

Postoperative Wound Discharge After Hip Arthroplasty in Elderly Patients: Hypoalbuminemia, Not Infection, Is the Cause

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Abstract

Background

Postoperative serous wound discharge after proximal femur fracture arthroplasty mimics surgical site infection (SSI) in elderly patients, driving unnecessary investigations and antibiotic escalation. Hypoalbuminemia lowers plasma colloid osmotic pressure sufficiently to generate transudative fluid through the disrupted wound bed, and independently predicts SSI, wound complications, and prolonged admission in this population. Concurrent non-wound infections, particularly urinary tract infection (UTI) and lower respiratory tract infection (LRTI), raise C-reactive protein (CRP) and white blood cell count (WBC) without contributing to wound pathology. This study aimed to determine whether hypoalbuminemia drives postoperative serous wound discharge after hip arthroplasty for proximal femur fractures in elderly patients, and to test directly whether broader antibiotic therapy for concurrent non-wound infections accounts for discharge resolution.

Methods

We conducted a single-centre retrospective observational study. Consecutive patients aged 70 years or older undergoing hemiarthroplasty or total hip arthroplasty (THA) via a posterior approach for proximal femur fractures (January 2023 to June 2025) who developed postoperative wound discharge with a sterile wound culture were identified. A uniform prophylactic antibiotic protocol was applied (intravenous [IV] cefuroxime 1.5 g at induction; oral cefuroxime 500 mg twice daily for 5 days); no additional antibiotics were prescribed for wound discharge alone. All 32 patients received IV 20% human albumin (100 mL twice daily for 3 days). The antibiotic confound was tested by comparing wound discharge resolution times between patients who did and did not receive broader antibiotics for concurrent non-wound infections. Minimum follow-up was 6 months. The study was classified as exempt from full ethics review by the Institutional Ethics Committee and conducted per the Declaration of Helsinki (2013 revision). STROBE guidelines were followed.

Results

All 32 patients were hypoalbuminemic (mean 2.58 g/dL) with universally sterile wound cultures. Pre-treatment albumin correlated with resolution time (Pearson $r = -0.81$, $R^2 = 0.65$, $p < 0.001$), and albumin supplementation resolved discharge in 100% of patients. Fourteen patients (43.8%) with concurrent UTI or LRTI had higher CRP (67.4 vs 35.4 mg/L; $p < 0.001$) and WBC (12.9 vs $9.0 \times 10^9/L$; $p < 0.001$) despite sterile wound cultures. Patients receiving broader antibiotics for concurrent infections resolved more slowly than those on cefuroxime alone (5.4 vs 4.8 days; $p = 0.20$), with the difference explained by lower albumin in the concurrent infection group, statistically refuting antibiotic effect as the mechanism. Mean LOS was 9.2 days versus an expected 4 to 5 days; 30 of 32 patients (93.75%) were infection-free at minimum 6-month follow-up.

Conclusions

Hypoalbuminemia, not infection, drives postoperative serous wound discharge in elderly patients undergoing proximal femur fracture arthroplasty via the posterior approach. Concurrent UTI and LRTI elevate inflammatory markers without infecting the wound, and broader antibiotic therapy for those infections does not resolve the discharge. Albumin supplementation should be incorporated into routine postoperative wound assessment in this population.

Background

Proximal femur fractures are among the most common orthopaedic emergencies in elderly patients worldwide, with an estimated global incidence of 1.66 million in 1990 projected to rise sharply by 2050 [1, 25]. For displaced intracapsular fractures and selected extracapsular patterns, hemiarthroplasty and THA have largely replaced internal fixation, offering more reliable outcomes and earlier mobilisation [3, 4]. The posterior approach is the most widely used surgical access route for

this procedure [5]. Nutritional status matters: hypoalbuminemia, almost universal in elderly hip fracture patients, independently predicts death, complications, SSI, and prolonged hospital stay [6, 7, 8, 9, 10, 11, 12, 13].

Postoperative wound discharge in this cohort creates a specific clinical problem. Serous or serosanguinous drainage from a recently operated hip triggers concern about SSI or periprosthetic joint infection (PJI), which require debridement and prolonged antibiotic therapy [14, 15, 24]. The resulting cascade -- inflammatory markers, wound cultures, joint aspiration, nuclear imaging -- adds morbidity in patients who are already frail and on multiple medications.

This is a diagnostic trap with several compounding features. Hypoalbuminemia lowers plasma colloid osmotic pressure enough to drive transudative fluid through the wound bed via the Starling mechanism [16], predicts wound complications and SSI after arthroplasty [10, 11, 12], and is worsened by the catabolic response to fracture [6, 13]. UTI and LRTI are common during hip fracture admissions and independently raise CRP, WBC, and temperature -- mimicking wound infection when the wound cultures are sterile [17]. And all patients in this setting are already receiving prophylactic antibiotics when discharge is noted, which raises a question that has not been directly answered in the literature: when a patient with concurrent UTI or LRTI receives broader antibiotic coverage and wound discharge then resolves, did the antibiotics clear occult wound bacteria, or did albumin repletion correct the underlying oncotic deficit?

No published study has directly tested this antibiotic confound in this population, quantified concurrent non-wound infections as independent inflammatory confounders, or reported minimum 6-month safety data for withholding antibiotic escalation when wound cultures are sterile. This study was designed to do all of that: to determine whether hypoalbuminemia drives postoperative sterile wound discharge with albumin predicting resolution time; whether concurrent UTI or LRTI independently elevate inflammatory markers without infecting the wound; whether broader antibiotic therapy accounts for discharge resolution; and what the LOS impact is, and whether withholding escalation is safe.

Methods

Study Design and Setting

We conducted a single-centre retrospective observational study of prospectively maintained clinical records at a tertiary orthopaedic unit between January 2023 and June 2025. Minimum follow-up was 6 months for all included patients. This study was classified as exempt from full ethics review by the Institutional Ethics Committee in accordance with institutional policy for retrospective clinical record analysis. The study was conducted per the Declaration of Helsinki (2013 revision). Informed consent was obtained per institutional requirements. STROBE guidelines were followed throughout.

Participants

Inclusion criteria

Age 70 years or older; hemiarthroplasty or primary THA via posterior approach for proximal femur fracture (AO/OTA classification type A or B); postoperative wound discharge first noted at post-operative day (POD) 3 or later; sterile wound culture obtained at the same clinical assessment as discharge identification.

Exclusion criteria

Culture-positive wound swab; chronic lymphoedema; haematological malignancy; immunosuppressive therapy; established hepatic cirrhosis; albumin administration prior to assessment; follow-up under 6 months.

Surgical Technique

All procedures were performed via the posterior approach under spinal or general anaesthesia by one of three consultant orthopaedic surgeons [5]. Hemiarthroplasty used cemented modular femoral stems; unipolar or bipolar head selection was based on intraoperative assessment of acetabular cartilage. THA used cemented or cementless femoral components based on pre-operative templating and intraoperative bone quality. Wound closure was layered: absorbable deep sutures, monofilament or staples for skin, and an occlusive dressing. The use of a single approach throughout the cohort means surgical access is not a confounding variable.

