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Cementless Hemiarthroplasty for Intracapsular Femoral Neck Fractures in the Octa- and Nonagenarians

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Background: Current evidence supports the use of cemented hemiarthroplasty for treatment of intracapsular femoral neck fractures since it is associated with a lower risk of implant-related complications. However, many medical centers employ the cementless technique for the frail elderly population because it is faster and has lower cardiovascular risks and perioperative mortality. This observational study reports the outcomes of cementless bipolar hemiarthroplasty for intracapsular femoral neck fractures in patients aged 80 years and older.

Methods: A total of 424 patients (female, 77.1%) with a mean age of 86.9 years were operated for intracapsular femoral neck fractures between January 2009 and December 2017. Of those, 66.7% had an American Society of Anaesthesiologists (ASA) score of 3 or more. All operations were performed with the posterolateral surgical approach and all patients received a cementless stem. Intraoperative and perioperative values and in-hospital outcomes were evaluated, and clinical and radiographical follow-up was done at 40 days, 90 days, and when possible between 5 months and 12 months postoperatively. Multivariate analysis was performed to evaluate if there were factors affecting mortality.

Results: The mean operative time was 50 minutes. There were no deaths intraoperatively. Intraoperative periprosthetic fractures occurred in 2.1% of the cases with 66.7% of them fixed through cerclage wires intraoperatively. The median length of hospitalization was 11 days (interquartile range, 8.75–15) and 2.4% of patients died while in hospital after surgery. Approximately 91.5% of patients presented with perioperative anemia. Only 1.9% of the complications were related to the implant, 62.5% of which were dislocations. More than 90% of patients were ambulatory either autonomously or with support at each follow-up assessment. Age, male sex, and higher ASA score were related to increased mortality.

Conclusions: Despite some limitations, this observational study underlines that a cementless femoral stem of modern design can give good clinical outcomes, thus being an appropriate solution especially for the frail elderly.

Keywords: *Femoral neck fractures, Cementless bipolar hemiarthroplasty, Frail elderly*

The population is aging and femoral neck fractures are becoming an "epidemic" worldwide.[1] In orthopedics, there is a wide debate concerning the optimal treatment of patients with femoral neck fractures: cemented or cementless hemiarthroplasty is one of the most discussed topics. Current evidence suggests that a cemented procedure is associated with a lower risk of implant-related complications, specifically periprosthetic fractures; however, many medical centers favor the cementless technique for the

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frail elderly population.[2,3)] This is because compared to the cemented technique, cementless hemiarthroplasty is faster and has lower cardiovascular risks and perioperative mortality.[4,5)]

METHODS

Study Design, Inclusion and Exclusion Criteria, Patient Demographics and Anesthesiologic Data

This is a retrospective cohort study with a case series of 424 patients, aged 80 years and older, who underwent cementless bipolar hemiarthroplasty between January 2009 and December 2017 for traumatic femoral neck fractures. Patients were selected from the Excel database of the operative unit. The study was conducted in line with the established ethical guidelines of the hospital: each patient at the hospital was asked to sign an informed consent whether to let his or her data public or private for future access, and only open access medical records were reviewed by the authors of the study. Since this is an observational retrospective study, it does not describe experimental studies on either humans or animals and so it does not need any ethical approval.

Atraumatic hip fractures, major preoperative complications, and private medical records were considered exclusion criteria and were ruled out from the study. The study outcomes were divided into 3 main parts: the first part included the intraoperative and perioperative values and in-hospital outcomes; the second part, follow-up data; and the last part, factors affecting mortality of patients who underwent the surgical procedure. Patient demographics and anesthesiologic data are presented in Table 1.

