Learning From Others:

A Case Report From the Anesthesia Incident Reporting System

Anesthesia Quality Institute
ANESTHESIA INCIDENT REPORTING SYSTEM (AIRS)

Review of unusual patient care experiences is a cornerstone of medical education. Each month, the AQI-AIRS Steering Committee abstracts a patient history submitted to the Anesthesia Incident Reporting System (AIRS) and authors a discussion of the safety and human factors challenges involved. Real-life case histories often include multiple clinical decisions, only some of which can be discussed in the space available. Absence of commentary should not be construed as agreement with the clinical decisions described. Feedback regarding this article can be sent by email to **airs@asahq.org**. Report incidents or download the AIRS mobile app at **www.aqiairs.org**.

Case 2018-10: Geriatric hip fracture

Elderly (over 90 years old) woman sustained femoral neck fracture from a fall. Taken to O.R. for hemiarthroplasty under spinal anesthetic. Brief hypotension with spinal anesthetic resolved with phenylephrine. Shortly after placement of bone cement, patient became severely hypoxic. Airway secured, turned supine, lost pulses, junctional rhythm, then full arrest. CPR via Lucas device unsuccessful.

Discussion

This month's case presents a regrettably common story that is familiar to many anesthesiologists. In the U.S., the national age-adjusted incidence of femoral neck fractures in patients at and over 65 years of age was 146 out of 100,000 in 2013.[1] The good news is that this rate has declined in the preceding 10 years from 242 out of 100,000 patients. Of those admitted to a hospital for a femoral neck fracture, 63.6 percent undergo a hemiarthroplasty. In-hospital mortality after a hip fracture ranges from 2.3 to 13.9 percent.[2] The risk of mortality after hip fracture is due to a triad of factors: advanced age, comorbidity burden and new acute medical conditions contracted after the fracture.

The high mortality in elderly hip fracture patients has led to recent reevaluations of the treatment choices made in this population. How should the fracture be treated? What kind of anesthetic technique should be used? What should be done prior to treatment to reduce the risk of mortality and morbidity?

Orthopedists are confronted with a variety of choices for treatment of a femoral neck fracture. Options include unipolar or bipolar hemiarthroplasty, total hip arthroplasty, internal fixation with a pin and nonsurgical treatment. (Unipolar versus bipolar refers to the type of head used on the femoral stem.) In 2013, hemiarthroplasty was the most popular treatment (63.6 percent) versus internal fixation (29.1 percent) and total hip arthroplasty (7.4 percent).[1]

Anesthesiologists may proceed with a regional or general anesthetic. In a retrospective study of older New York State patients undergoing surgery for hip fracture, 72 percent of patients received a general anesthetic.[3] The use of regional anesthesia was not associated with lower 30-day mortality but was associated with a slightly shorter length of stay.

The REGAIN trial is one of several prospective trials comparing anesthesia types for hip fracture surgery.[4] REGAIN is a pragmatic multicenter trial of patients over 50 years old presenting for hip fracture surgery. Patients are randomized to spinal anesthesia or general anesthesia. The primary outcome is a composite of mortality or inability to walk across a room at 60 days after randomization. Enrollment is ongoing and is predicted to conclude in 2019.

Table 1: Grades of Bone Cement Implantation Syndrome (BCIS)

BCIS Grade	Description	Incidence
Grade 1	SpO_2 less than 94 percent or systolic BP drop greater than 20 percent	21 percent
Grade 2	SpO_2 less than 88 percent, or systolic BP drop greater than 40 percent, or unexpected loss of consciousness	5.1 percent
Grade 3	Cardiovascular collapse requiring CPR	1.7 percent

Bone cement implantation syndrome (BCIS) is a hemiarthroplasty complication well known to anesthesiologists. BCIS manifests with hypoxia, sudden hypotension, pulmonary hypertension and ultimately cardiac arrest.[5] Table 1 shows a classification system for BCIS proposed by Donaldson et al. A 2014 retrospective study by Olsen looked at 1,019 patients undergoing cemented hemiarthroplasty and assigned a grade to each.[6] The incidence is displayed in Table 1.

"Bone cement" is polymethyl methacrylate (PMMA). PMMA was discovered and commercialized in the 1930s under the brand name "Lucite." It has a wide variety of commercial applications. PMMA has excellent compatibility with human tissue and has been used in surgery for decades. PMMA is provided in two components, one a powder and the other a liquid. The powder contains a co-polymer methyl methacrylate-styrene with initiator and radio-opacifier. The liquid contains methyl methacrylate monomer, promoter and stabilizer. When mixed together, the powder and liquid form a paste that heats up as the polymerization reaction proceeds.

The most common theory for the cause of BCIS is embolization. During cementation and the insertion of the prosthesis, the cement becomes very hot and expands in the bone channel around the prosthesis. In addition to expansion due to polymerization, the cement injection process can lead to increased pressure within the marrow. Air and the contents of the bone channel are forced into the circulation. The resulting embolic shower includes fat, marrow, air, bits of bone, clot aggregates and particles of cement. Debris can end up in vessels of the lungs, brain or heart. In addition to blocking vessels, endothelial damage can result in mediator release that leads to increased pulmonary vascular resistance. Other mediators cause a reduction in systemic vascular resistance (SVR). The emboli and vasoconstriction caused by mediators lead to shunting, which is a likely cause of hypoxemia.

Given that transesophageal echocardiography identifies embolic particles moving through the right atrium in virtually every patient having long bone surgery, the embolization hypothesis does not adequately explain all the complications observed in BCIS. Other possible mechanisms include anaphylaxis and complement activation. It is likely that some combination of these mechanisms leads to the clinical features of BCIS.

BCIS is more common in patients who are older, with preexisting pulmonary hypertension, osteoporosis, bony metastases, and related pathological or intertrochanteric hip fractures. Patient risk factors for grade 2 or 3 BCIS include ASA Physical Status III or IV, a history of COPD, and medication with diuretics or warfarin.

Orthopedists have investigated several techniques to reduce embolic risk, including pulsatile lavage of the femoral cavity to reduce the amount of embolic material, use of prostheses without cement and use of a vent hole drilled in the distal femoral shaft. Another technique is to use a cement gun to insert cement from distal to proximal (retrograde) within the cavity. A cement restrictor inserted into the cavity will limit the volume of cement required.

Anesthesiologists can perform several steps to reduce the risk of BCIS in high-risk patients, beginning with preoperative evaluation. As the hypotension in BCIS is thought to be due to decreased SVR and reduced cardiac output, some form of cardiac output monitoring will help to direct management if BCIS occurs. Addressing hypovolemia before cementation may reduce BCIS-related hypotension, while increasing FiO_2 to 100 percent may reduce the risk of hypoxia. Management recommendations for BCIS suggest that the cardiovascular collapse be treated as right ventricular failure. Alpha-1 agonists are first-line treatment for right-sided dysfunction and vasodilation, supplemented with intravenous fluids to increase preload.

As always, we thank the reporter of this case for providing a detailed synopsis to AIRS.

References:

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