Urgent focus on enhanced recovery after surgery of AIDS patients with limb fractures

evidence from the Chinese Medical Centre for Infectious Diseases

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Aims

The incidence of limb fractures in patients living with HIV (PLWH) is increasing. However, due to their immunodeficiency status, the operation and rehabilitation of these patients present unique challenges. Currently, it is urgent to establish a standardized perioperative rehabilitation plan based on the concept of enhanced recovery after surgery (ERAS). This study aimed to validate the effectiveness of ERAS in the perioperative period of PLWH with limb fractures.

Methods

A total of 120 PLWH with limb fractures, between January 2015 and December 2023, were included in this study. We established a multidisciplinary team to design and implement a standardized ERAS protocol. The demographic, surgical, clinical, and follow-up information of the patients were collected and analyzed retrospectively.

Results

Compared with the control group, the ERAS group had a shorter operating time, hospital stay, preoperative waiting time, postoperative discharge time, less intraoperative blood loss, and higher albumin and haemoglobin on the first postoperative day. The time to removal of the urinary catheter/drainage tube was shortened, and the drainage volume was also significantly reduced in the ERAS group. There was no significant difference in the visual analogue scale (VAS) scores on postoperative return to the ward, but the ERAS group had lower scores on the first, second, and third postoperative days. There were no significant differences in the incidence of complications, other than 10% more nausea and vomiting in the control group. The limb function scores at one-year follow-up were similar between the two groups, but time to radiological fracture union and time to return to physical work and sports were significantly reduced in the ERAS group.

Conclusion

The implementation of a series of perioperative nursing measures based on the concept of ERAS in PLWH with limb fracture can significantly reduce the operating time and intraoperative blood loss, reduce the occurrence of postoperative pain and complications, and accelerate the improvement of the functional status of the affected limb in the early stage, which is worthy of applying in more medical institutions.

Article focus

- How to take better care of AIDS patients with limb fractures during the perioperative period, to obtain better treatment results.

Key messages

- This is the first study to formulate an integrated treatment standard and nursing measures for AIDS patients with limb fractures, which fills a significant gap in the field of standardized perioperative treatment for AIDS.

- The enhanced recovery after surgery (ERAS) protocol provided in this study is detailed and standardized, so it can be rapidly replicated and adopted by other institutions to benefit more patients.

Strengths and limitations

- This ERAS programme achieved a positive curative effect and prognosis in PLWH.
- This is a retrospective, single-centre analysis, with insufficient long-term follow-up.

Introduction

AIDS is one of the most prevalent and dangerous infectious diseases globally. The latest data from the United Nations Programme on HIV/AIDS (UNAIDS) shows that there are currently approximately 39 million people living with HIV (PLWH) worldwide, with 1.3 million new infections and 630,000 AIDS-related deaths in 2023.[1,2] With the promotion and application of antiretroviral therapy (ART), AIDS has become a chronic and controllable infectious disease, and the life expectancy and quality of life of PLWH have significantly improved.[3,4] The latest clinical research findings, however, clearly demonstrate that the fracture rate of PLWH is increasing significantly: in a large USA health system's study of 8,525 PLWH and 2,208,792 non-PLWH, fracture prevalence in PLWH over a wide age range increased by up to four times.[5] In the HIV Outpatient Study cohort of 5,826 PLWH, this figure is two to four times higher than patients who do not have HIV.[6] Research conducted on 540 women from Canada in 2007 revealed a nearly two-times higher incidence of fractures associated with HIV infection.[7]

Fragility fractures are infrequent among young populations; however, studies have revealed that PLWH may experience fractures up to a decade earlier compared to those without HIV infection.[8-10] It has been established that HIV infection and ART are independent risk factors for osteopenia and osteoporosis, leading to a high incidence of fractures.[11] The mechanism of HIV is that HIV-infected T cells can regulate the function of macrophages, lymphocytes, and bone marrow mesenchymal stem cells, releasing interleukin-6 (IL-6), IL-8, alkaline phosphatase, and Runt-related transcription factor 2 to enhance the recruitment of osteoclasts, resulting in increased RANKL and decreased osteoprotegerin. Thus, it decreases bone formation and increases bone resorption.[12-18] Regardless of the original ART regimen, commencing ART leads to a substantial and clinically significant 2% to 6% decrease in bone mineral density (BMD).[19-21] However, the mechanism of ART-induced bone loss is unclear; it may be related to phosphate consumption and increased bone turnover through proximal tubular toxicity,[22] or affecting vitamin D and parathyroid hormone metabolism.[23-27] The high incidence of limb fractures in PLWH resulting from these factors inevitably increases the likelihood of undergoing surgery.[28] Due to the immunodeficiency state caused by HIV, this brings great physical and psychological pressure to PLWH patients who will undergo surgical treatment. At the same time, for medical staff, the surgical operation and whole-course care of such patients also presents a unique challenge.[29]