Surgery and Postoperative Management

At induction of anesthesia, 2 g of intravenous cefazolin was administered. All operations were performed with the same posterolateral surgical approach and all patients underwent cementless bipolar hemiarthroplasty. The operations were performed by an attending orthopedic surgeon, who was randomly assigned from a traumatological team of 10 surgeons. The femoral stem designs used in the study were the Zweymuller femoral stem-Taper 12/14 made of Ti6Al4V, the Collarless Stem with hydroxyapatite coating, and the CLS stem design. The choice of the stem depended mainly on the surgeon's preference. On the first postoperative day, the patient was asked to mobilize by putting the legs outside the bed. On the second postoperative day, the patient was able to sit on an armchair and on the third postoperative day, the patient walked with the use of a walker. Thromboprophylaxis with low-molecular-weight heparin (LMWH) at 4,000 IU per day was mandatory for at least 35–40 days for all patients. Drugs for osteoporosis, such as calcium carbonate and cholecalciferol, were prescribed at discharge. Partial weight-bearing on the operated hips with use of crutches was initiated. It is crucial for at least the first 3 months to avoid movements that pose a risk for dislocation, such as hip intrarotation with the knee flexed and low sitting. Aids such as higher toilet seats and a pillow between the legs when turning in the bed were used. After discharge, radiological follow-up examination was performed at 40 days and 90 days postoperatively and between 5 months and 12 months postoperatively. This timeline was established in the hospital trauma protocol for patients with femoral neck fractures.

Factors Affecting Mortality

The last part of the study outcome was to determine factors affecting mortality of all patients who underwent the surgical procedure. Through the regional database website, it was possible to extract patient data on the day of death,

Table 1. Patient Demographics and Anesthesiologic Data

Variable	Outcome
No. of patients	424
Age (yr)	86.9 ± 4.7 (80–104)
Sex	
Female	327 (77.1)
Male	97 (22.9)
No. of comorbidities	
0–1	290 (68.4)
≥ 2	134 (31.6)
Anesthesia	
General	187 (44.1)
Locoregional (spinal)	233 (55.0)
Other	4 (0.9)
ASA score	
1–2	88 (20.8)
3	243 (57.3)
4	40 (9.4)
Not found	53 (12.5)

Values are presented as mean ± standard deviation (range) or number (%).
ASA: American Society of Anaesthesiologists.

even if they were lost during the follow-up. So, mortality was calculated at 12 months and multivariate analysis was performed to evaluate if there were factors affecting mortality.

Statistical Methods

Data are described as numbers and percentages or means and standard deviations (SD) as appropriate. Associations between categorical variables were explored with the chi-square test with Fisher correction, if necessary. Mortality

Table 2. Intraoperative, Perioperative and in-Hospital Outcomes

Variable	Outcome
Overall waiting time before surgery	61 ± 50 hr (31 min–355 hr)
Operative time	50 ± 17 min (21 min–2 hr)
Hb level 1 day preoperatively (g/dL)	12.20 ± 1.66
Hb level 1 day postoperatively (g/dL)	10.13 ± 1.55
Mean of the difference (g/dL)	2.06 (1.62)
Intraoperative complication	
No complication	413 (97.4)
Periprosthetic fracture	9 (2.1)
Cerclage wire fixation	6 (1.4)
Reoperation/revision (Vancouver type B1 and B2)	2 (0.5)
Revision refused (Vancouver type B1)	1 (0.2)
Abnormal intramedullary femoral canal bleeding	1 (0.2)
Unstable implant	1 (0.2)
Median length of hospitalization in days (IQR)	11 (8.75–15)
Complication during hospitalization	
No complication	26 (6.1)
Perioperative anemia	388 (91.5)
Death after surgery	10 (2.4)
Complication related to implant	8 (1.9)
Dislocation reduced by closed procedure	3 (0.7)
Repeated dislocation, infection Girdlestone procedure	2 (0.5)
Hematoma (no antibiotic treatment)	1 (0.2)
Paresis of common peroneal nerve	1 (0.2)
Dehiscence of surgical wound (antibiotic treatment)	1 (0.2)
Systemic complication	143 (33.7)
Urinary tract apparatus	27 (6.4)
Respiratory tract apparatus	22 (5.2)
Disorientation, psychomotor agitation	21 (5.0)
Other	73 (17.2)

Values are presented as mean ± SD (range), mean ± SD, or number (%) otherwise indicated.
Hb: hemoglobin, IQR: interquartile range, SD: standard deviation.

was calculated from surgery to 365 days after surgery. After checking for proportionality of the hazard, impact on mortality of the risk factors was explored with a proportional hazard Cox regression model. All factors with a *p*-value < 0.2 were then submitted to multivariable backward cox regression analysis with a *p*-value of exclusion of 0.05. A *p*-value < 0.05 was considered statistically significant.