Antibiotic Protocol

All patients received IV cefuroxime 1.5 g at anaesthetic induction followed by oral cefuroxime 500 mg twice daily for 5 post-operative days, in line with national hip fracture management guidance [18]. No additional antibiotics were prescribed for wound discharge alone provided the wound culture was sterile. Patients with a concurrent non-wound infection (UTI or LRTI) received targeted antibiotic therapy for that infection, prescribed independently of wound care.

Outcome Measures and Assessment Protocol

When wound discharge was first identified, the following were obtained for all patients: wound swab (aerobic and anaerobic culture), serum albumin, CRP, full blood count (FBC) with differential WBC, body temperature, urinalysis with culture, and chest radiograph where clinically indicated. A concurrent non-wound infection was defined as microbiologically or clinically confirmed UTI or LRTI during the same admission. All patients received IV 20% human albumin (100 mL twice daily for 3 days) alongside oral nutritional supplementation [19]. The primary outcome was days to complete wound discharge resolution. Secondary outcomes were LOS, post-treatment serum albumin, and infection status at minimum 6-month follow-up.

Follow-up

Patients were reviewed at 6 weeks, 3 months, and a minimum of 6 months post-operatively, per national guidance [18]. Any wound complication at follow-up was assessed with wound culture, inflammatory markers, and imaging as clinically indicated.

Statistical Analysis

Statistical analysis was performed using SPSS version 28.0 (IBM, Armonk, NY, USA) and Python SciPy 1.11.0. Continuous variables are reported as mean $\pm$ standard deviation (SD) with 95% confidence intervals (CIs). Pre- and post-treatment albumin levels were compared with a paired t-test. Pearson correlation coefficients (r) were calculated for pre-treatment albumin versus days to resolution, pre-treatment albumin versus discharge onset day, and resolution days versus LOS. Linear regression derived the coefficient of determination (R^2) and standardised beta coefficient (B) for albumin as a predictor of resolution days. Resolution days were compared between severe and mild hypoalbuminemia subgroups, and between the broader antibiotic group and the cefuroxime-only group, using independent t-tests and Mann-Whitney U tests. Chi-square tests without Yates correction ($n > 30$) assessed associations between concurrent non-wound infection and elevated CRP (above 60 mg/L), between surgery type and discharge character, and between fracture type and discharge character. A two-tailed p value below 0.05 was considered statistically significant.

Results

Patient Demographics and Wound Discharge Characteristics

Thirty-two patients met inclusion criteria: 24 female (75.0%), 17 undergoing hemiarthroplasty (53.1%) and 15 THA (46.9%). Mean age was 78.9 $\pm$ 5.3 years (range 70 to 89). Mean BMI was 21.7 $\pm$ 2.7 kg/m². Intracapsular fractures were slightly

more common (17 of 32; 53.1%). Mean follow-up was 15.3 +/- 7.4 months (range 6 to 29 months). Full patient-level data are presented in Table 1. The distribution of pre-treatment serum albumin across the cohort is shown in Fig. 5.

At wound discharge identification, all 32 patients were hypoalbuminemic (mean pre-treatment albumin 2.58 +/- 0.28 g/dL; range 2.00 to 3.10 g/dL). Nine patients (28.1%) had severe hypoalbuminemia (albumin below 2.4 g/dL). All 32 wound cultures were sterile. Discharge appeared at a mean of 5.2 +/- 1.7 PODs (range POD 3 to 9), with serous character in 25 of 32 patients (78.1%).

Hypoalbuminemia as the Primary Driver of Wound Discharge

After IV albumin supplementation, post-treatment albumin rose from 2.58 +/- 0.28 to 3.43 +/- 0.28 g/dL – a mean rise of + 0.85 +/- 0.10 g/dL (paired t-test: $t = -47.42$, $df = 31$, $p < 0.001$). Individual albumin trajectories are shown in Fig. 2. Wound discharge resolved in all 32 patients. Pre-treatment albumin predicted resolution time (Pearson $r = -0.81$, $R^2 = 0.65$, $p < 0.001$): lower albumin meant longer time to resolution ($B = -3.64$) (Fig. 1). Patients with severe hypoalbuminemia took longer to resolve than those with mild hypoalbuminemia (6.3 +/- 1.0 vs 4.5 +/- 0.9 days; $t = 4.79$, $df = 30$, $p < 0.001$; Mann-Whitney $U = 186.5$, $p < 0.001$) (Fig. 3). No patient required wound exploration, debridement, or implant revision.

Concurrent Non-Wound Infections as Inflammatory Confounders

Fourteen patients (43.8%) had a concurrent non-wound infection during the admission: UTI in eight (25.0%) and LRTI in six (18.8%); the distribution of infection types is shown in Fig. 6. Targeted antibiotic therapy was prescribed for each infection by the relevant medical team, independently of wound management. CRP was higher in the concurrent infection group (67.4 +/- 19.3 vs 35.4 +/- 8.4 mg/L; $t = 6.32$, $df = 30$, $p < 0.001$), as was WBC (12.9 +/- 1.9 vs 9.0 +/- 1.6 x10⁹/L; $t = 6.36$, $df = 30$, $p < 0.001$). Nine of 14 patients with concurrent infection (64.3%) had CRP above 60 mg/L – the 2018 ICM PJI threshold [14] – against zero of 18 without (chi-square = 16.10, $df = 1$, $p < 0.001$) (Fig. 4). Wound cultures were sterile in every patient. Summary statistics are in Table 2 and the full statistical analysis in Table 3.

The Antibiotic Confound: Direct Test and Rejection

The concurrent infection group (broader antibiotics, $n = 14$) resolved wound discharge in a mean of 5.4 +/- 1.4 days; the non-concurrent infection group (cefuroxime only, $n = 18$) resolved in a mean of 4.8 +/- 1.1 days ($t = 1.31$, $df = 30$, $p = 0.20$; Mann-Whitney U : $p = 0.21$). The broader antibiotic group resolved more slowly, not faster – the opposite of antibiotic-driven resolution (Fig. 7). When albumin is entered as the predictor in the regression model, it accounts for 65% of variance in resolution time ($R^2 = 0.65$, $p < 0.001$), while antibiotic group membership adds no independent predictive value ($p = 0.20$). The wound swabs were sterile before albumin therapy started, meaning there was no microbiological target for antibiotics at the wound.

Length of Stay and 6-Month Follow-up Safety

Mean LOS was 9.2 +/- 2.3 days (range 5 to 15), against an expected 4 to 5 days for uncomplicated arthroplasty – roughly 4.7 excess bed-days per patient (Fig. 8A). Resolution days predicted LOS (Pearson $r = 0.70$, $p < 0.001$) (Fig. 8B). Surgery type and fracture type were not associated with discharge character (chi-square $p = 0.14$ and $p = 0.39$).