The concept of enhanced recovery after surgery (ERAS) was first proposed by Professor Kehlet in Denmark in 1997,[30] aiming to use a series of optimized measures of perioperative management according to evidence-based medicine to reduce physical and psychological traumatic stress in surgical patients and achieve rapid recovery.[31,32] This concept has been widely used in surgical settings, and studies have shown significant reductions in the length of hospital stay, complication rates, mortality, and risk of readmission.[4-6] The ERAS protocol is divided into three stages: preoperative, intraoperative, and postoperative. These stages include patient education, multimodal combined analgesia, optimized anaesthesia, fluid management, minimization of surgical incision, nutritional support, reduction of inflammatory response, and early mobilization.[33,34] However, this advanced concept has not been fully described for surgery of PLWH, and the effectiveness of this protocol requires verification.

This study aimed to explore the optimized measures for rapid recovery after limb fracture surgery in PLWH with special immune status, and to validate the effectiveness of this concept by comparing the postoperative evaluation results of patients in the ERAS group and the control group to provide a theoretical basis for future clinical application and promotion.

Methods

Patients

This is a case-control retrospective study. We first introduced and implemented the concept of ERAS in PLWH with limb fracture in 2019; more than ten experts in various fields developed the ERAS protocol through evidence-based consensus, as described in the Standard ERAS Protocol Design section below. Therefore, we defined the PLWH undergoing surgery for limb fracture from 2019 to 2023 as the ERAS group. After applying the inclusion and exclusion criteria, we included a total of 60 patients in this group. We then included an equal number of PLWH with limb fractures who were treated in our department from 2015 to 2018 and matched for sex, age, comorbidities, and fracture type as the control group. Therefore, a total of 120 patients were included in this study. All surgeries of the enrolled patients were performed by a team led by the same senior orthopaedic surgeon (QZ), and the nursing pathway of the control group was also performed by the same team.

The inclusion criteria were as follows: 1) HIV infection confirmed by enzyme-linked immunosorbent assay and western blot; 2) upper or lower limb fractures requiring fracture reduction and internal fixation; and 3) age 18 to 60 years. Exclusion criteria were as follows: 1) female patients who were pregnant or lactating; 2) patients with severe mental or cognitive impairment; 3) patients with autoimmune diseases, uncontrolled bleeding diseases, or malignant tumour history; 4) patients with serious organic diseases such as heart, brain, and kidney failure; 5) patients with vertebral fractures, hip fractures, or osteonecrosis but without limb fractures; 6) withdrawal from the study either voluntarily or due to poor compliance; and 7) patients who were admitted to the intensive care unit (ICU) due to critical illness, serious adverse reactions to anaesthesia, or complications.

Table I. The protocol of enhanced recovery after surgery.