RESULTS

Intraoperative and Perioperative Data and in-Hospital Outcomes

Of note, 97.4% of the patients had no intraoperative complications. Intraoperative complications included 9 cases of periprosthetic fractures (2.1%), 1 case of abnormal bleeding of intramedullary femoral canal, and 1 case of implant instability. Six of the 9 periprosthetic fractures were fixed with cerclage wires intraoperatively, 2 fractures (1 Vancouver B1 type and 1 Vancouver B2 type) needed further surgical revision, and another Vancouver type B1 fracture was not revised due to the patient's own decision. All the outcomes are reported in Table 2.

Outcomes and Complications During the Follow-up

At each follow-up session, we performed traumatological evaluation for patients who came back for the scheduled follow-up or complications. The patient follow-up rate was poor: of the initial 424 patients, 25% (n = 106) had a known course, 96 patients completed the follow-up, and 10 patients died during hospitalization. The remaining 75% (n = 318) were all considered lost to follow-up since they did not receive a clinical evaluation; using the regional database, it was noted that actually 23% (n = 96) died during the follow-up and 52% (n = 222) simply did not come back for follow-up.

Table 3. Outcomes: from Surgery to 40 Days after Surgery

Variable	No. (%)
No. of patients	219
Ambulatory in autonomous manner or with use of aids	198 (90.4)
Normal X-ray and no implant complication	194 (88.6)
Dislocation reduced with closed procedure	2 (0.9)
Hematoma with surgical drainage and revision	2 (0.9)
Bedridden or wheelchair-bound	21 (9.6)
Not regaining mobility after surgery	8 (3.7)
Dislocation with open surgical revision	3 (1.4)
Infection	6 (2.7)
Death	3 (1.4)
Open surgical revision + antibiotic treatment	2 (0.9)
Antibiotic treatment	1 (0.5)
Immobility before surgery	2 (0.9)
Periprosthetic fracture (1 Vancouver A, 1 Vancouver B2)–(conservative treatment)	2 (0.9)

From Surgery to 40 Days after Surgery

At 40 days postoperatively, 52.9% (n = 219) of the patients recovering during hospitalization received a traumatological evaluation. On the contrary, 47.1% (n = 195) patients were lost to follow-up. All data are presented in Table 3.

From 40 Days to 90 Days after Surgery

Of the 219 patients who underwent the previous evaluation, 80.4% (n = 176) were available for traumatological evaluation in this period, whereas 19.6% (n = 43) were lost to follow-up. All data are presented in Table 4.

From 5 Months to 12 Months after Surgery

Of the 176 patients who had been available for the previous follow-up evaluation, 54.5% (n = 96) underwent trauma evaluation between 5 and 12 months after surgery, whereas 45.5% (n = 80) were lost to follow-up. Of the 96 patients, 95.8% (n = 92) were able to stand and walk either autonomously or with the use of aids; 4.2% (n = 4) were bedridden or wheelchair-bound. Of the 96 patients who were included in the complete follow-up, 69.8% (n = 67) exhibited no specific findings on X-rays, whereas 28.1% (n

Table 4. Outcomes: from 40 Days to 90 Days after Surgery

Variable	No. (%)
No. of patients	176
Ambulatory in autonomous manner or with use of aids	163 (92.6)
Normal X-ray and no implant complication	162 (92.0)
Conservative trochanteric hematoma	1 (0.6)
Bedridden or wheelchair-bound	13 (7.4)
Not regaining mobility after surgery	8 (4.5)
Infection	2 (1.1)
Death	1 (0.6)
Antibiotic treatment	1 (0.6)
Immobility before surgery	2 (1.1)
Periprosthetic fracture with reoperation (Vancouver B2)	1 (0.6)

= 27) showed heterotopic ossifications, especially in proximity of the greater trochanter. Heterometry was present in 10 patients and the discrepancy was a few millimeters in both of lengthening (n = 2) and shortening (n = 8).

