



Never too old for hip arthroplasty: a 111-year-old woman walks out of hospital—a case report and literature review

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Abstract: Centenarians population is proliferating, and hip fractures are responsible for more than 10% of all hospital admissions for centenarian patients, which represents a considerable challenge to patients and healthcare providers. Herein, we first report a case of a 111-year-old woman who suffered from a hip fracture and was successfully managed with cemented hemiarthroplasty surgery. In addition, we further reviewed case reports, news, and related studies to address the central points in managing hip fractures in the centenarian population.

Keywords: Anesthesia; centenarian; delirium; enhanced recover after surgery; hemiarthroplasty; hip fracture

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Introduction

Although centenarians (people ages ≥ 100) are still unusual, their population is growing rapidly. According to United Nations estimates (1), there are over half a million centenarians worldwide, which is projected to grow eightfold by 2050. As the number of centenarians is expected to increase considerably in the coming years, the need for joint arthroplasty in this population represents an enormous challenge to patients, surgeons, and anesthesiologists. Currently, hip fractures are responsible for $>10\%$ of all hospital admissions for centenarian patients (2). Therefore, thoroughly investigate, review, and summarize the existing literature would contribute to developing a comprehensive knowledge base for future management practices.

Case presentation

A 111-year-old woman was referred to our emergency department with symptoms of right hip pain after a

mechanical fall from standing height. Physical examination revealed external rotation and shortening of the right lower extremity. Radiographs confirmed a complete fracture of the femoral neck with partial displacement (*Figure 1*). She was admitted and scheduled for surgery.

She was 1.57-meter-high, 54 kg, body mass index (BMI) 21.91 kg/m^2 . Echocardiogram revealed an ejection fraction of 61%, a light mitral and tricuspid insufficiency. Dynamic electrocardiography (DCG) presented atrial flutter with 2–6:1 conduction (heart rate: maximum 160 bpm, average 98 bpm). The numerical rating scale (NRS) for pain was 4 at rest and 6 when active, the Pittsburgh sleep quality index (PSQI) was 15. Preoperative ultrasound screening for the detection of thrombosis came back negative. The main abnormal perioperative laboratory tests are shown in *Table 1*. Other laboratory results, such as clotting time and liver function, were within the normal range. Arterial blood gas (ABG) analysis (at a continuous oxygen flow 2 L/min): oxygen pressure 131 mmHg, oxygenation index 451 mmHg. Based on these careful preoperative

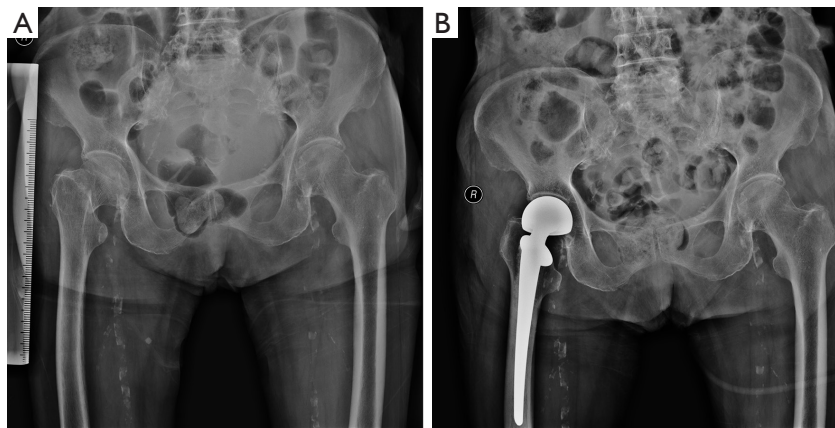


Figure 1 Preoperative and postoperative X-ray radiography of the pelvis. (A) displaced femoral neck fracture of the right hip (Garden classification: grade III), preoperative anteroposterior radiograph, (B) postoperation, anteroposterior radiograph on postoperative day 2.