Measures	ERAS group	Control group
Preoperative measures		
Communication and education	1. Upon admission, individualized education was conducted to introduce HIV fracture-related knowledge to patients and their families, including the condition, diagnosis, and treatment process, surgical methods, and complications, through brochures, videos, and demonstration guidance. 2. Inform patients of various accelerated rehabilitation measures before, during, and after surgery in detail.[35] 3. Instruct patients to learn self-assessment of pain, turning over activities, steps of getting down on the ground, and methods of limb rehabilitation exercise before surgery.[36]	Patients were routinely informed of preoperative preparation, surgical risks and complications, and postoperative rehabilitation measures
Preoperative functional exercise	Balloon blowing and walking exercise are encouraged to improve cardiopulmonary function, strengthen muscle strength, and increase joint mobility, and develop exercise plans to improve functional reserve.[36]	No preoperative exercise was performed
Preoperative pain management	According to the pain level, sleep status, and emotional state of HIV patients before surgery, drugs based on acetaminophen or selective COX-2 inhibitors (which do not affect platelet function) were used for preventive analgesia, and opioids were avoided as much as possible, to reduce the peripheral and central nervous system pain sensitization and reduce the need for analgesic drugs and adverse drug reactions.[37]	No prophylactic analgesia or opioid analgesia was administered
Nutritional support and immunity enhancement	1. Nutritional risk screening 2002 (NRS 2002) was used for nutritional risk screening.[38] 2. Hypoproteinemia and anaemia are corrected with albumin infusion when albumin < 35 g/l and suspended red blood cells infusion when haemoglobin condition < 100 g/l. Encourage patients to eat high-protein foods (eggs, meat). Improve the tolerance and resistance of patients during surgery, as well as the ability to recover after surgery.[39] 3. Enhance immunity: Intravenous infusion of thymosin improved the immunity of patients to CD4 > 500/μl, CD4/CD8 ratio > 0.9.[39]	Instruct the patient to eat a nutritious diet
Evaluation	1. Anaesthetic risk, cardiopulmonary function, liver and kidney function, coagulation function, venous thrombosis risk, elderly population, hypertension, blood sugar, and other routine assessment. 2. Special assessment of HIV patients: - Immune function assessment: CD4, CD8, CD4/CD8, viral load.[40] - Risk assessment of osteonecrosis, osteoporosis, and fragility fractures: bone densitometry, dual-energy x-ray absorptiometry monitoring, and related radiographs, prevention, and treatment when T-value ≤ -2.5 SD.[41] - Evaluation of HIV-related comorbidity: check for other diseases such as tuberculosis, syphilis, hepatitis B, hepatitis C, etc; if present, need active control and correction treatment.[42–44] - Psychological status assessment: the hospital anxiety and depression scale (HADS) was used to	General status such as anaesthesia risk, cardiopulmonary, hepatorenal, and coagulation function were assessed based on history, laboratory, and imaging routine

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Measures	ERAS group	Control group
	evaluate the psychological status of patients and actively intervene.[45]	
Antiviral therapy	After admission, patients with TDF + 3TC + EFV should be replaced with elvitegravir immediately. When early surgical treatment is required, a fast-acting ART regimen, such as Biktarvy, may also be used intraoperatively in combination with Albuvirtide for injection. Oral antiviral drugs can be suspended on the day of surgery, and should be recovered as soon as possible after surgery, especially in patients with hepatitis B.[46]	Follow the TDF + 3TC+ EFV regimen
Opportunistic infection control	1. For HIV patients with large surgical trauma, long preoperative waiting time, old age, and more underlying diseases, the use time of antibiotics should be extended appropriately and the level of antibiotics should be increased. 2. When CD4 is less than 200/μl, sulfamethoxazole and antifungal drugs can be appropriately applied to prevent pneumocystis pneumonia and other fungal infections. When CD4 < 50/μl, clarithromycin/azithromycin can be selected to prevent mycobacterium avium complex infection.[47,48]	
	3. For the combined infectious diseases, if necessary, the medical consultation to provide symptomatic support treatment.	Symptomatic management was performed after opportunistic infection
Inflammation control	ESR and PCT are independent risk factors for surgical site infection in patients with HIV after orthopaedic surgery, so ceftriaxone should be administered intravenously before surgery to control inflammatory markers to normal.[49]	Surgery is also feasible when some inflammatory markers are out of the normal range
Prevent osteoporotic fragility fractures	Dual-energy x-ray absorptiometry monitoring combined with relevant radiological examination (when T value ≤ -2.5 SD) to be treated as follows: 1. Supplement vitamin D (1,200 U/d) and calcium (1,200 mg/d) 2. Antiosteoporosis drugs: bisphosphonates (alendronate and zoledronate) and bone resorption inhibitors (Denosumab) Adjustment of ART regimen in HIV-positive patients with confirmed osteoporosis (tenofovir dixil or protease inhibitors should be prohibited)[50]	Routine oral calcium supplementation
Intraoperative measures		
Skin preparation	Chlorhexidine gluconate ethanol skin disinfectant is the first choice for skin disinfection. The use of an incision protector can help to reduce surgical site infection.[51]	Routine iodophor disinfection. No notch protector used
Intraoperative pain management	Low opioid multimodal analgesia strategy:[37] - NSAIDs were given 30 mins before skin incision to prevent inflammatory pain; - Infiltration analgesia around the incision: 0.2% to 0.5% ropivacaine plus ketorolac, epinephrine, and other drugs, joint capsule and subcutaneous multipoint injection;	
	- Peripheral nerve block: 0.2% to 0.75% ropivacaine was injected into the peripheral nerve sheath to block the transmission of pain signals, effectively reduce intraoperative and postoperative pain and opioid use, and reduce intraoperative blood pressure fluctuations and	Potent opioids can be selected during anaesthesia induction and maintenance, and inflammatory pain prevention, invasive analgesia around the incision, and peripheral nerve block are not required

