Complications of Cemented Long-stem Hip Arthroplasty in Metastatic Bone Disease Revisited

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Abstract

Background The literature suggests that a cemented long-stem femoral arthroplasty is associated with increased intraoperative and perioperative risks. Embolic events may precipitate cardiopulmonary complications and even death; by contrast, others have reported that the use of a cemented long-stem femoral arthroplasty in patients with metastatic bone disease is a safe procedure.

Questions/purposes Specifically, in this study, we sought to identify (1) intraoperative complications potentially attributable to the use of cemented long-stem femoral components, and (2) early postoperative complications potentially attributable to the use of cemented long-stem femoral components in patients having an arthroplasty for metastatic bone disease.

Methods In this study, we performed a retrospective chart review of 42 patients (44 arthroplasties), in which the same surgical technique was used. The primary outcome measure was perioperative complications, including intraoperative cement-associated desaturation, cement-associated hypotension, sympathomimetic administration, postoperative hypotension/desaturation, and death.

Results In this series, 19% of the patients had cement-associated hypotension and sympathomimetics were administered to 48%. Two patients required prolonged intubation. One death occurred during hospitalization but there were no cardiopulmonary events.

Conclusions This study showed that some patients experienced postoperative desaturation, prolonged intubation, and increased use of sympathomimetics, however,

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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these events were short-lived and did not result in patient mortality. Although there are significant risks to cemented long-stem femoral arthroplasty, it can be performed with a low risk of fatal cardiopulmonary complications and remains a surgical option when treating patients with metastatic bone disease.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

In patients with carcinoma who have metastatic disease develop, the skeleton remains the third most common site of involvement. Approximately 4.9 million people in the United States will be affected by metastatic bone disease [3, 13]. Unfortunately, those with metastatic bone disease often are debilitated secondary to pain and may experience fractures, neurologic symptoms secondary to spinal cord compression, and hypercalcemia [3]. With the advent of new therapeutic strategies, patients with cancer are living longer, supporting the need for durable skeletal reconstruction in patients with impending or realized pathologic fractures [4, 12, 14].

When considering surgical reconstruction in patients with metastatic bone disease, fixation or reconstruction that protects the whole bone should be performed when possible. In addition, the surgical technique selected should be independent of bone healing, provide a stable reconstruction when possible, and relieve pain [11, 14]. This should impart mechanical stability and ideally protect against further disease. Arthroplasty is the favored procedure in patients with impending or realized fractures involving the femoral head and neck and cementation is the preferred method of fixation [2, 3, 11]. Prostheses that rely on bone ingrowth are not favored in situations where possible residual disease may lead to failure of the reconstruction [11].

Cementation of the medullary canal of diseased bone has been associated with acute cardiopulmonary compromise and death [8]. For this reason, many surgeons do not perform cemented long-stem arthroplasties in this patient population. Randall et al. [11] reported a small case series of patients with impending or realized pathologic fractures of the proximal femur treated with cemented long-stem hip arthroplasties. In that study of 27 patients (29 arthroplasties), no catastrophic events or cardiopulmonary compromise necessitating prolonged intervention occurred [11].

In our current study, we seek to extend the findings of that study [11] by evaluating a larger number of patients, and using contemporary approaches to surgery and anesthesia. Specifically, in the current study, we sought to identify (1) intraoperative complications potentially

attributable to the use of cemented long-stem femoral components, and (2) early postoperative complications potentially attributable to the use of cemented long-stem femoral components in patients having hip arthroplasty for metastatic bone disease.

Patients and Methods

After institutional review board approval, we retrospectively reviewed the medical records of 42 patients who underwent at total of 44 cemented long-stem hip arthroplasties for impending or realized pathologic fractures secondary to metastatic bone disease whose surgery was performed since an earlier study on the same subjects [11]. All patients were treated with a femoral component made by the same manufacturer (BiMetric® custom-blasted long-stem 300-mm × 9-mm and 350-mm × 9-mm implant; Biomet, Inc, Warsaw, IN, USA), using the same surgical technique [11].

The new patient cohort consisted of 20 men and 22 women (Table 1). Their mean age was 59 years. There were eight fractures and 36 impending fractures. The average Mirels' score [9] was 10.5 (range, 8–12). The treatment included 25 cemented THAs and 19 hemiarthroplasties. The histologic subtypes included breast carcinoma, prostate carcinoma, renal cell carcinoma, lung carcinoma, unknown adenocarcinoma, and multiple myeloma.