At minimum 6-month follow-up (mean 15.3 +/- 7.4 months), 30 of 32 patients (93.75%) were free of confirmed infection (Fig. 6A). Two late secondary infections occurred. Patient A developed a superficial methicillin-sensitive *Staphylococcus aureus* (MSSA) SSI at 4 months, treated with oral co-amoxiclav without re-operation; the index discharge at POD 7 had been sterile and resolved before discharge. Patient B developed a deep coagulase-negative staphylococcal (CoNS) infection meeting 2018 ICM PJI criteria [14] at 6 months, attributed to haematogenous seeding after a dental procedure at month 5, managed with two-stage revision [15]; the index discharge at POD 6 had resolved with albumin 5 months earlier. Neither case was related to the primary sterile discharge.

Table 1

Patient-level data for all 32 patients. Pre-Alb = pre-treatment serum albumin (g/dL); Post-Alb = post-treatment albumin day 5 (g/dL); POD = post-operative day; Conc. Inf. = concurrent non-wound infection; Res. = days to complete resolution; LOS = length of stay (days). * Severe hypoalbuminemia (albumin < 2.4 g/dL). Hemi = hemiarthroplasty; Intracap. = intracapsular; Extracap. = extracapsular; UTI = urinary tract infection; LRTI = lower respiratory tract infection; PJI = periprosthetic joint infection; SSI = surgical site infection. (d) Late secondary infection unrelated to primary sterile discharge.

Pt #	Age (yr)	Sex	Surgery	Fracture	Pre-Alb	Post-Alb	Onset (POD)	Wound Swab	Conc. Inf.	Res. (days)	LOS (days)	F/U Outcome
1	85	F	THA	Intracap.	2.96	3.91	POD 5	Negative	--	3	7	No infection
2	74	F	THA	Intracap.	2.71	3.52	POD 4	Negative	--	5	8	No infection
3	73	F	Hemi	Intracap.	2.59	3.45	POD 3	Negative	LRTI	6	8	No infection
4	89	F	THA	Extracap.	2.71	3.49	POD 4	Negative	--	5	8	No infection
5	77	F	Hemi	Extracap.	2.82	3.50	POD 7	Negative	UTI	5	11	SSI at 4 mo(d)
6	84	F	THA	Extracap.	2.21*	3.15	POD 8	Negative	UTI	8	15	No infection
7	78	M	Hemi	Extracap.	2.82	3.75	POD 8	Negative	UTI	4	11	No infection
8	84	F	THA	Extracap.	2.91	3.88	POD 3	Negative	--	4	6	No infection
9	80	F	Hemi	Extracap.	2.52	3.37	POD 6	Negative	LRTI	5	10	No infection
10	78	F	Hemi	Intracap.	2.71	3.56	POD 7	Negative	--	4	10	No infection
11	77	M	THA	Intracap.	2.41	3.30	POD 5	Negative	--	6	10	No infection
12	76	F	THA	Extracap.	2.58	3.37	POD 5	Negative	--	5	9	No infection
13	74	F	THA	Intracap.	2.91	3.81	POD 5	Negative	UTI	3	7	No infection
14	86	F	Hemi	Extracap.	2.74	3.45	POD 7	Negative	--	5	11	No infection
15	77	F	Hemi	Intracap.	2.39*	3.29	POD 6	Negative	LRTI	7	12	No infection
16	82	F	Hemi	Intracap.	2.28*	3.18	POD 5	Negative	--	7	11	No infection
17	70	F	THA	Intracap.	2.71	3.55	POD 8	Negative	LRTI	5	12	No infection
18	81	M	Hemi	Extracap.	2.14*	3.00	POD 7	Negative	UTI	7	13	No infection
19	76	F	THA	Extracap.	2.00*	3.00	POD 6	Negative	LRTI	6	11	PJI at 6 mo(d)
20	89	F	Hemi	Extracap.	2.10*	3.00	POD 4	Negative	--	6	9	No infection

Pt #	Age (yr)	Sex	Surgery	Fracture	Pre-Alb	Post-Alb	Onset (POD)	Wound Swab	Conc. Inf.	Res. (days)	LOS (days)	F/U Outcome
21	82	M	Hemi	Extracap.	2.64	3.37	POD 3	Negative	--	4	6	No infection
22	75	M	THA	Extracap.	2.36*	3.00	POD 3	Negative	--	5	7	No infection
23	86	F	THA	Intracap.	2.68	3.46	POD 3	Negative	--	5	7	No infection
24	70	F	Hemi	Intracap.	2.87	3.89	POD 3	Negative	--	4	6	No infection
25	72	F	Hemi	Intracap.	2.76	3.49	POD 8	Negative	--	4	11	No infection
26	79	F	THA	Extracap.	2.36*	3.03	POD 5	Negative	UTI	5	9	No infection
27	84	M	Hemi	Intracap.	2.62	3.55	POD 6	Negative	--	5	10	No infection
28	76	F	Hemi	Intracap.	2.47	3.22	POD 6	Negative	--	6	11	No infection
29	74	F	THA	Intracap.	2.08*	3.06	POD 4	Negative	LRTI	6	9	No infection
30	84	M	Hemi	Intracap.	2.73	3.59	POD 3	Negative	UTI	3	5	No infection
31	79	F	Hemi	Extracap.	3.10	3.91	POD 5	Negative	--	3	7	No infection
32	73	M	THA	Intracap.	2.62	3.58	POD 4	Negative	UTI	5	8	No infection

Table 2

Summary descriptive statistics. BMI = body mass index; CRP = C-reactive protein; IV = intravenous; LOS = length of stay; LRTI = lower respiratory tract infection; POD = post-operative day; THA = total hip arthroplasty; UTI = urinary tract infection; WBC = white blood cell count.

Variable	Value	95% CI or range
PATIENT DEMOGRAPHICS		
Total patients	n = 32	--
Study period	January 2023 to June 2025	--
Age (years)	78.9 +/- 5.3	70 to 89
Female sex	24 (75.0%)	--
BMI (kg/m ²)	21.7 +/- 2.7	--
Hemiarthroplasty	17 (53.1%)	--
THA	15 (46.9%)	--
Intracapsular fracture	17 (53.1%)	--
Posterior approach	All patients (100%)	--
Mean follow-up (months)	15.3 +/- 7.4	6 to 29
WOUND DISCHARGE		
Mean discharge onset (POD)	5.2 +/- 1.7	POD 3 to 9
Serous discharge character	25 (78.1%)	--
Positive wound culture	0 of 32 (0%)	--
CONCURRENT NON-WOUND INFECTIONS		
Patients with concurrent infection	14 (43.8%)	--
-- UTI	8 (25.0%)	--
-- LRTI	6 (18.8%)	--
CRP (mg/L) -- concurrent infection	67.4 +/- 19.3	--
CRP (mg/L) -- no concurrent infection	35.4 +/- 8.4	--
WBC (x10 ⁹ /L) -- concurrent infection	12.9 +/- 1.9	--
WBC (x10 ⁹ /L) -- no concurrent infection	9.0 +/- 1.6	--
ALBUMIN		
Pre-treatment albumin (g/dL)	2.58 +/- 0.28	2.48 to 2.68
Severe hypoalbuminemia (< 2.4 g/dL)	9 (28.1%)	--
Intervention	IV 20% human albumin 100 mL twice daily x 3 days	--
Post-treatment albumin day 5 (g/dL)	3.43 +/- 0.28	3.33 to 3.53
Mean albumin rise (g/dL)	+ 0.85 +/- 0.10	--
LENGTH OF STAY		
Expected LOS (uncomplicated arthroplasty)	4 to 5 days	--

