diseases, and age, which affect results (8, 9).

Objectives

Due to its importance for anesthesia and surgical teams, this study aimed to identify and prevent the risks of possible hemodynamic changes and related factors when using bone cement in knee arthroplasty candidates.

Patients and Methods

Study design

This descriptive-analytical study of 63 knee arthroplasty candidates in Shohada and Imam Reza hospitals (affiliated with the Tabriz University of Medical Sciences) was conducted in 2020 using the available sampling method and by observing the inclusion and exclusion criteria.

The inclusion criteria included 18-65 years of age, elective arthroplasty candidates on one knee, and the consent of participants; and the exclusion criteria included a history of bone cement allergy, taking corticosteroids, history of immunodeficiency disorders, ASA class IV patients, and a history of severe seasonal and other allergies.

After entering the operating room, the hemodynamic status of all patients was monitored and 500 cc of normal saline was intravenously administered. Then, spinal anesthesia was inducted to all patients in seated position via injection of 15 mg of bupivacaine into the L3/L4 or L4/L5 segment using the gauge-25 needle. To treat 30% hypotension from the baseline, 10 mg of ephedrine was administered, and to treat bradycardia (heart rate below 50 bpm), 0.6 mg of intravenous atropine was injected. All patients received oxygen therapy with a facemask at 6 L/m and an operating room nurse and a recovery

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Implication for health policy/practice/research/medical education

The hemodynamic status (heart rate, blood pressure, and arterial oxygen saturation (SaO2)) of 63 knee arthroplasty candidates was recorded and changes were calculated three minutes before, during, and three minutes after using bone cement. The results showed that using bone cement causes minor changes in (systolic and diastolic) blood pressure and heart rate.

anesthesiologist collected the data. To collect data before induction of anesthesia, age, gender, and weight were obtained from interviews and patient records, and systolic and diastolic blood pressure, heart rate, and arterial oxygen saturation were obtained and recorded in the checklist by monitoring, sphygmomanometer, and pulse oximetry. The variables were measured 30 minutes before the operation, during bone cement use, and 30 minutes after the operation.

Statistical analysis

The collected data were entered into SPSS version 21 and the quantitative information was shown using descriptive statistics such as frequency, percentage, mean, and standard deviation. The obtained data was compared using analysis of variance (ANOVA). ***P*** value less than 0.05 was considered significant.

Results

Out of the 63 participants, 29 (46.03%) were female and 41 (65.07%) received right leg arthroplasty. The mean age, height, weight, and body mass index (BMI) of participants were respectively 55.29 ± 5.41 years, 165.96 ± 12.29 cm, 81.55 ± 5.19 kg, and 28.85 ± 3.64 kg/m². The records showed 52 participants (82.53%) with a history of controlled hypertension, 32 (50.79%) with a history of diabetes mellitus, and 28 (44.44%) with a history of anesthesia.

Blood pressure analysis showed that the increase in diastolic ($P=0.221$) and systolic ($P=0.195$) blood pressure over time (before and after using bone cement) was statistically insignificant ($P=0.125$). Moreover, the increase in the average heart rate of all patients was statistically insignificant ($P=0.099$), whereas their arterial oxygen saturation remained constant ($P=0.999$). Table 1 shows the hemodynamic changes of participants.

Discussion

Hemodynamic stability is of secondary importance after airway support by anesthesiologists to ensure adequate ventilation for patients. Hemodynamic changes exceeding 20%-30% from the baseline can cause irrecoverable damages, such as cardiac and cerebral ischemia, need for long-term hospitalization, increased need for pharmacotherapy and risk of cardiopulmonary resuscitation, and higher mortality. Therefore, after providing proper ventilation and keeping the airway open, monitoring hemodynamic status is incredibly important and considered by anesthesiologists as a major challenge in anesthesia management. Due to its importance, hemodynamic status is continuously monitored during operation to report the slightest changes (10). Various factors can affect hemodynamic status during operation, including bleeding, extent of surgical incision, blood transfusion, injection of anesthetics, and intraoperative procedures. The use of foreign materials such as bone cement may change hemodynamic status during surgical procedures. The body recognizes bone cement as a foreign material and reacts accordingly. To prevent this, it is recommended to administer corticosteroids 10-30 minutes before use. Despite these preventive measures, however, some individuals may exhibit severe reactions, such as hemodynamic changes leading to future complications (11-13).

The study by Olsen et al entitled Bone Cement Implantation Syndrome in Hemiarthroplasty showed that the highest rate of mortality occurs 48 hours after using bone cement (14). The study by Hines et al entitled Bone Cement Implantation Syndrome showed that although changing the amount of bone cement used in orthopedic surgery can change the patient's hemodynamic status, it does not pose serious risks (4). Therefore, it is recommended that future studies also consider the amount of bone cement used.

Conclusion

The results showed that using bone cement causes minor changes in (systolic and diastolic) blood pressure and heart rate.

Limitations of the study

The small number of samples and the lack of examination

Table 1. Analyzing the hemodynamic changes of participants before, during, and after using bone cement

Variable	Time of using bone cement			*P* value
	Before	During	After	
Heart rate	86.10±11.35	91.10±24.85	95.11±33.09	0.099
Systolic blood pressure	135.15±02.22	142.18±85.95	148.14±52.75	0.221
Diastolic blood pressure	83.10±30.33	90.10±57.96	95.12±44.45	0.195
Arterial oxygen saturation	100	100	100	0.265

of the hemodynamic status after surgery were the limitations of our study, which should be addressed in future studies in order to achieve better results.

Authors' contribution

Conceptualization; AM and NA, Methodology; AM, Validation; NA, Formal Analysis; NA, Investigation; AM and NA, Resources; AM and NA, Data Curation; AM and NA, Writing—Original Draft Preparation; AM and NA, Writing—Review and Editing; AM and NA, Visualization; NA, Supervision; NA, Project Administration; NA, Funding Acquisition; NA

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical issues

The research conducted in accordance with the tenets of the Declaration of Helsinki. The Ethics Committee of Tabriz University of Medical Sciences approved this study. The institutional ethical committee at Tabriz University of Medical Sciences accepted all study protocols (IR.TBZMED.REC.1400.820).

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