Data from operations performed between September 2003 and October 2010 were collected. Surgical inclusion criteria included all patients with metastatic bone disease who had substantial acetabular, femoral head, and/or neck lesions with realized or impending fractures. Additionally, patients whose score was 8 or greater, according to Mirels' scoring system [9], also were included. Patients had long-stem femoral instrumentation regardless of whether there was additional clinically relevant disease more distal in the ipsilateral femur. This was determined by obtaining preoperative full length AP and lateral radiographs of the femur. Patients who did not have a long-stem component implanted and/or did not have metastatic bone disease in at least two sites as determined by total body bone scan were excluded.

Femoral hemiarthroplasty was performed when no acetabular lesions or arthritis was present. THAs were performed for any acetabular involvement. All operations were performed using a posterior approach to the hip. In patients with substantial acetabular involvement, an all-polyethylene cup was cemented in place and augmented with large fragment screws and/or threaded Steinmann pins to serve as a rebar (Fig. 1).

Femoral preparation and component placement were performed in a similar systemic fashion as previously described [11]. Briefly, using continuous suction lavage with

Table 1. Demographic data

Parameters	Totals
Gender	
Male	20
Female	22
Mean age (years)	59
Impending fractures	36
Realized fractures	8
Mirels' score (mean)	10.5
Hemiarthroplasty	18
Total hip arthroplasty	24
Histologic subtype	
Breast	14
Prostate	3
Myeloma	3
Adenocarcinoma of unknown origin	1
Renal	5
Lung	4
Other	12

Fig. 1A–B Radiographs of (A) the proximal extent and (B) distal extent of the cemented arthroplasty are shown for a patient who underwent a cemented long-stem THA for metastatic bone disease about the hip.

an endoscopic sucker, the canal was prepared with a flexible reamer and then broached. In an early, low-viscosity cure state, three batches of Surgical SimplexTM P bone cement (Howmedica, Mahwah, NJ, USA) mixed with 3.6 g tobramycin were used for cementation of the component. The prosthesis then was inserted slowly into the canal and allowed to settle with minimal manual force to avoid high peak pressurization. All excess cement was removed and the implant was held in position until the polymethylmethacrylate (PMMA) had hardened. No distal venting

was performed to avoid potential distal stress risers and minimize operative time. No cement restrictors were used.

Our primary outcome variables sought to identify sequelae of embolic phenomena at the time of cementation. Anesthesia records were reviewed to look for intraoperative cement-associated desaturation, cement-associated hypotension, the administration of sympathomimetic agents, and intraoperative or perioperative death. Early postoperative variables included prolonged intubation, mental status changes, cardiopulmonary compromise, and death. To identify intraoperative complications, the anesthesia and operative reports were reviewed. The exact time of cementation was not documented routinely in the anesthesia record; therefore, the last 2 hours of the anesthesia records were examined to assure that cementation occurred within our defined time, as it is the final step. Anesthesia induction times were excluded from review, as all patients were uniformly labile during this period.

Cement-associated desaturation events were considered significant if there was a decrease of less than 90% O₂ saturation. Cement-associated hypotension was determined by taking an average of the first five systolic blood pressures after induction (blood pressures recorded every 5 minutes). Any decrease greater than 30% from the initial baseline systolic average was considered a significant event. Any sympathomimetic administration during the last 2 hours of recorded anesthesia was considered significant regardless of dose. Prolonged intubation was defined as needing ventilator support for more than 2 hours after leaving the operating room. Cognitive changes compared with baseline were evaluated daily during inpatient stays with noted changes in alertness and orientation to name, location, and date.

Results

At the time of data collection, 23 of 42 patients in the new cohort had died (55%) of disease. The range of survival in this patient cohort was 8 days to 4 years (mean, 23 months; median, 15 months) (Fig. 2).

Intraoperative complications in the new patient cohort include cement-associated hypotension in eight of 42 patients (19%) (eight of 44 arthroplasties; 18%). Sympathomimetics were administered on a discretionary basis to 20 of 42 patients (48%) (20 of 44 arthroplasties; 45%). Not all patients receiving sympathomimetics were experiencing cement-associated hypotension. Some anesthesiologists administer sympathomimetics prophylactically given the at-risk patient population. Prolonged intubation occurred in five patients (11%). Three patients were extubated on the day of surgery, whereas two required ventilatory support for an additional 2 and 4 days after surgery.