Variable	Value	95% CI or range
PATIENT DEMOGRAPHICS		
Actual mean LOS	9.2 +/- 2.3 days	5 to 15 days
Estimated excess LOS	approximately 4.7 days	--
Pearson r: resolution days vs LOS	r = 0.70, p < 0.001	--
OUTCOMES		
Complete discharge resolution	32 of 32 (100%)	--
Mean days to resolution	5.0 +/- 1.3	4.60 to 5.47
Days to resolution -- severe hypoalbuminemia	6.3 +/- 1.0 days	--
Days to resolution -- mild hypoalbuminemia	4.5 +/- 0.9 days	--
Confirmed infection -- primary episode	0 of 32 (0%)	--
Secondary infection at 6 months or later	2 of 32 (6.25%)	--

Table 3

Full statistical analysis. NS = not significant. CRP = C-reactive protein; LOS = length of stay; WBC = white blood cell count. All t-tests two-tailed. p < 0.05 statistically significant.

Statistical Test	Statistic	df or n	p Value
PRIMARY ALBUMIN ANALYSIS			
Paired t-test: pre- vs post-treatment albumin	t = -47.42	df = 31	< 0.001
Pearson r: pre-albumin vs days to resolution	r = -0.81	n = 32	< 0.001
Linear regression: R ² and B	R ² = 0.65, B = -3.64	n = 32	< 0.001
ALBUMIN SUBGROUPS			
Independent t-test: severe vs mild hypoalbuminemia	t = 4.79	df = 30	< 0.001
Mann-Whitney U	U = 186.5	n = 32	< 0.001
ANTIBIOTIC CONFOUND TEST			
Independent t-test: broader abx vs cefuroxime-only	t = 1.31	df = 30	0.20 (NS)
Mann-Whitney U	--	n = 32	0.21 (NS)
CONCURRENT INFECTION AS CONFOUNDER			
Independent t-test: CRP	t = 6.32	df = 30	< 0.001
Independent t-test: WBC	t = 6.36	df = 30	< 0.001
Chi-square: concurrent infection vs CRP > 60 mg/L	chi ² = 16.10	df = 1	< 0.001
LENGTH OF STAY			
Pearson r: resolution days vs LOS	r = 0.70	n = 32	< 0.001
SURGICAL VARIABLES			
Chi-square: surgery type vs discharge character	chi ² = 2.17	df = 1	0.14 (NS)
Chi-square: fracture type vs discharge character	chi ² = 0.74	df = 1	0.39 (NS)

Discussion

Every patient in this cohort was hypoalbuminemic. Every wound culture was sterile. And the group that received broader antibiotics took longer to resolve, not less time. Together these findings support a single conclusion: hypoalbuminemia, not infection, drives postoperative serous wound discharge in this population, and the antibiotic confound was tested directly rather than simply raised as an alternative and set aside.

Hypoalbuminemia as the Oncotic Driver

Pre-treatment albumin predicted resolution time with $r = -0.81$ ($R^2 = 0.65$), meaning albumin alone accounts for 65% of variance in how long a patient's discharge took to resolve. The mechanism is the Starling oncotic pathway [16]: when serum albumin falls, the wound bed – where capillary permeability is already raised by surgical disruption – becomes a low-resistance pathway for transudative fluid. The association between hypoalbuminemia and impaired wound healing in hip fracture patients [6, 13] and the repeated confirmation of hypoalbuminemia as an independent predictor of SSI, wound complications, prolonged LOS, and death across large registry studies of hip arthroplasty and hip fracture surgery [7, 8, 9, 10, 11, 12] both point in the same direction. Hip fracture compounds baseline nutritional depletion through the catabolic response to injury [6, 13]; measuring albumin at fracture diagnosis and starting nutritional supplementation before surgery are therefore interventions worth adding to standard fracture protocols [20, 21].

Concurrent Non-Wound Infections as Inflammatory Confounders

Nine of the 14 patients with concurrent UTI or LRTI had CRP above 60 mg/L – the 2018 ICM PJI diagnostic threshold [14] – yet every wound culture was sterile. The raised CRP came from the UTI or LRTI, not the wound. Treating a UTI-driven CRP as a wound-infection signal would expose patients to antibiotic regimens appropriate for PJI: broader in spectrum, longer in duration, and carrying a real risk of *Clostridium difficile*, drug resistance, and adverse effects [17]. This is not a theoretical risk in a frail elderly population on multiple existing medications. Identifying the source of an elevated CRP before attributing it to the wound – by doing urinalysis and chest assessment at the time of discharge identification – is therefore part of the assessment protocol we propose.

The Antibiotic Confound

The most important alternative explanation was that broader antibiotics given for UTI or LRTI happened to clear occult wound bacteria, which would mean the apparent success of albumin supplementation was misleading. The data argue against this on every available measure. The broader antibiotic group resolved more slowly, not faster – the opposite direction from antibiotic-driven resolution. Wound swabs were sterile before albumin therapy started, so there was no microbiological substrate for antibiotics to act on. And in the regression model, albumin accounts for 65% of variance in resolution time while antibiotic group adds nothing [22, 23]. This hypothesis was not merely raised and dismissed; it was tested with a direct comparison and found to add nothing to the model.

Length of Stay and Safety

Each extra day to wound discharge resolution extended hospital stay ($r = 0.70$, $p < 0.001$), producing a mean LOS of 9.2 days against an expected 4 to 5. At roughly 4.7 excess bed-days per patient, the institutional cost accumulates quickly and accrues before any investigation for suspected infection is even initiated. Prior work links hypoalbuminemia directly to prolonged LOS after arthroplasty and hip fracture surgery [8, 9, 13], and the pathway in this cohort is straightforward: lower albumin produces slower discharge resolution, which extends the stay. Measuring albumin at fracture presentation and supplementing nutritionally in the days before surgery would therefore address both the discharge and the bed-day cost at the same time [20, 21].

The 6.25% late infection rate at minimum 6-month follow-up is low and neither of the two cases was related to the primary sterile discharge. Patient A's MSSA SSI at 4 months is temporally separate from an index discharge that had resolved before

discharge from hospital. Patient B's CoNS haematogenous PJI at 6 months followed a dental procedure at month 5 [15] – with more than 5 months between wound healing and late infection, a causal link to the original discharge is not plausible.