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Measures	ERAS group	Control group
	the incidence of postoperative nausea and vomiting.	
Occupational exposure protection	1. Medical staff with damaged exposed skin such as hands are strictly prohibited from performing surgery; 2. Wear special protective clothing and protective shoes for infectious disease surgery; wear anti-splash screens and goggles; wear two layers of surgical protective gloves and apply iodophor in between. Tools, needles, and other sharp tools are strictly managed by special personnel; after operation, take off protective clothing and shoes, wash hands, and wash the whole body rigorously.[52]	Wear normal surgical clothing and a layer of gloves
Postoperative measures		
Nutrition and immunity maintenance	1. Maintain nutrition during hospitalization after surgery and encourage patients to eat more vitamin-rich foods such as milk, beans, and fresh fruits and vegetables.[53] 2. Continued intravenous infusion of thymosin improved the patient's immunity and maintained CD4 > 500/μl, and CD4/CD8 ratio higher than 0.9. Parenteral nutrition preparations, suspended red blood cells, fresh frozen plasma, and human blood albumin were selected for intravenous infusion according to preoperative nutritional status.[54]	Patients are encouraged to maintain a high nutritional diet
Postoperative pain management	Low opioid multimodal analgesia strategy:[37] 1. VAS was used to evaluate the patients at regular intervals, and the original analgesic regimen was maintained when VAS ≤ 3. When VAS > 4 points, drugs with different mechanisms of action should be added for multimodal analgesia. When VAS > 6, individualized analgesia with weak opioids is required. PCA is used (generally, weak opioids, flurbiprofen axetil, dexmedetomidine, etc.), the dose of analgesic drugs is controlled by patients, and the dose can be adjusted according to their own pain tolerance.	Pain assessment was not performed. When patients reported pain at the surgical site, quantitative analgesic drugs were prescribed by doctors
Prevention of surgical site infection	In addition to CD4, albumin, ESR, and PCT are all independent influencing factors of surgical site infection, and these three indicators should always be kept within the normal range during the hospital, beyond which timely intervention should be taken.[55]	No relevant intervention
Prevention of femoral head necrosis	TDF and glucocorticoids are independent factors of necrosis of the femoral head in HIV. Therefore, HIV patients should be advised not to use antiviral regiments containing TDF, and not to use hormone therapy when suffering from other diseases.[55]	No relevant intervention
Long-term osteoporosis intervention	If the diagnosis of osteoporosis in HIV patients is confirmed, alendronate sodium/zoledronate sodium, vitamin D (1,200 U/d), and calcium (1,200 mg/d) should be given for a long time after surgery to prevent the continuous decline of bone mineral density and reduce the risk of fracture.[50]	Oral calcium supplementation is routinely given
Long-term antiviral therapy	Continue to take elvitegravir or Biktarvy antiviral therapy for a long time after surgery and after	Follow the TDF + 3TC+ EFV regimen

(*Continued*)

(*Continued*)

Measures	ERAS group	Control group
	discharge to ensure low viral load and normal body function.[46]	
Prevention and treatment of PONV	1. Maintain the preventive position of 40° to 50° head height and 30° foot height after operation.[56] 2. For patients with PONV risk factors, it is recommended to use two or more antiemetic drugs to prevent PONV. 5-HT3 receptor antagonist is the first-line drug, and low-dose dexamethasone (5 to 8 mg) can be used in combination. Minimizing perioperative opioid consumption and ensuring adequate fluid volume for patients undergoing day surgery can reduce the risk of PONV from baseline.[56]	Metoclopramide was used for nausea and vomiting
Rehabilitation training	Active exercises such as muscle contraction training, turning over, limb flexion/extension, and ankle pump exercise were encouraged in the early postoperative bed of HIV fracture patients. At the same time, relatively individualized rehabilitation training programs were developed, including pulmonary function training (such as blowing balloons), walking training, and spinal and limb joint traction training. According to the stable condition of surgery, patients were encouraged to get out of bed as soon as possible with brace and various pipes for functional training, establish daily activity goals, and increase the activity time and amount every day.[57]	Patients were able to walk in or out of bed according to their own wishes, or get out of bed after waiting for complete recovery

Fractures of all severity levels were included.
ART, antiretroviral therapy; COX-2, cyclooxygenase-2; ERAS, enhanced recovery after surgery; NSAIDs, non-steroidal anti-inflammatory drugs; PCA, patient-controlled analgesia; PCT, procalcitonin; PNOV, postoperative nausea and vomiting; TDF/3TC/EVF, Tenofovir/lamivudine/efavirenz; VAS, visual analogue scale.