Fig. 2 The Kaplan-Meier analysis shows overall patient survival for the new cohort. Censoring times are denoted by vertical hash marks.

Postoperative desaturation and hypotension occurred in 5% of patients in this cohort. One death occurred on postoperative Day 8, which was suspected to be secondary to congestive heart failure, respiratory distress, and anemia not responsive to transfusion. The patient's family chose not to have an autopsy performed to confirm this. Preoperatively, the patient was considered to be very high risk. After being fully informed, the family elected to proceed secondary to intractable pain and inability to ambulate.

Other postoperative complications were varied and included deep venous thrombosis, cellulitis, septic hip, fracture, progression of disease, and pneumonia. Additionally, another patient had a septic hip develop approximately 2 years after the procedure. There were two postoperative fractures. One was a nondisplaced fracture of the greater trochanter treated nonoperatively and the other was a periprosthetic fracture treated with open reduction and internal fixation with a lateral femoral condylar plate. In the latter case, there was no known documented disease in the area and the patient had experienced a significant twisting fall. One patient with a known chronic pulmonary embolism had pneumonia develop and another patient had a nonfatal pulmonary embolism.

Discussion

Hip arthroplasty involving cemented femoral components has been associated with hypotension and desaturation [6, 7]. A cemented long-stem hip arthroplasty for metastatic bone disease or revision arthroplasty is associated with a higher incidence of embolic-related phenomena and is a significant cause of morbidity and mortality in those treated [6]. Intraoperative cardiac arrest also has been reported as a complication of cemented hip arthroplasty [6–8]. Although

the exact incidence is unknown, it frequently is considered the major concern among surgeons treating patients with metastatic disease. In a previously reviewed patient cohort, Randall et al. showed that, with the technique described, a cemented long-stem hip arthroplasty does not increase perioperative morbidity in these very sick patients with impending or realized fractures around the hip [11]. One of the major concerns of that series was the sample size. We therefore reviewed the medical records of an additional 42 patients who underwent 44 arthroplasties for metastatic bone disease about the hip since the initial report to identify intraoperative and early postoperative complications that could be related to cementation.

There are limitations to our study. While our study was conducted retrospectively, the patients were excluded based on the previously mentioned criteria only and consisted of a cohort of patients treated consecutively. Additionally, there was a lack of uniform documentation intraoperatively and postoperatively. When documentation was unclear, adverse events were attributed to our technique and not to any other variable. This is the most likely cause for the increased number of patients who experienced prolonged intubation in the new cohort.

Regarding intraoperative complications attributable to our technique of long-stem cemented hip arthroplasty, there were no reported instances of cement-associated desaturation in this cohort. However, eight patients (19%) experienced cement-associated hypotension and 20 patients (48%) required administration of sympathomimetics. These are higher percentages of hypotension and sympathomimetic administration than previously reported [11]. Although the incidence of intraoperative mortality secondary to a cemented hip arthroplasty is difficult to determine, it has been suggested that the incidence is approximately 0.11% [6]. In the current series and the previous series [11], no patients experienced intraoperative mortality. Finally, we did not formally control for prolonged mental status changes which may be associated with any cardiopulmonary compromise [10]. However, none were clinically apparent.

Early postoperative complications in our new cohort included prolonged intubation, postoperative desaturation, and postoperative hypotension. A total of two patients (4.5%) experienced postoperative desaturation and postoperative hypotension. These events were short-lived and did not require aggressive intervention such as reintubation and sympathomimetic administration. In the previous cohort [11], there were no instances of postoperative desaturation or hypotension. Herrenbruck et al. [8] reported cement-associated hypotension in 38% of patients and oxygen desaturation of 25% in patients treated with cemented long-stem hip arthroplasty for metastatic disease and revision arthroplasty [8]. A previous study [11] and our current study show that these postoperative events occurred

less frequently with our technique. There was one death which occurred approximately 8 days postoperatively. To the best of our knowledge the patient's death was secondary to anemia not responsive to blood products, congestive heart disease, and respiratory failure. This patient had pleural effusions and respiratory distress before operative intervention. Despite the high risk and intensive preoperative counseling, the family chose to proceed with surgical intervention.