Proposed Clinical Algorithm

At first identification of wound discharge: obtain a wound swab, serum albumin, CRP, FBC, urinalysis, and chest assessment if symptomatic. Before interpreting inflammatory markers, confirm or exclude UTI and LRTI. If the culture is sterile and albumin is below 3.5 g/dL, continue cefuroxime without escalation, start IV 20% albumin 100 mL twice daily for 3 days, and treat any concurrent non-wound infection through the appropriate medical team [18]. Review daily; expect resolution in 3 to 8 days. If culture becomes positive, sepsis develops, discharge persists beyond 10 days, or albumin fails to rise, escalate and initiate PJI work-up per 2018 ICM criteria [14, 24].

Limitations

The retrospective single-centre design introduces selection bias: patients whose discharge was attributed to infection without albumin measurement were not captured. There is no control arm in which albumin was withheld. Pre-operative albumin was unavailable for all patients. The antibiotic confound was tested statistically rather than by experimental control; a randomised design would be needed for definitive proof. A sample of 32 limits subgroup power, and 6-month follow-up was not available for all patients. Despite this, the convergence of universal hypoalbuminemia, sterile cultures in every patient, a clear dose-response relationship between albumin and resolution time, and failure of antibiotic group to predict resolution supports the conclusion. Multicentre randomised trials are the appropriate next step.

Conclusions

Postoperative wound discharge in elderly patients undergoing hemiarthroplasty or THA via the posterior approach for proximal femur fractures is driven by hypoalbuminemia, not infection. Concurrent UTI and LRTI – present in 43.8% of patients – raise inflammatory markers without infecting the wound, and broader antibiotic therapy for those infections does not resolve the discharge. When wound cultures are sterile and hypoalbuminemia is confirmed, antibiotic escalation is not warranted and albumin supplementation is the appropriate intervention; in this cohort it resolved discharge in all 32 patients and reduced excess LOS. The two late infections at minimum 6-month follow-up were not related to the primary sterile discharge episodes.

Declarations

Ethics approval and consent to participate: This retrospective study was classified as exempt from full ethics review by the Institutional Ethics Committee of Primus Super Speciality Hospital, New Delhi, in accordance with institutional policy for retrospective clinical record analysis. The study was conducted in accordance with the principles of the Declaration of Helsinki (2013 revision). Informed consent was waived by the committee given the retrospective nature of the study.

Consent for publication: Not applicable. No individually identifiable patient data are published.

Availability of data and materials: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: SA conceptualised the study, designed the data collection protocol, identified and enrolled all patients, curated the clinical dataset, performed the formal statistical analysis, and wrote the original draft. CSY conceived the study, supervised clinical management, critically revised the manuscript for important intellectual content, and provided overall supervision. NK contributed to study design, assisted in patient management and follow-up, critically revised the manuscript,

and provided final approval. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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Figures

Fig. 1 Pre-treatment albumin vs days to resolution
(Pearson $r = -0.81$, $R^2 = 0.65$, $p < 0.001$)

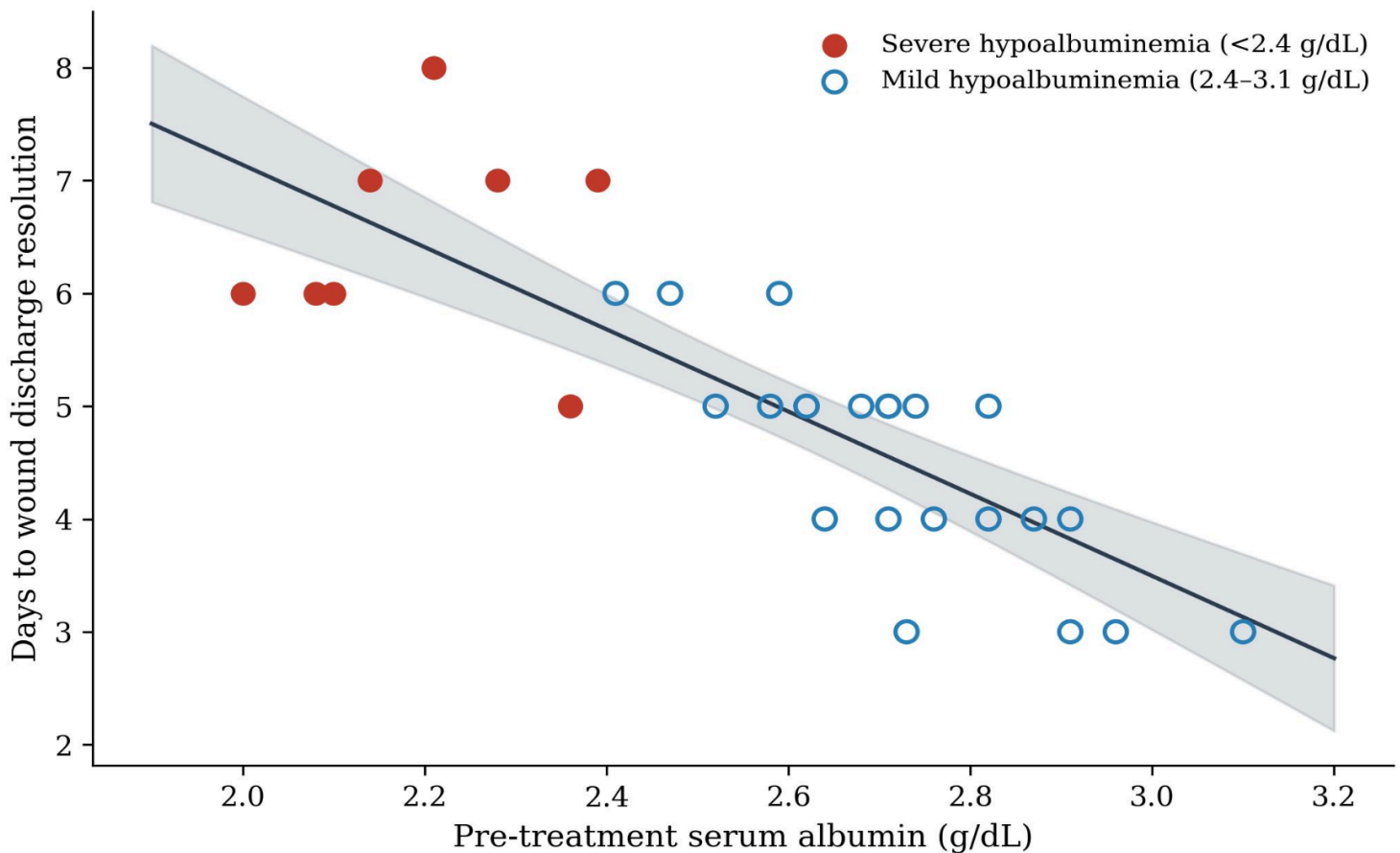


Figure 1

Pre-treatment albumin (g/dL) vs days to wound discharge resolution (Pearson $r = -0.81$, $R^2 = 0.65$, $p < 0.001$). Shaded band = 95% CI of regression. Closed red circles: severe hypoalbuminemia (<2.4 g/dL). Open blue circles: mild hypoalbuminemia (2.4-3.1 g/dL).