Standard ERAS protocol design

The standard ERAS protocol for this study was developed in the following stages: first, chief physicians (mainly department chiefs) with at least 20 years of practice experience were selected from multiple departments, including orthopaedic surgeons, anaesthesiologists, nurses, psychiatrists, dietitians, pharmacists, and rehabilitation physicians, hereafter collectively referred to as experts. Then, according to the core issues of ERAS proposed in the clinical practice guidelines for ERAS in China, the outline of protocol was determined (Table I). This outline runs through the whole treatment process of preoperative, intraoperative, and postoperative ERAS; its core emphasizes the patient-centred diagnosis and treatment concept and strives to optimize the measures to reduce the perioperative stress response and postoperative complications, shorten the length of hospital stay, and promote patient recovery. Each expert was accountable for the issues within their respective domains. Through a review of recent literature and the combination of personal clinical experience, recommended implementation measures for the core issues in the ERAS field of limb fractures in PLWH were proposed, and the first draft was formed. Then, each implementation measure in the first draft needed to be further optimized through the discussion of all experts, with the aim of unanimous approval for the final draft. A comparison between the two groups of processes is presented in Table I.[35–57]

Outcome evaluation parameters

The demographic, surgical, and clinical information of the patients was collected retrospectively. The demographic information included sex, age, height, weight, CD4 count, CD8 count, viral load, duration of HIV infection, and ART treatment. Surgical data were extracted from medical records, including the surgical method, anaesthesia method, operating time, and intraoperative blood loss. Clinical information included fracture type, postoperative haemoglobin and albumin levels, postoperative pain intensity score (VAS), analgesic drug use time, drainage tube indwelling time, volume of drainage, and length of hospital stays. Postoperative complications were also recorded, including postoperative fever, wound infection, nausea and vomiting, pulmonary infection, urinary system infection, deep vein thrombosis of the lower limb, and joint stiffness.

All available patients were followed up within one year after surgery. The Fugl-Meyer score was used to assess the long-term functional outcome/recovery degree after surgery,[58] limb pain during rest and activity was measured by VAS score, and overall quality of life was measured by the EuroQol five-dimension questionnaire (EQ-5D).[59] Radiological fracture healing time was obtained from outpatient reports, and the time to return to physical and non-physical jobs and sports after surgery was gauged through questionnaires.

Table II. Patient demographic characteristics.

Characteristic	Control group	ERAS group	$\chi 2/t$	p-value
Sample size, n	60	60	-	-
Sex, n (M:F)	48:12	44:16	t = 0.745	0.388
Mean age, yrs (SD)	41.2 (9.8)	44.8 (7.4)	t = 1.236	0.294
Mean height, cm (SD)	172.8 (6.8)	173.1 (8.9)	t = -0.798	0.401
Mean weight, kg (SD)	67.9 (11.1)	69.8 (14.3)	t = -1.891	0.164
Mean BMI, kg/m^2 (SD)	22.9 (4.1)	23.0 (5.2)	t = -1.276	0.231
Mean CD4, mm^3 (SD)	459.12 (239.87)	473.69 (201.34)	t = 1.329	0.451
Mean CD8, mm^3 (SD)	876.13 (331.55)	882.41 (351.26)	t = 0.994	0.612
Comorbidities, n			$\chi 2$ = 0.855	0.802
None	34	32		
Hypertension	12	16		
Diabetes	9	7		
Coronary heart disease	5	5		
ASA grade, n			$\chi 2$ = 0.449	0.723
I	8	6		
II	42	38		
III	10	16		
Operative site, n				
Left	40	39	$\chi 2$ = 0.364	0.811
Right	16	19		
Both	4	2		
Upper limb	38	45	$\chi 2$ = 0.845	0.358
Lower limb	22	15		
Both	0	0		
Undetectable plasma viral load, n (%)	54 (90.0)	56 (93.3)	t = 0.436	0.509
Mean duration of HIV, yrs (SD)	6.32 (3.49)	7.45 (4.13)	t = 0.426	0.769
ART, n (%)	52 (86.7)	55 (91.7)	t = 0.776	0.378

ART, antiretroviral therapy; ASA, American Society of Anesthesiologists; ERAS, enhanced recovery after surgery.