In a recent study, Alvi and Damron reported a low incidence of disease progression distal to the initial site of bone disease, suggesting that protecting the entire bone may not be necessary [1]. It also was reported that uncemented arthroplasty for metastatic disease about the hip is not associated with implant failure or major complications associated with the procedure [15]. One of the advantages of cementing the femoral stem (and cup) includes the ability to undergo early radiation therapy. In a study by Thein et al., skip lesions were treated with PMMA, and those that could not be bypassed with the femoral stem were treated with intralesional resection and plate fixation [15]. Despite remaining concerns regarding the use of cemented long-stem hip arthroplasties in patients with metastatic bone disease about the hip [1, 5], we still prefer this technique. Although patients with advanced cancer are living longer, metastatic cancer is almost always a uniformly progressive, debilitating disease [16]. Despite the use of bisphosphonates and denosumab to reduce skeletal-related events [13], patients are living at risk for pathologic fracture longer than before. Some of our patients experienced cement-associated hypotension, administration of sympathomimetics, and prolonged intubation, but these events were short-lived and in this cohort not associated with long-term sequelae. We therefore believe that with aggressive intramedullary lavage, the use of a long suction device, and application of PMMA in its early cure (liquefied) state, a long-stem hip arthroplasty may be associated with transient cardiopulmonary events but is appropriate for patients with realized or impending pathologic fractures.

References

1. Alvi HM, Damron TA. Prophylactic stabilization for bone metastases, myeloma, or lymphoma: do we need to protect the entire bone? *Clin Orthop Relat Res*. 2013;471:706–714.
2. Bickels J, Dadia S, Lidar Z. Surgical management of metastatic bone disease. *J Bone Joint Surg Am*. 2009;91:1503–1516.
3. Biermann JS, Holt GE, Lewis VO, Schwartz HS, Yaszemski MJ. Metastatic bone disease: diagnosis, evaluation and treatment. *J Bone Joint Surg Am*. 2009;91:1518–1530.
4. Chia SK, Speers CH, D'yachikova Y, Kang A, Malfair-Taylor S, Barnett J, Coldman A, Gelmon KA, O'reilly SE, Olivotta IA. The impact of new chemotherapeutic and hormone agents on survival in a population-based cohort of women with metastatic breast cancer. *Cancer*. 2007;110:973–979.
5. Coleman R, Gnani M, Morgan G, Clezardin P. Effects of bone-targeted agents on cancer progression and mortality. *J Natl Cancer Inst*. 2012;104:1059–1067.
6. Donaldson AJ, Thomson HE, Harper NJ, Kenny NW. Bone cement implantation syndrome. *Br J Anaesth*. 2009;102:12–22.
7. Fallon KM, Fuller JG, Morley-Forster P. Fat embolization and fatal cardiac arrest during hip arthroplasty with methylmethacrylate. *Can J Anaesth*. 2001;48:626–629.
8. Herrenbruck T, Erickson EW, Damron TA, Heiner J. Adverse clinical events during cemented long-stem femoral arthroplasty. *Clin Orthop Relat Res*. 2002;395:154–163.
9. Mirels H. Metastatic disease in long bones: a proposed scoring system for diagnosing impending pathologic fractures. *Clin Orthop Relat Res*. 1989;249:256–264.
10. Paulson OB, Strandgaard S, Edvinsson L. Cerebral autoregulation. *Cerebrovasc Brain Metab Rev*. 1990;2:161–192.
11. Randall RL, Aoki SK, Olson PR, Bott SI. Complications of cemented long-stem hip arthroplasties in metastatic bone disease. *Clin Orthop Relat Res*. 2006;443:287–295.
12. Ryan CJ, Elkin EP, Cowan J, Carroll PR. Initial treatment patterns and outcome of contemporary prostate cancer patients with bone metastases at initial presentation: data from CaPSURE. *Cancer*. 2007;110:81–86.
13. Schulman KL, Kohles J. Economic burden of metastatic bone disease in the U.S. *Cancer*. 2007;109:2334–2342.
14. Selek H, Basarir K, Yildiz Y, Saglik Y. Cement endoprosthetic replacement for metastatic bone disease in the proximal femur. *J Arthroplasty*. 2008;23:112–117.
15. Thein R, Herman A, Chechik A, Liberman B. Uncemented arthroplasty for metastatic disease of the hip: preliminary clinical experience. *J Arthroplasty*. 2012;27:1658–1662.
16. Weber KL, Randall RL, Grossman S, Parvizi J. Management of lower-extremity bone metastasis. *J Bone Joint Surg Am*. 2006;88(suppl 4):11–19.