Factors Affecting Mortality

The 1-year mortality was 25.5% (95% confidence interval, 21.6–29.9) Multivariate analysis was done to investigate any factors affecting mortality (Table 5). When the results were adjusted for the year of surgery, mortality increased with age, male sex, and ASA score of 4. In this analysis, 12.5% (n = 53) of the patients whose characteristics were similar to the others were excluded since the ASA score was not found in the medical record.

DISCUSSION

The population analyzed in this study was 80 years old or older.[6] The operative time (mean, 50 minutes; SD, 17 minutes) was comparable to that of a randomized controlled trial (RCT) by Parker et al.[4] (mean, 48.5 minutes; SD, 13.2 minutes). The operative time was shorter than that for cemented procedures since cementing requires polymerization, which leads to an increase in the duration of surgery.[2,4,5]

Considering hemoglobin behavior, the result of the current study was not so precise since it was impossible to determine if the patient underwent blood transfusion during surgery. However, the difference between pre- and postoperative hemoglobin seemed low. Li et al.[7] showed the same quantity of blood loss for both techniques. Figved et al.[8] reported a reduced blood loss with the cementless technique.

There were no deaths intraoperatively. Bone cement implantation syndrome was not encountered.[9,10] Although some authors support the use of cement due to the improvement in surgical techniques and modern stem designs, as well as intraoperative monitoring, Middleton et al.[11] reported increased perioperative mortality in patients receiving cemented rather than cementless prostheses and thus recommended cementless hemiarthroplasty in the elderly.[3,5,12]

In our study, death occurred after surgery during hospitalization due to complications, such as septic and hypovolemic shock, followed by cardiovascular col-

Table 5. Multivariate Analysis: Factors Affecting Mortality

Factor	Univariate		Multivariate	
	HR	*p*-value	HR	*p*-value
Age	1.08 (1.05–1.10)	< 0.001	1.07 (1.04–1.09)	< 0.001
Sex (male)	1.66 (1.27–2.16)	< 0.001	1.68 (1.26–2.24)	< 0.001
Time to surgery (> 48 hr)	1.44 (1.13–1.83)	0.003	-	
Surgery length (min)	0.995 (0.988–1.002)	0.160	-	
Hb 1 day after surgery (g/dL)	1.03 (0.96–1.11)	0.436	-	
Δ Hb (preoperative and postoperative)	0.94 (0.87–1.01)	0.078	-	
No. of comorbidities (≥ 2)	1.35 (1.04–1.75)	0.024	-	
In-hospital stay (day)	1.02 (0.999–1.03)	0.062	-	
Complications during hospitalization	0.93 (0.59–1.46)	0.752	-	
General anesthesia	1		-	
Locoregional anesthesia	1.04 (0.82–1.33)	0.741	-	
Other types of anesthesia	0.45 (0.11–1.81)	0.258	-	
ASA score	2.09 (1.67–2.62)	< 0.001	-	
1–2	1		1	
3	2.01 (1.43–2.82)	< 0.001	1.69 (1.19–2.39)	0.003
4	4.38 (2.81–6.83)	< 0.001	3.45 (2.18–5.46)	< 0.001

HR: hazard ratio, Hb: hemoglobin, ASA: American Society of Anaesthesiologists.

lapse. Almost all patients presented with perioperative anemia, which is commonly reported in the literature as an independent risk factor for decline in physical performance.[13,14] One third of the patients had systemic complications during hospitalization. During the postoperative period, preexisting medical conditions could exacerbate, predisposing the patient to increased mortality.[15,16] Complications related to the implant itself during hospitalization were few, with the majority being dislocations and infections. Dislocations were related to the patient characteristics or implant characteristics.[17,18] Risk factors related to the patient include dementia, cognitive dysfunction, and reduced mobility. This is because it is difficult to maintain patients with impaired cognitive function in an appropriate posture postoperatively.