Table 1 The perioperative laboratory tests of the patient

Blood test	Component	Reference range	Admission	Pre	POD1	POD3	POD5
Complete blood count (CBC)	WBC $\times 10^9/L$	3.5–9.5	10.24	9.3	12.42	4.47	5.66
	Neutrophil (%)	40–75	80.3	77.6	88.2	61.8	61.3
	Hb (g/L)	115–150	122	127	102	100	105
Comprehensive metabolic panel (CMP)	Prealbumin (g/L)	200–400	282	169	104	104	140
	Albumin (g/L)	40–55	47	40	38	35	37
	Urea (mmol/L)	3.1–8.8	7.4	8.4	12.7	15.2	10.1
	Creatinine ($\mu\text{mol/L}$)	41–81	98	101	108	101	97
	EGFR ($\text{mL}/\text{min}\times 1.73 \text{ m}^2$)	>90	39.4	38	35.1	38	36
Acute Phase Reactants (APRs)	CRP (mg/L)	0–8	12.7	114	93.2	93.2	28
	ESR (mm/h)	2–38	35	50	50	45	25
	IL-6 (pg/mL)	0–3.4	25.8	39.5	28.1	8.5	6.4
	PCT (ng/mL)	<0.05	0.06	0.85	–	–	0.39
Cardiac biomarkers	BNP (ng/L)	0–526	2,030	1,596	2,561	–	–
	Troponin ($\mu\text{g/L}$)	0–0.030	0.023	0.022	0.033	–	–
	CK-MB ($\mu\text{g/L}$)	0–4.9	2.8	3	4.8	–	–
	Myoglobin ($\mu\text{g/L}$)	25.0–58.0	221.6	56.7	383.7	–	–
Coagulation tests	FDP ($\mu\text{g/mL}$)	0–5.0	35.1	–	5.2	7.8	–
	D-D (mg/L)	0–0.55	12.94	–	1.7	2.21	–

APRs, acute phase reactants; CBC, complete blood count; CK-MB, creatine kinase-myoglobin; CMP, comprehensive metabolic panel; CRP, C-reactive protein; EGFR, estimated glomerular filtration rate; ESR, erythrocyte sedimentation rate; Hb, hemoglobin; IL-6, interleukin-6; PCT, procalcitonin; Pre, preoperative; POD, postoperative day; WBC, white blood cell.

assessments, the enhanced recovery after surgery multidisciplinary team (ERAS-MDT) taken a number of measures to improve the patient's clinical state: (I) selective COX-2 inhibitor was used to relieve pain and control NRS at 1–2 when rest and 3–4 when active; (II) sleep intervention such as desultory conversation with family members during daytime, reducing noise and distraction at night to treat situational insomnia, and the PSQI score was improved to 13; (III) nutritionist prepared small-peptide and whole-protein for oral administration; (IV) continuous low-flow oxygen via nasal cannula to enhance oxygenation, breathing exercises to improve pulmonary function; (V) maintaining fluid balance to prevent heart failure and other heart problems; (VI) perioperative tests for acute phase reactants were obtained to monitor and diagnose of infections.

After a three-day improvement of clinical state, she received a cemented hemiarthroplasty surgery. General anesthesia in combination with a single femoral nerve block was used to tailor to individual patient requirements. The intraoperative fluid administration was restricted to 1,000 mL. The surgery was uneventful and lasted for 35 minutes. Tranexamic acid was injected intra-articular to reduce blood loss. No blood products were required.

Vital signs were monitored closely after surgery. The postoperative target for fluid administration was to keep the daily fluid balance. Patient-controlled analgesia was used for pain relief. Weight-bearing was started about 1.5 hours after surgery when the patient completely recovered from anesthesia in the post-anesthesia care unit, and independent ambulation with a walker was achieved on postoperative day 1. Low-molecular-weight heparin (4,000 IU) was administered subcutaneously 8 hours postoperatively for thromboprophylaxis and once daily until discharge. Oral feeding formula containing small peptides, whole protein, and probiotics was given after surgery (3). Despite the preventable measures taken, delirium occurred the night following the surgery. The motor subtypes of postoperative delirium (POD) were both hyperactive and hypoactive delirium (also called mixed delirium). Olanzapine (5 mg) was added after a psychiatry consultation, other measures including active surveillance, continuous low-flow oxygen, minimizing the complexities of the physical constraints, kept the patient oriented, familiar family members talk about family news to provide mental stimulation throughout the daytime, reducing noise and distraction to ensure the patient obtains maximum uninterrupted sleep at night. The improvement of delirious symptoms was continued until postoperative day 2, and fully recovered from delirium

on postoperative day 3. The patient was discarded to a rehabilitation facility on postoperative day 6, aware, oriented, and pain-free. At 7 months of telephone follow-up, the patient was able to walk 50 meters with a metal walker.