Fig. 2 Individual serum albumin trajectories pre- to post-treatment
(Mean rise +0.85 g/dL; paired t-test $p < 0.001$)

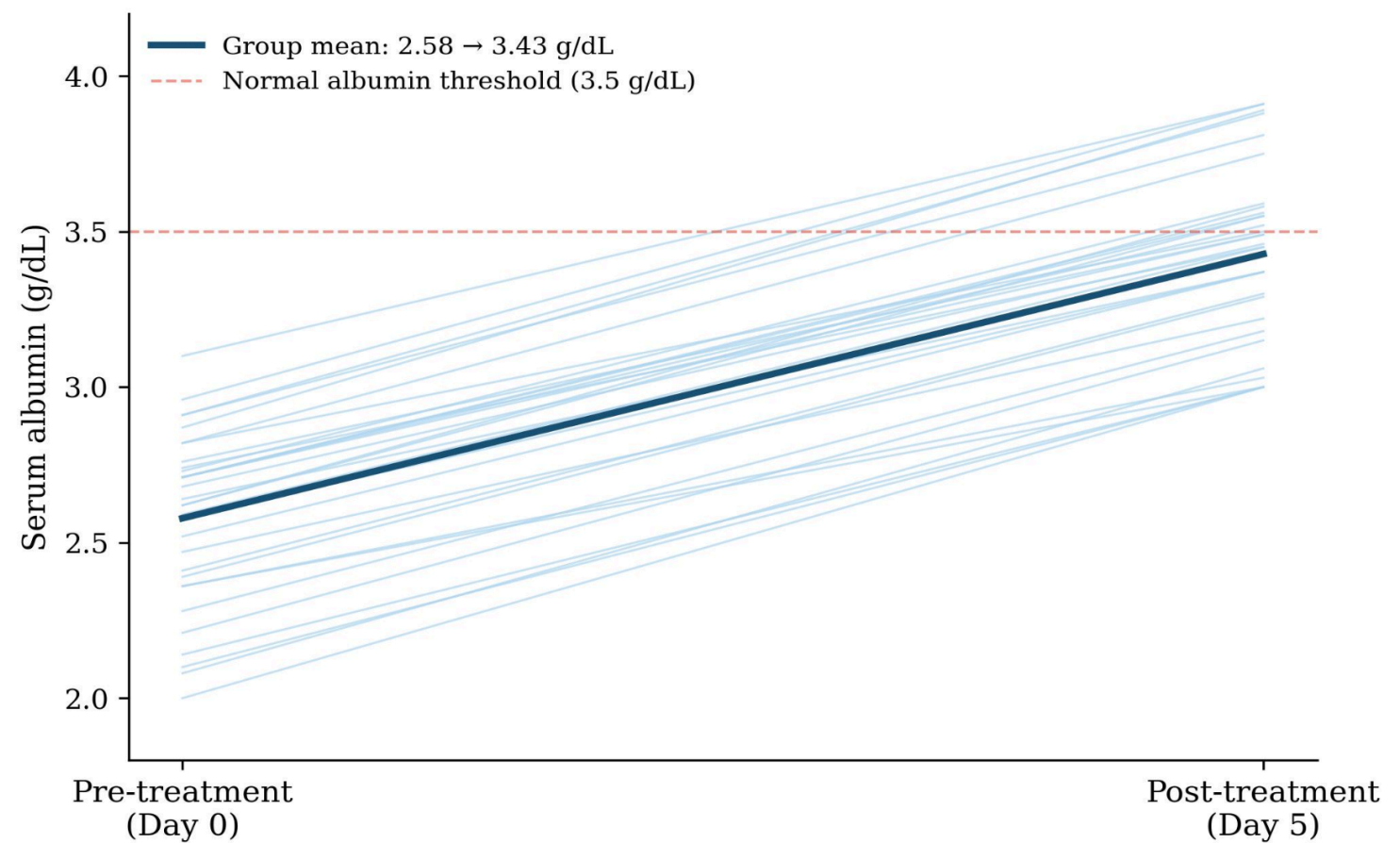


Figure 2

Individual serum albumin trajectories pre-treatment to post-treatment day 5 ($n = 32$). Bold dark line = group mean. Dashed red line = normal albumin threshold (3.5 g/dL). Mean rise +0.85 g/dL (paired t-test $p < 0.001$).

Fig. 3 Days to resolution by albumin subgroup
($p < 0.001$)