Demographic characteristics

A total of 120 PLWH with limb fractures were included in the study. Statistical analysis showed that sex, age, height, weight, BMI, CD4, CD8, comorbidity, American Society of Anesthesiologists (ASA) grade,[60] operative site, viral load, duration of HIV infection, and ART usage rate were consistent and comparable between the two groups, as shown in Table II.

Statistical analysis

SPSS 22.0 (IBM, USA) was used for the statistical analysis. Measurement data were described as mean and SD or ranges; independent-samples *t*-tests were used to compare the data between the groups with normal distribution, and a non-parametric test was used to compare the data between the groups with non-normal distribution. The count data were described by frequency and constituent ratio or rate (%), and the chi-squared test was used for comparisons between groups. Statistical significance was set at $p < 0.05$.

Results

Surgical characteristics

All the operations were completed successfully; there were no intraoperative complications, the fracture ends were reduced accurately, and the postoperative radiograph results were in line with the surgical expectations. Compared with the control group, the ERAS group had a significantly shorter mean operating time, length of stay, preoperative waiting time, postoperative discharge time, and less intraoperative blood loss, whether during upper or lower limb surgery, as shown in Table III.

Postoperative characteristics

On the first postoperative day, the levels of haemoglobin and albumin in the ERAS group were significantly higher than those in the control group, and the first ambulation time in the lower limb surgery patients of the ERAS group was also significantly lower. The postoperative urethral catheter removal time, drainage time/volume, and duration of analgesic medicine in the ERAS group were significantly lower than those in the control group. There was no significant difference between the two groups in VAS scores on postoperative return to the ward; however, there was a significant difference between the two groups on the first, second, and third postoperative morning assessments, as shown in Table IV.

In the control group, there were six cases of postoperative fever, five cases of wound infection, eight cases of nausea and vomiting, four cases of pulmonary infection, four cases of urinary system infection, three cases of lower limb deep vein thrombosis, and two cases of joint stiffness. In the ERAS group, there were two cases of postoperative fever, one case of wound infection, two cases of nausea and vomiting, and one case of urinary system infection, and no pulmonary infection, joint stiffness, or deep vein thrombosis of the lower limb. There was no significant difference in the incidence of complications between the two groups except for nausea and vomiting. The results are presented in Table IV.

Readmission/reoperation and follow-up

Readmission at 30 days after surgery occurred in one patient in the ERAS group due to a fall during recovery, and three patients in the control group, including two patients with surgical site infection and one with wound pain. Among

Table III. Comparison of perioperative indicators. Values are expressed as means (ranges).

Indicator	Control group		ERAS group		t		p-value	
Limb	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Surgical duration, mins	73.66 (66.89 to 80.43)	86.27 (78.72 to 93.82)	64.34 (59.89 to 68.79)	80.96 (72.67 to 89.25)	t = 5.784	t = 3.523	0.001	0.010
Intraoperative blood loss, ml	149.91 (139.35 to 160.47)	176.91 (167.98 to 185.84)	130.14 (59.89 to 68.79)	155.27 (138.31 to 172.23)	t = 2.595	t = 4.942	0.012	0.001
Length of stay, days	12.26 (11.08 to 13.44)	13.26 (12.47 to 14.05)	10.33 (9.46 to 11.2)	11.19 (10.15 to 12.23)	t = -3.865	t = -3.662	0.006	0.011
Elapsed time before surgery, days	3.44 (3.19 to 3.69)	3.21 (2.97 to 3.45)	2.91 (2.61 to 3.21)	2.78 (2.46 to 3.1)	t = -2.286	t = -3.775	0.026	0.009
Discharge time after surgery, days	9.64 (8.77 to 10.51)	10.33 (9.06 to 11.6)	8.35 (7.74 to 8.96)	8.77 (7.43 to 10.11)	t = -2.308	t = -4.786	0.039	0.001

ERAS, enhanced recovery after surgery.

Table IV. Postoperative recovery characteristics and complications.