Discussion

In this case, we reported a 111-year-old woman who received a cemented hemiarthroplasty to treat a displaced femoral neck fracture. To our best knowledge, this woman should be one of the oldest patients in the world to have had a joint arthroplasty. In order to draw lessons from this case and optimize the perioperative and intraoperative management, we searched PubMed and Embase for case reports of centenarian patients who underwent hip fracture surgery or joint arthroplasty. To ensure literature saturation, a supplementary search was further conducted using Google for news reports. Data such as year, location, gender, age, hospital, surgical indication, types of surgery, types of anesthesia used was retrieved and summarized in *Table 2*.

First, there is little controversy over the necessity of joint arthroplasty among the oldest age group even if short-term postoperative life expectancy estimates (4–7). A widely accepted philosophy is never too old for joint arthroplasty. Several case reports and numerous news have described successful hip hemiarthroplasty, total hip arthroplasty (THA), and revision THA in patients range 100–112 years (8–10) (*Table S1*). A couple of retrospective studies have found that the short-term outcomes among centenarians were comparable with those younger cohorts with similar fracture patterns (4,5,11), which suggested that hip arthroplasty is worthwhile to maintain quality of life, and should not be refused solely on account of extreme age or the concern of high in-hospital mortality risk.

Second, the surgical time in patients with hip fracture remains disputed. Although guidelines from both AAOS (12) and NICE (13) guidelines recommend surgery within 48 hours after admission, and a recent study (14) even suggested healthcare institutions and clinicians to reduce time to hip fracture surgery ideally within 24 hours as the standard, the optimal surgical time for the centenarian population was rarely investigated. A retrospective cohort study (11) found that time to surgery does not appear to affect short-term mortality rates of this extremely elderly population, which manifested a potential benefit from preoperative optimization. We should bear in mind that the primary challenge for centenarian candidates

Table 2 Reported centenarians who underwent joint replacement

Source	Country	Year	Age	Gender	Hospital	Surgical indication	Types of surgery	Types of anesthesia
Literature	Brazil	2013	107	Female	Complexo Hospitalar Mangabeira	Hip fracture	Hip surgery	Spinal anesthesia
Literature	Turkey	2016	100	Female	Dr. Lütfi Kırdar Training and Research Hospital	Hip fracture	Hip surgery	Spinal anesthesia
Literature	Brazil	2017	108	Female	Complexo Hospitalar Mangabeira	Hip fracture	Hip surgery	Spinal anesthesia
News	USA	2006	100	Female	University of Arkansas for Medical Sciences	Knee osteoarthritis	Total knee replacement	NA
News	Israel	2011	100	Male	Haifa's Carmel Medical Center	Hip fracture	Hip replacement	NA
News	UK	2011	102	Male	Pinderfields Hospital in Wakefield	NA	Revision total hip replacement	NA
News	China	2011	100	Female	Hefei First People's Hospital	Hip fracture	Hip hemiarthroplasty	General anesthesia
News	China	2013	100	Female	Tianjin First Central Hospital	Hip fracture	Hip hemiarthroplasty	NA
News	UK	2015	112	Female	St Mary's Hospital	Hip fracture	Hip hemiarthroplasty	Spinal anesthetic
News	UK	2016	104	Female	Leicester General Hospital	Loosening of hip prosthesis	Revision total hip replacement	Spinal anesthetic
News	China	2016	101	Female	The First Affiliated Hospital of Hunan University of Medicine	Hip fracture	Hip replacement	NA
News	India	2017	104	Female	Advance Orthopaedic Hospital	Hip fracture	Hip hemiarthroplasty	NA
News	India	2018	100	Female	Kovai Medical Centre and Hospital (KMCH)	Hip fracture	Hip surgery	NA
Source	Country	Year	Age	Gender	Hospital	Surgical indication	Types of surgery	Types of anesthesia
News	China	2018	101	Male	Bijie First Municipal People's Hospital	Hip fracture	Hip replacement	Combined spinal-epidural anesthesia
News	China	2019	112	Female	Sichuan Provincial Orthopedic Hospital	Hip fracture	Total hip replacement	General anesthesia
News	China	2019	102	Female	Xiangya Changde Hospital	Hip fracture	Hip replacement	Spinal anesthesia + sciatic nerve block

NA, not available.

is not the surgery itself, but the frail bodies are lack of physiological reserve, they could tolerate operations, but not complications. In this case, a thorough examination was conducted to identify and treat correctable comorbidities immediately so that surgery could be arranged without delay.