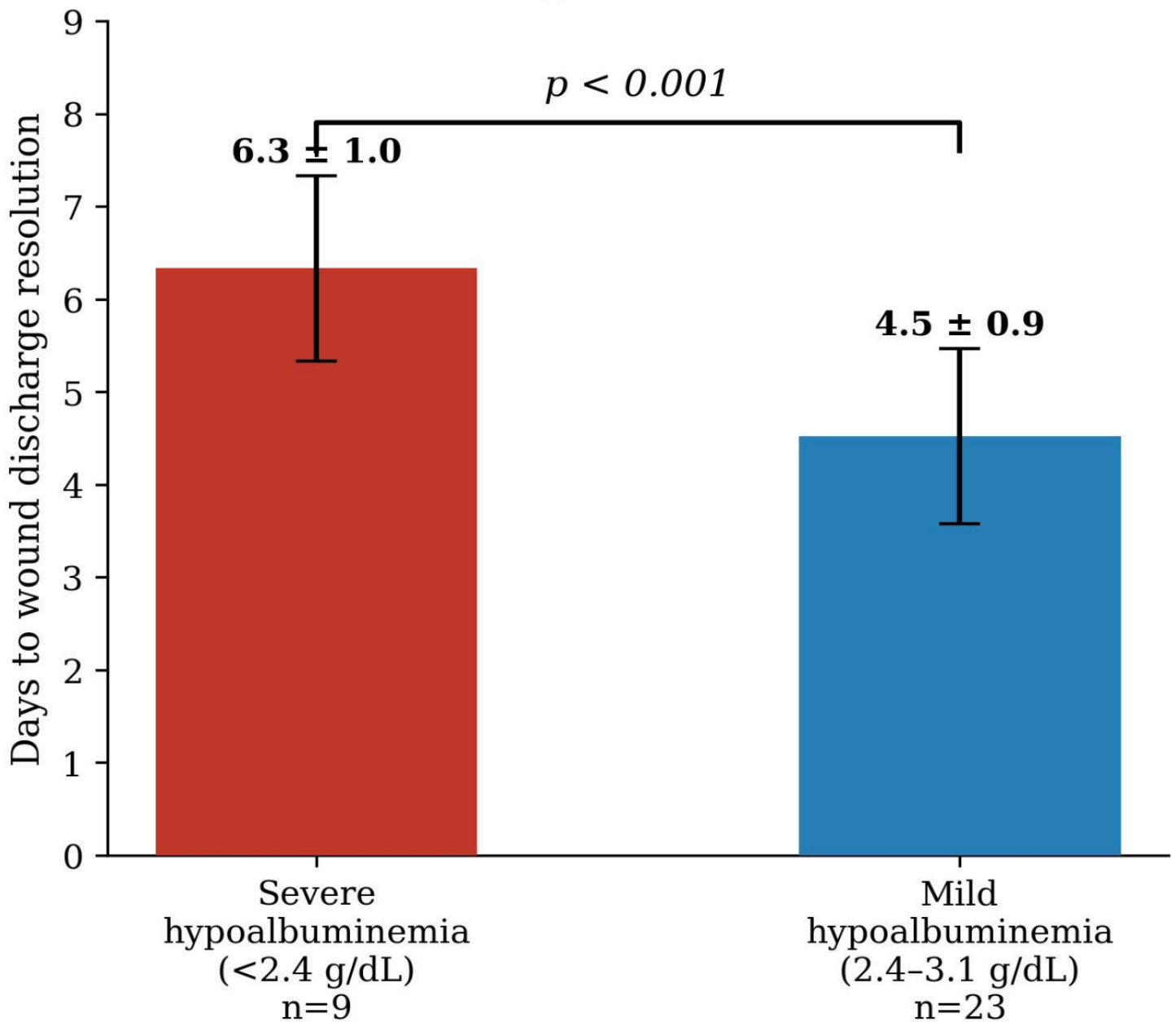


Figure 3

Days to wound discharge resolution by albumin subgroup. Severe hypoalbuminemia (<2.4 g/dL; $n = 9$): 6.3 $\pm$ 1.0 days. Mild hypoalbuminemia (2.4-3.1 g/dL; $n = 23$): 4.5 $\pm$ 0.9 days. $p < 0.001$. Error bars = 1 SD.

Fig. 4 Inflammatory markers by concurrent non-wound infection status
(Wound cultures sterile in all patients in both groups)

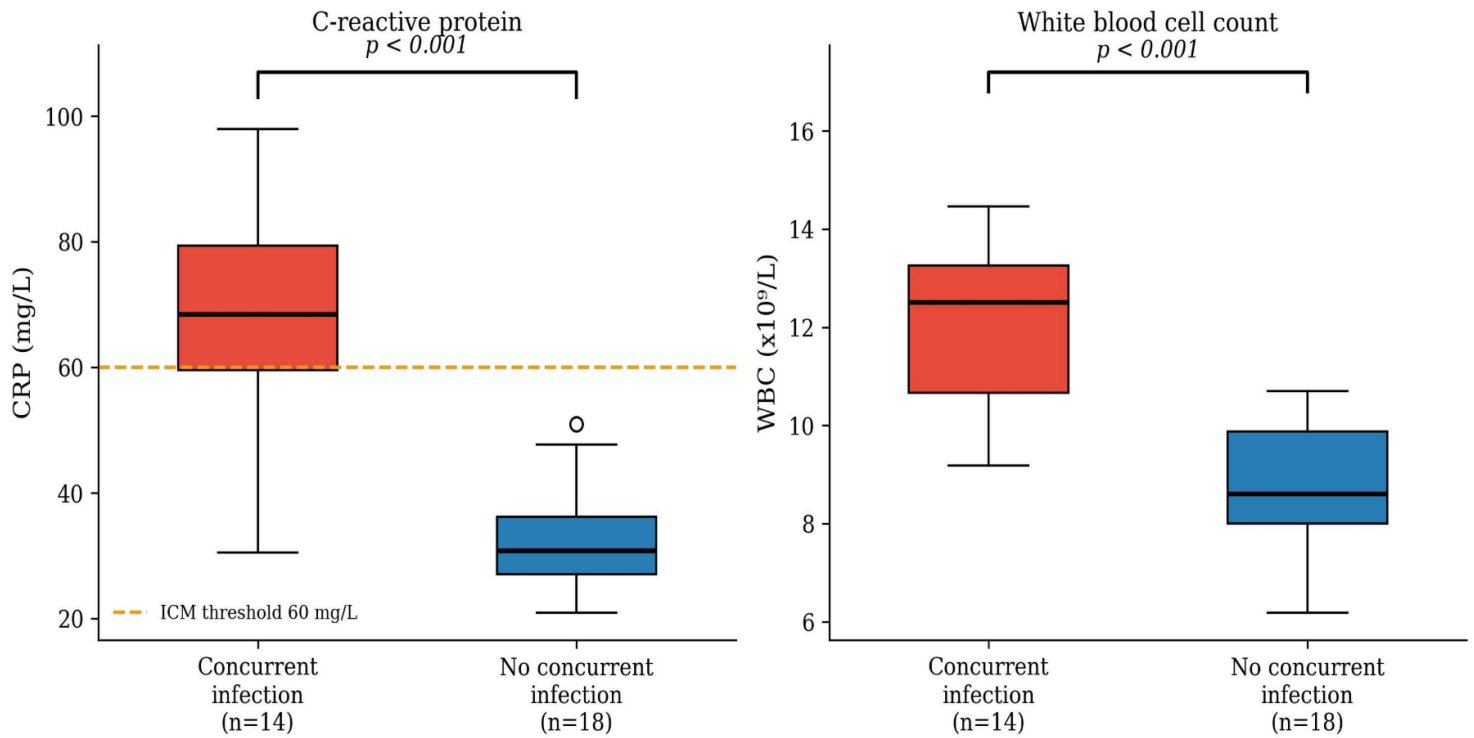


Figure 4

CRP (mg/L) and WBC ($\times 10^9/L$) by concurrent non-wound infection status. Red boxes = concurrent infection ($n = 14$). Blue boxes = no concurrent infection ($n = 18$). Dashed line = 60 mg/L ICM PJI threshold. All wound cultures sterile ($p < 0.001$ for both comparisons).

Fig. 5 Distribution of pre-treatment serum albumin
(All 32 patients hypoalbuminemic; mean 2.58 ± 0.28 g/dL)

