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ABSTRACT

Introduction
Bone cement implantation syndrome is an important cause of perioperative morbidity and mortality (0.6%-1%) in patients undergoing cemented hip arthroplasty. Clinical features include cardiac, neurologic and respiratory impairments that may lead to cardiac arrest. It has been proposed that the effect of systemically absorbed methylmethacrylate and release of endogenous mediators can be the main process which leads to multiorgan dysfunction.

Case Report
We describe a case of bone cement implantation syndrome developed in a hip arthroplasty with a catastrophic outcome, resulting in the death of the patient.

Conclusion
The review of clinical cases of bone cement implantation syndrome is essential in our clinical practice given that early recognition and management of this syndrome may improve the overall prognosis.

Keywords: cement, arthroplasty, embolism, cardiac arrest.
INTRODUCTION
Bone cement implantation syndrome (BCIS) is a poorly defined entity, responsible for significant perioperative morbidity and mortality (0.6%-1%) [1,2] in patients undergoing cemented hip arthroplasty. According to the literature, it may include respiratory (hypoxia, pulmonary hypertension, pulmonary edema and bronchospasm), hematologic (thrombocytopenia), cardiovascular (hypotension, arrhythmia and cardiac arrest) and neurologic dysfunction (loss of consciousness) [3]. The etiology and pathophysiology of BCIS are not fully established [1], although several mechanisms have been proposed such as toxic effect of systemically absorbed methylmethacrylate, fat and bone marrow embolism, use of high pressure during cementing, exothermic reaction, anaphylactic reaction, and release of endogenous mediators (histamine, complement activation, vasodilator cannabinoids) [4,5]. In this article we report a case of BCIS relating to a cemented hip arthroplasty, with catastrophic outcome, resulting in the death of the patient.

CASE REPORT
A 73-year-old woman was admitted into the emergency department after a mechanical fall, with a diagnosis of left femur neck fracture, and was proposed for total hip replacement. The fracture (Figure 1) occurred approximately 8 hours before the surgery. Aside from essential hypertension, the patient had no other co morbidities and was independent in her daily activities. The patient had good functional capacity with more than four metabolic equivalents in exercise testing, and there were no previous signs of important cardiorespiratory compromise.
Preoperative investigation, namely, renal function, ionogram, coagulation and haemogram were within normal limits as well as the electrocardiogram (ECG). On the day of the surgery, the patient was hemodynamically stable having peripheral oxygen saturation (SpO₂) of 99% on room air. The patient was administered 1 mg of diazepam on the night before the surgery and also on the day of the surgery. Antihypertensive medication was stopped on the day of the surgery.
The patient was placed in right side decubitus after standard monitoring with oximetry, ECG and non-invasive arterial blood pressure (BP), and Ringer’s solution was administered.

Subarachnoid block was performed using a 25-Gauge Whitacre needle in the L4-L5 interspace. Levobupivacaine 0.5% (8 mg) and 0.002 mg of sufentanyl were injected after free flow of cerebral fluid. Sensory analgesia up to T8-T10 dermatome was confirmed. Hemodynamic parameters remained stable following subarachnoid block.

Intravenous cephazolin (2 g) was administered for surgical infection prophylaxis and the surgery was started.

During the surgery the patient’s hemodynamic parameters were stable with pulse rate varying between 64-82/min with sinus rhythm, systolic BP between 108-122 mmHg and diastolic BP between 68-85 mmHg, SpO2 $\geq$ 98% (room air) and normal state of consciousness, until just before the bone cement placement.

Seconds after the placement of methylmethacrylate (bone cement) there was a sudden decrease of level of consciousness, from Glasgow Coma Scale 15 to 7, accompanied by hypotension (83/45 mmHg), sinus tachycardia (130 bpm) and desaturation (from 99% at 21% of oxygen to 82% with high flow of oxygen). Pulmonary auscultation was normal, intra operatory ECG showed sinus tachycardia and arterial blood gas analysis showed metabolic acidosis and hypoxemia. The surgery was stopped immediately.

Orotracheal intubation and mechanical ventilation with 100% of oxygen were performed. Aggressive fluid therapy and bolus of ephedrine (total of 20 mg) were administered without consistent improvement and hence an intravenous infusion of norepinephrine (0.15 mcg.Kg.min $^{-1}$) was started with hemodynamic improvement that allowed the surgery to proceed.

The surgery lasted for 80 minutes (figure 2). The patient’s estimated blood loss was 250mL, receiving a total of 2.5L of crystalloids without the need of blood transfusion.

At end of the surgery the patient was transferred to the intensive care unit (ICU).

In the ICU, laboratory investigation, brain computed tomography, cervical doppler, transcranial ultrasound and computed tomography pulmonary angiogram revealed no acute abnormalities.
Despite the support provided in the ICU, a progressive deterioration of the general status resulted in the patient’s death 24h after the surgery.