The rate of dislocation in our patients was 1.2% during hospitalization. In the first 40 days of follow-up, further 2.3% dislocations occurred. Barnes et al.[19] reported a comparable dislocation rate (1.5%). Dislocation is more frequent in the first few months after surgery than in the following period due to the reduced strength of soft tissues.[17,19,20] Once a patient experiences dislocation, the risk of having recurrent dislocation increases.[19] Intraoperative periprosthetic fractures were found in 2.1% and they were mainly related to the implant insertion. The majority of the fractures were fixed with cerclage wires intraoperatively, while 2 underwent subsequent revision with a plate or revision stem. The rate of aseptic loosening was low with only 1 case found at 12 months. During follow-up, complications, such as postoperative periprosthetic fractures, were few, which could be explained in part by the low follow-up rate but largely by the fact that patients who continued to be followed up were completely assisted by a multidisciplinary team made up of physiotherapists, rheumatologists and orthopedics, who helped treat osteoporosis and prevent further falling, which increases the risk for implant instability.

The main outcomes reached were the return to the ambulatory status (either in an autonomous manner or with the use of aids) and the inability to do ambulation (patients bedridden or wheelchair-bound). In literature, however, there is a tendency for the cemented procedure to produce better functional outcomes as underlined by the RCT of Parker et al.[4] and by the systematic review of Luo et al.[21] On the contrary, Figved et al.,[8] DeAngelis et al.,[22] and Grammatopoulos et al.[23] reported good functional outcomes for both cemented and cementless techniques. Our study is in line with the second group of studies since at each follow-up assessment, more than 90% of patients were ambulatory either autonomously or with the use of walking aids.

Heterotopic ossification was present in one third of the X-rays of the patients, but none was reoperated. One of the main reasons could be the posterolateral surgical approach.[24] In addition, according to the literature, thromboprophylaxis with LMWH 4,000 IU per day was continued for 35–40 days and patients managed it autonomously without any bleeding complications.[25]

In the literature, there is a wide debate concerning the prevention of a secondary fracture after a fragility fracture.[25,26] This involves 2 main aspects: the adoption of safeguarding measures to prevent falls, thus minimizing their occurrence, and the reduction of the manifestations of severe osteoporosis.[25] Thus, we prescribed basic drugs for osteoporosis at discharge and conducted a rheumatological consult in order to further evaluate the disease in time. After the calculation of mortality, we performed multivariate analysis to evaluate factors having an effect on mortality. According to Petersen et al.[16] in order of significance, the 5 factors associated with increased mortality at 3 months were the following: cardiac complications, dementia, male sex, age, and waiting time for surgery. Our results were in line with the literature since the age, the male sex, and higher ASA score were associated with increased mortality risk. On the contrary, the time before surgery had no significant effect on mortality in our patients. A more focused analysis on the waiting time before surgery with other exclusion and inclusion criteria would have been necessary.

The study has some limitations, which are mainly related to the old age of the patients. First, many patients were lost during the follow-up, either because they died or because they simply did not come for follow-up visits. This could create a big bias in the study, so we tried to investigate why many patients simply did not return by surveying through phone the ones still alive: for some patients who did not regain mobility, it was difficult to come back as they were really old and did not have any assistance; the others who did really well without complications did not return to the hospital. Second, functional outcomes were not evaluated through the Harris Hip Score or the EQ-5D because many patients were already dead at the time of the study. For those who were alive, due to the advanced age, it would have been difficult to understand the questionnaires or to compile them.

In summary judging from the results obtained with the use of cementless stems, it seems that a femoral stem of modern design can give good clinical outcomes, thus being an appropriate solution especially for the frail elderly. However, the study has some limitations: patient's death, loss to follow-up, lack of functional assessment with scores. Despite these limitations, this study supports the use of cementless stems for the frail elderly and serves as a starting point for future high-quality RCTs or large multicenter RCTs, which will be necessary to determine the adequacy of the cementless technique for the frail elderly population.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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