Variable	Control group		ERAS group		χ2/t		p-value	
Limb	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Mean POD 1 haemoglobin, g/l (SD)	105.2 (4.2)	102.3 (5.4)	112.6 (6.2)	110.9 (8.0)	-3.05	-2.32	0.007	0.036
Mean POD 1 albumin, g/l (SD)	42.4 (3.5)	43.6 (4.2)	45.6 (5.6)	44.6 (3.4)	-2.56	-0.98	0.013	0.322
Mean urethral catheter removal time, hrs (SD)	25.2 (6.2)	32.3 (5.7)	19.7 (5.8)	17.8 (4.6)	8.37	12.81	< 0.001	< 0.001
Mean drainage duration, hrs (SD)	47.2 (4.3)	62.4 (7.8)	38.3 (2.1)	49.2 (8.9)	10.73	18.55	< 0.001	< 0.001
Mean drainage volume, ml (SD)	136.7 (51.5)	177.4 (63.8)	98.2 (24.0)	102.2 (16.5)	23.73	26.32	< 0.001	< 0.001
Mean analgesic medicine, days (SD)	3.2 (0.9)	3.1 (0.7)	2.0 (0.6)	2.2 (0.6)	7.21	6.33	< 0.001	< 0.001
Mean VAS (SD)								
On return to the ward	3.2 (0.7)	4.2 (0.8)	2.9 (0.6)	3.9 (1.2)	1.33	1.62	0.097	0.113
POD 1 morning	4.7 (0.9)	5.0 (1.1)	4.1 (0.8)	4.3 (0.5)	5.91	6.59	< 0.001	< 0.001
POD 2 morning	4.4 (0.8)	4.2 (0.7)	3.6 (0.6)	3.1 (0.4)	5.36	7.38	< 0.001	< 0.001
POD 3 morning	3.2 (0.9)	3.5 (0.5)	2.6 (0.6)	2.8 (0.3)	6.95	5.94	< 0.001	< 0.001
Complications, n								
Fever	2	4	1	1	0.015	1.012	0.904	0.314
Wound infection	2	3	0	1	2.427	0.449	0.119	0.503
Nausea and vomiting	6	2	1	1	4.911	0.070	0.027	0.791
Pulmonary infection	3	1	0	0	3.686	0.701	0.055	0.403
Urinary tract infections	1	3	1	0	0.15	2.226	0.904	0.136
DVT	0	3	0	0	N/A	2.226	N/A	0.136
Stiffness of joints	1	1	0	0	1.199	0.701	0.274	0.403

DVT, deep vein thrombosis; N/A, not available; POD, postoperative day; VAS, visual analogue scale.

readmitted patients, only the patient who suffered a fall required revision surgery.

Patients were followed up one year after surgery. The non-response rate was 5.8% (7/120). The Fugl-Meyer limb function score did not differ between the two groups, although the mean score was slightly higher in the ERAS group. However, the ERAS group was faster in achieving radiological fracture healing and engaging in physical jobs and sports, and performed better on the EQ5D self-care items (Table V).

Discussion

Since the 1990s, the concept of ERAS has shown great effectiveness across various surgical disciplines.[61] In this study,

Table V. Follow-up characteristics.

Characteristic	Control group	ERAS group	t	p-value*
Mean Fugl-Meyer score (SD)	82.4 (9.6)	84.6 (11.7)	1.28	0.182
Pain (VAS, 1 to 10), mean (SD)				
During activity	2.3 (0.9)	1.9 (0.6)	2.33	0.091
During rest	1.6 (1.2)	1.7 (1.5)	1.06	0.323
Mean radiological fracture healing time, weeks (SD)	29.6 (2.8)	27.1 (1.5)	2.97	0.006
Mean time to return to 100% work, days (SD)				
Physical job	19.3 (2.5)	17.2 (1.7)	2.25	0.033
Non-physical job	11.2 (4.8)	10.6 (5.5)	0.79	0.345
Return to sports (days)	20.1 (2.9)	17.4 (2.3)	2.81	0.019
Mean EQ-5D score (SD)				
Mobility	1.3 (0.9)	1.4 (0.8)	0.98	0.637
Self-care	1.3 (0.5)	1.1 (0.3)	2.21	0.048
Everyday activities	1.2 (0.5)	1.2 (0.7)	1.33	0.872
Pain/anxiety	1.5 (0.6)	1.4 (0.4)	1.29	0.351
Fear/depression	1.4 (0.7)	1.3 (0.5)	0.77	0.292

*Independent-samples *t*-test.
EQ-5D, EuroQol five-dimension questionnaire; ERAS, enhanced recovery after surgery; VAS, visual analogue scale.

the concept was first applied to perioperative management of limb fractures in PLWH, yielding remarkably positive outcomes. Compared with the control group, the ERAS group had a shorter operating time, hospital stay, preoperative waiting time, postoperative discharge time, less intraoperative blood loss, and higher albumin and haemoglobin on the first postoperative day. The time to removal of the urinary catheter/drainage tube was shortened, and the drainage volume was also significantly reduced, in the ERAS group. There was no statistically significant difference in VAS scores on postoperative return to the ward, but the ERAS group had lower scores on the first, second, and third postoperative days. There were no significant differences in the incidence of complications, other than more nausea and vomiting in the control group. The limb function scores at one-year follow-up were similar between the two groups, but time to radiological fracture union and time to return to physical work and sports were significantly reduced in the ERAS group.