Third, the choice of regional or general anesthesia is an age-old debate. More and more evidence suggested that spinal anesthesia should be considered over general anesthesia for hip fracture repair procedures, although the optimal anesthesia modality for the surgical treatment of hip fractures is controversial, and no recent study was able to address or appreciate the clinical differences fully (13,15-17). Compared with general anesthesia, regional anesthesia has been shown to reduce rates of in-hospital mortality, thromboembolism, transfusion, operative time, superficial wound infection, and length of hospitalization (18-20). In particular, for centenarians who suffered from hip fracture, a comprehensive patient-specific preoperative evaluation by the anesthesia team play a crucial role in determining anesthesia type (21). Notably, there was consolidate evidence that supports peripheral nerve blocks in hip fractures, which not only decreases pain on movement but also reduces the risk of pneumonia, decreases time to first mobilization and cost of the analgesic drugs (22).

Fourth, there are few studies focused on treatment patterns of hip fracture in the centenarian population. Manoli *et al.* reported that approximately 92% were internal fixation for extracapsular hip fractures, and 60% were hemiarthroplasty for intracapsular fractures (11). The management of osteoporosis-related hip fractures in such a population is always challenging because they may never be able to tolerate re-operation. Both short-term and long-term studies have found a higher incidence of re-operation after internal fixation and recommend arthroplasty for lucid elderly patients (23-25). Therefore, arthroplasty may be a better choice for hip fractures. Hemiarthroplasty, which is associated with a lower risk of dislocation, without the requirement of acetabular reaming, and decreased operative time and blood loss, is more suitable for this lower-demand population (26,27). The usage of cemented fixation could decrease the risk of periprosthetic fracture and loosening (28).

Fifth, it is understandable that prolonged operative time would increase the risk of multiple postoperative complications, including anemia requiring transfusion, wound dehiscence, renal insufficiency, and surgical site infection (29,30), and these risks tended to increase with increasing age. Therefore, a number of factors such as

accurate preoperative planning, highly experienced surgeon, well-trained surgical assistants, circulating nurses, would shorten the operative time and should be given priority and efforts. More specifically, the minimally invasive anterolateral approach and abbreviated cementing technique also contribute to completing the surgery expeditiously (31-34). Notably, no compromise in surgical technique should be made to obtain a shorter operative time, since cemented hemiarthroplasty consists of many standardized surgical procedures, which would take some time and could not accelerate anymore (29,30).

Next, as the centenarian population continues mounting in the near future, they also represent a significant challenge to perioperative care. Although recent advances in perioperative care, especially the implementation of the ERAS program, have led to a significant decline in complications, centenarians who characterized by multimorbidity demand higher quality of perioperative care. Considering multimorbidity in centenarians is quite common, the integration of a multidisciplinary approach (ERAS-MDT) is of paramount importance in perioperative care, which would be helpful for prevention and management of various complications including delirium, congestive heart failure, malnutrition, renal disease, pain, etc. (35).

In addition, although most of the perioperative complications (e.g., urinary tract infections, pneumonia, and deep venous thrombosis) are manageable, one of the most troublesome complications is POD, which has also occurred in this case. POD is strongly associated with both short-term and long-term adverse consequences in older patients (36,37). However, over the past decades, no new effective treatment options have emerged for POD, and antipsychotics are still the most commonly used medication to treat the symptoms of delirium. There has been a general consensus regarding the role of unmodifiable risk factors (e.g., older age, history of psychiatric illness, higher comorbidity burden), the role of modifiable risk factors (e.g., operation time, electrolyte disorders, hemoglobin, and albumin level), and the role of disputed risk factors (e.g., perioperative medications, type of anesthesia) for POD (38-44). Perioperative improvement of the modifiable medical risk factors may exacerbate or attenuate the risk of POD, and further research is warranted to investigate other risk factors that impact on POD.