**DISCUSSION**

Hemodynamic effects of pulmonary emboli and sudden increase in pulmonary vascular resistance (PVR) associated with the use of cement has been described to be the key feature of BCIS [5]. Embolization usually results from pressurization of bone cavity (often > 300 mm Hg) during cementing and prosthesis insertion, with release of vasoactive mediators in pulmonary circulation and increase of the PVR [1,2,5]. Clinical deterioration which can occur within seconds to minutes of cement implantation [1,5] is the result of right ventricular (RV) failure due to high PVR which leads to a reduced cardiac output. Acutely increased RV pressure promotes dilatation of RV which pushes the intraventricular septum to the left, leading to poor filling of left ventricle, reduction in cardiac output, systemic hypotension, decrease in coronary perfusion pressure resulting in ischemia and may result in cardiac arrest [1,2,5]. It has also been proposed that emboli can reach cerebral circulation through patent foramen ovale or pulmonary, circulation which can be seen by transesophageal echocardiography and transcranial Doppler [5]. Embolization cannot explain all features of BCIS and other mechanisms can be involved, such as histamine release, complement activation and endogenous cannabinoid-mediated vasodilatation [2].

There are some high-risk patients and surgical criteria for developing of BCIS. In 2015 was published a guideline in order to reduce the risk from cemented arthroplasty for hip fracture [6]. Increased patient’s age, higher grade of American Society of Anesthesiologists physical grade (III or IV), presence of significant cardiopulmonary disease, use of diuretics, male sex, presence of osteoporosis, malignant disease, revision surgery, surgery in uninstrumented femur, use of excessive pressure during cementing and use of long-stem prosthesis are some of the factors that may increase the risk of developing BCIS [6]. The risk should be minimized by a proper selection of patients, preoperative optimization, improving communication between anesthesiologist and surgeon,
increasing the inspired oxygen concentration and avoiding intravascular volume depletion during cementing.

Management of BCIS is mostly supportive and includes use of 100% oxygen, fluids, vasopressors, pulmonary vasodilators, invasive monitoring, and intensive care [1,3,4,6].

In high-risk patients, the use of noncemented prosthesis, use of short-stem prosthesis, low-viscosity cement, retrograde application of the cement, and avoidance of excessive pressure may be helpful strategies to reduce the risk of developing BCIS [6].

Hip fracture surgeries using cemented prosthesis are associated with approximately 20% more adverse cardiovascular events compared with noncemented prosthesis [6,7]. Nonetheless, the use of cemented prostheses for hip fracture surgery increases the likelihood of pain-free mobility after surgery [8], reduces the risk of re-operation and is associated with a lower mortality rate at 30 days [6].

There is no evidence that spinal anesthesia is better than general anesthesia and a retrospective analysis of a 65 535 patient national dataset did not find any significant difference in either five-day or 30-day postoperative mortality between general and spinal anesthesia [9]. In our case we opted for single-shot spinal anesthesia, which is routinely performed as anesthetic technique for hip fracture in older patients, with a good outcome in the procedures conductive in our hospital.

BCIS is a time-limited phenomenon, and high PVR usually normalizes within 24-48 hours. Healthy patients may recover quickly from the insult, while others with risk factors, can present with a tragic manifestation resulting in death. Nevertheless, there exist many cases of patients without risk factors who died in consequence of BCIS. Early and aggressive resuscitation as well as surgical operative modifications may be the key to the prevention of this catastrophic syndrome. We suggest that a cemented prosthesis should be avoided in patients who are at high risk of BCIS unless there are overriding orthopedic considerations, as well as it should be considered the use of cemented prostheses in view of their risk and benefits. The final decision should be a multidisciplinary team decision.
CONCLUSION

BCIS is a significant cause of morbidity and mortality in orthopedic surgery. High index of suspicion and close monitoring is required at the time of cement insertion for early clinical diagnosis and outcome improvement. In selected patients, treatment with noncemented prosthesis or a conservative approach of the fracture may reduce the mortality and so its potential risks and benefits compared with cemented arthroplasty should be pondered. It highlights the need for individualized medical team decision for each patient.

CONFLICT OF INTEREST

Authors report no conflict of interest.

AUTHOR’S CONTRIBUTIONS

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Group 1 - Conception and design, Acquisition of data, Analysis and interpretation of data
Group 2 - Drafting the article, Critical revision of the article
Group 3 - Final approval of the version to be published

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Group 1 - Conception and design, Acquisition of data, Analysis and interpretation of data

Group 2 - Drafting the article, Critical revision of the article

Group 3 - Final approval of the version to be published

REFERENCES


FIGURE LEGENDS

Figure 1: Anteroposterior x-ray film displaying a left femoral neck fracture (arrows).

Figure 2: Anteroposterior left hip x-ray displaying left total hip replacement in situ (arrows).

FIGURES

Figure 1: Anteroposterior x-ray film displaying a left femoral neck fracture (arrows).
Figure 2: Anteroposterior left hip x-ray displaying left total hip replacement in situ (arrows).