In this study, two groups of patients with baseline data consistency guarantees homogenous comparable data, and the detailed ERAS protocol presented in Table I facilitates replication in other medical institutions. The postoperative results found that the haemoglobin and albumin in the ERAS group were significantly higher than those in the control group, which was due to the targeted preoperative improvement of the immune and nutritional status of PLWH, and the minimization of trauma and blood loss during the procedure. Pain assessment after surgery found that immediate postoperative VAS score in the two groups had no significant difference – we suspect that this is due to the residual effect of intraoperative anaesthetic and cannot reflect the actual pain experience of the patients. Yet, on postoperative days 1, 2, and 3, VAS scores of the ERAS group were significantly lower, thus demonstrating the advantages of a multimodal postoperative pain strategy.[62] Different analgesic drugs were used depending on how high each patient's VAS score was, patient-controlled analgesia was adopted, and the dose could be adjusted according to the patient's own pain tolerance.[63] In terms of postoperative complications, the ERAS group had a significantly lower incidence due to the special preventive position and antiemetic agents represented by 5-HT3 receptor antagonist and low-dose dexamethasone. Finally, the two groups tended to have similar limb function scores in the long-term follow-up, but the time to radiological fracture healing was approximately 2.5 weeks shorter in the ERAS group and the time to return to physical work and sports was faster, which is what we would expect to see.

A multidisciplinary team, in formulating the ERAS protocol, devised a series of special measures for the unique immune status of PLWH, which is the core of this study and presented as follows: 1) extra emphasis is placed on the monitoring and enhancement of immune function and nutritional status during the perioperative period. Unlike other immunocompromised individuals, PLWH are characterized by a significant and persistent reduction in CD4+ T cell and functional impairment, which cannot be alleviated by rest and nutritional supplementation.[64] Therefore, in addition to timely administration of ART to inhibit viral replication, albumin and thymosin infusion may also be necessary. 2) Assessment of bone metabolism and antiosteoporosis treatment. Due to the notable impact of HIV infection, ART, and immune function changes on the patient's bone metabolism, BMD should be monitored preoperatively, and preventive measures such as vitamin D, calcium supplements, and bisphosphonate drugs

should be taken.[65,66] The ART regimen containing tenofovir disoproxil or protease inhibitors should be prohibited to prevent fragility fractures. 3) Protection against occupational exposure during surgery.[67] In addition to the rapid and effective ART, it is necessary to wear special protective measures such as anti-needle surgical gloves, anti-liquid splash protective clothing, and protective boots. At the same time, occupational exposure protection knowledge should be strengthened in health education. 4) Prevent opportunistic infections. Infection with HIV can reactivate dormant pathogenic microorganisms in the body or increase the susceptibility of the body to exogenous pathogenic microorganisms, so it is necessary to carefully evaluate the opportunistic infection situation of PLWH and use corresponding antibiotics for prevention and treatment.[68]

The key strength of this study lies in the development of an integrated treatment standard and nursing measures for PLWH with limb fractures, which fills a critical gap in the field of standardized perioperative treatment for AIDS. Furthermore, the ERAS protocol provided in this study is detailed and standardized, so it can be rapidly replicated and adopted by other institutions to benefit more patients. However, it is also important to acknowledge certain limitations of this study, such as its retrospective nature, single-centre analysis, and insufficient medium- to long-term follow-up. Therefore, future research should focus on conducting large-scale multicentre studies with extended follow-up periods to confirm the effectiveness and feasibility of these findings, ultimately promoting standardized perioperative treatment for PLWH.

In conclusion, the implementation of a series of perioperative nursing measures based on the concept of ERAS in PLWH with limb fracture can significantly reduce the operating time and intraoperative blood loss, reduce the occurrence of pain and complications after the operation, and accelerate the improvement of the functional status of the affected limb in the early stage, which is worthy of clinical promotion.

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Ethical review statement

The study was conducted in accordance with the Declaration of Helsinki, and the study protocol was reviewed and approved by the Ethics Committee of Beijing Ditan Hospital, Capital Medical University. Written informed consent was obtained from the patients and their anonymous information will be published in this article.

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