Finally, the steady increase of centenarians is undoubtedly a phenomenal achievement of the public healthcare system. Nevertheless, centenarians also pose an unprecedented

challenge to the healthcare system in turn. Recent research has shown that the centenarians can exceptionally fit as well as younger counterparts after procedures ranging from laparoscopic cholecystectomy, vascular procedures, aortic valve repair, to spine surgery, primary and even revision joint arthroplasty (8-10,45-48). Therefore, centenarians should not be denied on the basis of chronologic age, and they deserve equal resources as younger people.

In summary, although hip fractures in centenarians pose a challenge, it is never too old for joint arthroplasty. Preoperative assessment, medical optimization, optimal anesthesia management, expeditious surgery, coordinated multidisciplinary approach, and meticulous perioperative care are paramount in treating these patients.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Supplementary
Table S1 Reported centenarians who underwent joint replacement

Source	Country	Year	Age	Gender	Hospital	Surgical indication	Types of surgery	Types of Anesthesia	Available source website
Literature	Brazil	2013	107	Female	Complexo Hospitalar Mangabeira	Hip fracture	Hip surgery	Spinal anesthesia	https://doi.org/10.12659/AJCR.889961
Literature	Turkey	2016	100	Female	Dr. Lütfi Kırdar Training and Research Hospital	Hip fracture	Hip surgery	Spinal anesthesia	https://doi.org/10.1093/bja/el_13688
Literature	Brazil	2017	108	Female	Complexo Hospitalar Mangabeira	Hip fracture	Hip surgery	Spinal anesthesia	https://doi.org/10.15406/jaccoa.2017.07.00257
News	USA	2006	100	Female	University of Arkansas for Medical Sciences	Knee osteoarthritis	Total knee replacement	NA	http://www.nbcnews.com/id/28282424/ns/health-aging/t/surgery-super-old-success-what-price/#.XZoXBygzZPY
News	Israel	2011	100	Male	Haifa's Carmel Medical Center	Hip fracture	Hip replacement	NA	https://www.jpost.com/Health-and-Science/100-year-old-man-walks-out-of-hospital-post-hip-replacement
News	UK	2011	102	Male	Pinderfields Hospital in Wakefield	NA	Revision total hip replacement	NA	https://www.guinnessworldrecords.com/world-records/oldest-person-to-have-a-total-hip-replacement
News	China	2011	100	Female	Hefei First People's Hospital	Hip fracture	Hip hemiarthroplasty	General anesthesia	http://hfyy.cn/bhwz/display.asp?id=333
News	China	2013	100	Female	Tianjin First Central Hospital	Hip fracture	Hip hemiarthroplasty	NA	http://www.tj-fch.com/system/2013/02/19/001602190.shtml
News	UK	2015	112	Female	St Mary's Hospital	Hip fracture	Hip hemiarthroplasty	Spinal anesthetic	https://www.bbc.com/news/uk-england-hampshire-34547263
News	UK	2016	104	Female	Leicester General Hospital	Loosening of hip prosthesis	Revision total hip replacement	Spinal anesthetic	https://www.bbc.com/news/uk-england-leicestershire-35748777
News	China	2016	101	Female	The First Affiliated Hospital of Hunan University of Medicine	Hip fracture	Hip replacement	NA	http://hunan.voc.com.cn/xhn/article/201606/201606021626161607.html
News	India	2017	104	Female	Advance Orthopaedic Hospital	Hip fracture	Hip hemiarthroplasty	NA	https://www.youtube.com/watch?v=3ZwANxKJDSY
News	India	2018	100	Female	Kovai Medical Centre and Hospital (KMCH)	Hip fracture	Hip surgery	NA	https://timesofindia.indiatimes.com/city/coimbatore/100-year-old-woman-undergoes-hip-fracture-surgery-walks-next-day/articleshow/66126543.cms
News	China	2018	101	Male	Bijie First Municipal People's Hospital	Hip fracture	Hip replacement	Combined spinal-epidural anesthesia	http://m.bjyqw.com/article/25715
News	China	2019	112	Female	Sichuan Provincial Orthopedic Hospital	Hip fracture	Total hip replacement	General anesthesia	http://scnews.newssc.org/system/20190326/000953105.html
News	China	2019	102	Female	Xiangya Changde Hospital	Hip fracture	Hip replacement	Spinal anesthesia + sciatic nerve block	https://new.qq.com/omn/20190919/20190919A0PSXE00.html

NA, not available.