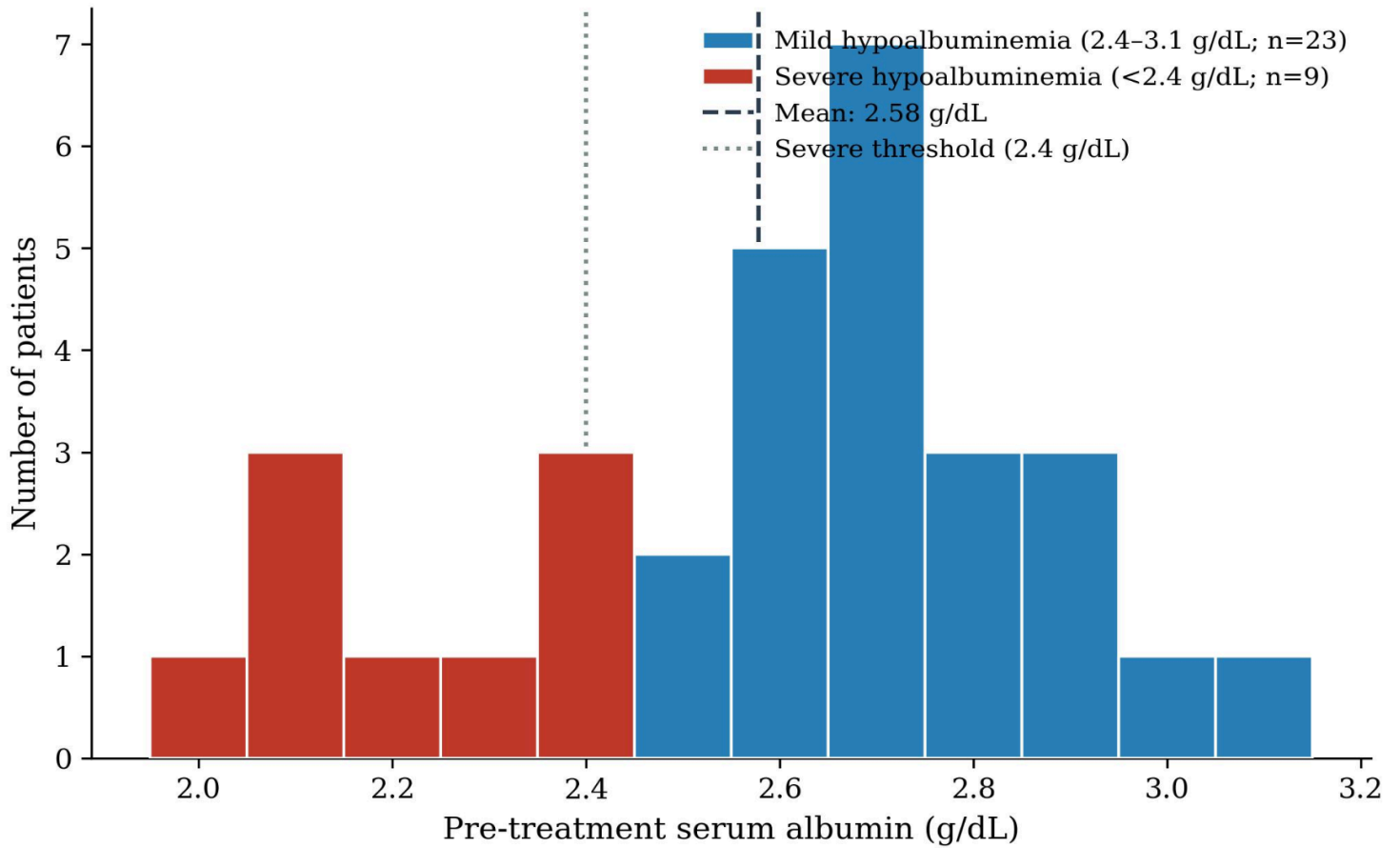


Figure 5

Distribution of pre-treatment serum albumin (n = 32). All patients were hypoalbuminemic (mean 2.58 ± 0.28 g/dL). Red bars: severe hypoalbuminemia (<2.4 g/dL; n = 9). Blue bars: mild hypoalbuminemia (2.4-3.1 g/dL; n = 23). Dashed lines mark the mean and severe threshold.

Fig. 6 Follow-up outcomes and concurrent non-wound infection distribution
 (A) Follow-up outcomes at minimum 6 months
 (B) Distribution of concurrent non-wound infections

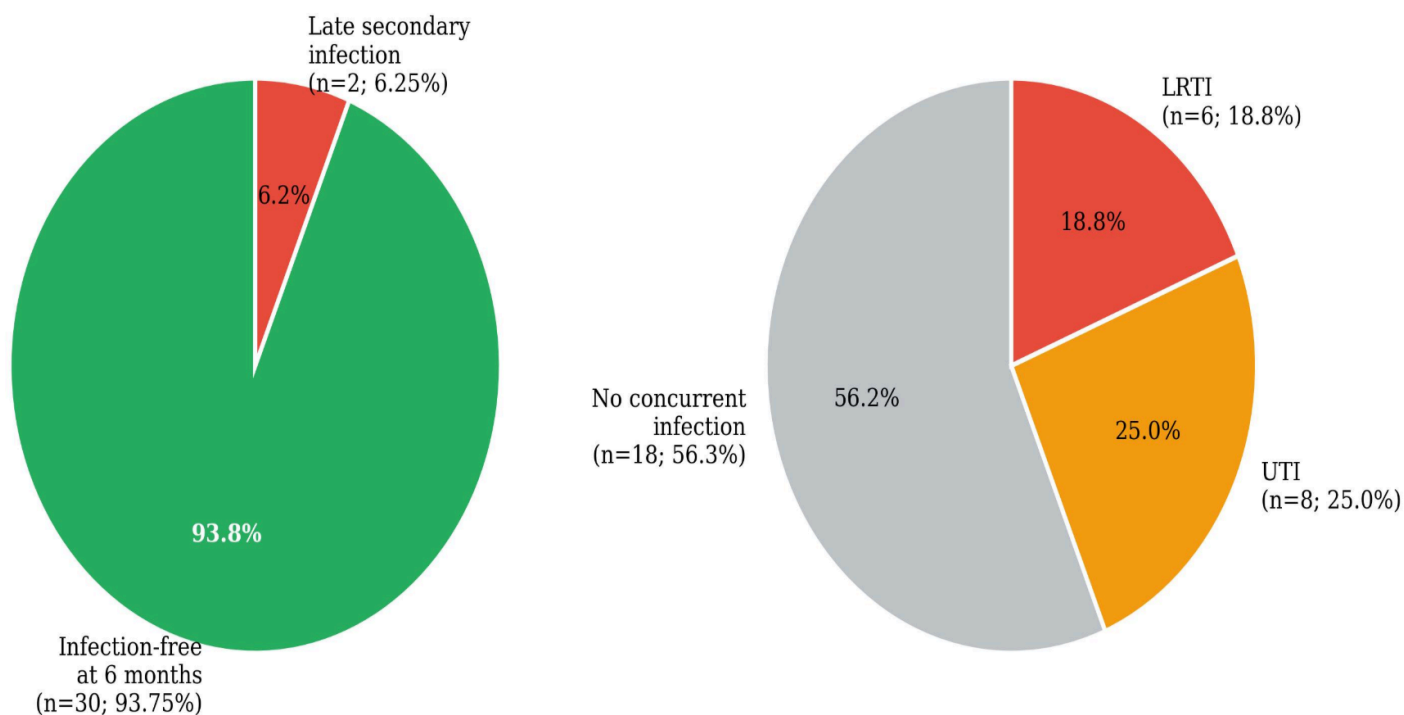


Figure 6

(A) Follow-up outcome distribution at minimum 6 months: 30 of 32 patients (93.75%) infection-free; two with late secondary infections unrelated to primary sterile discharge. (B) Concurrent non-wound infection distribution: UTI n = 8 (25.0%), LRTI n = 6 (18.8%), none n = 18 (56.3%).

Fig. 7 Antibiotic confound test
($p = 0.20$, not significant)

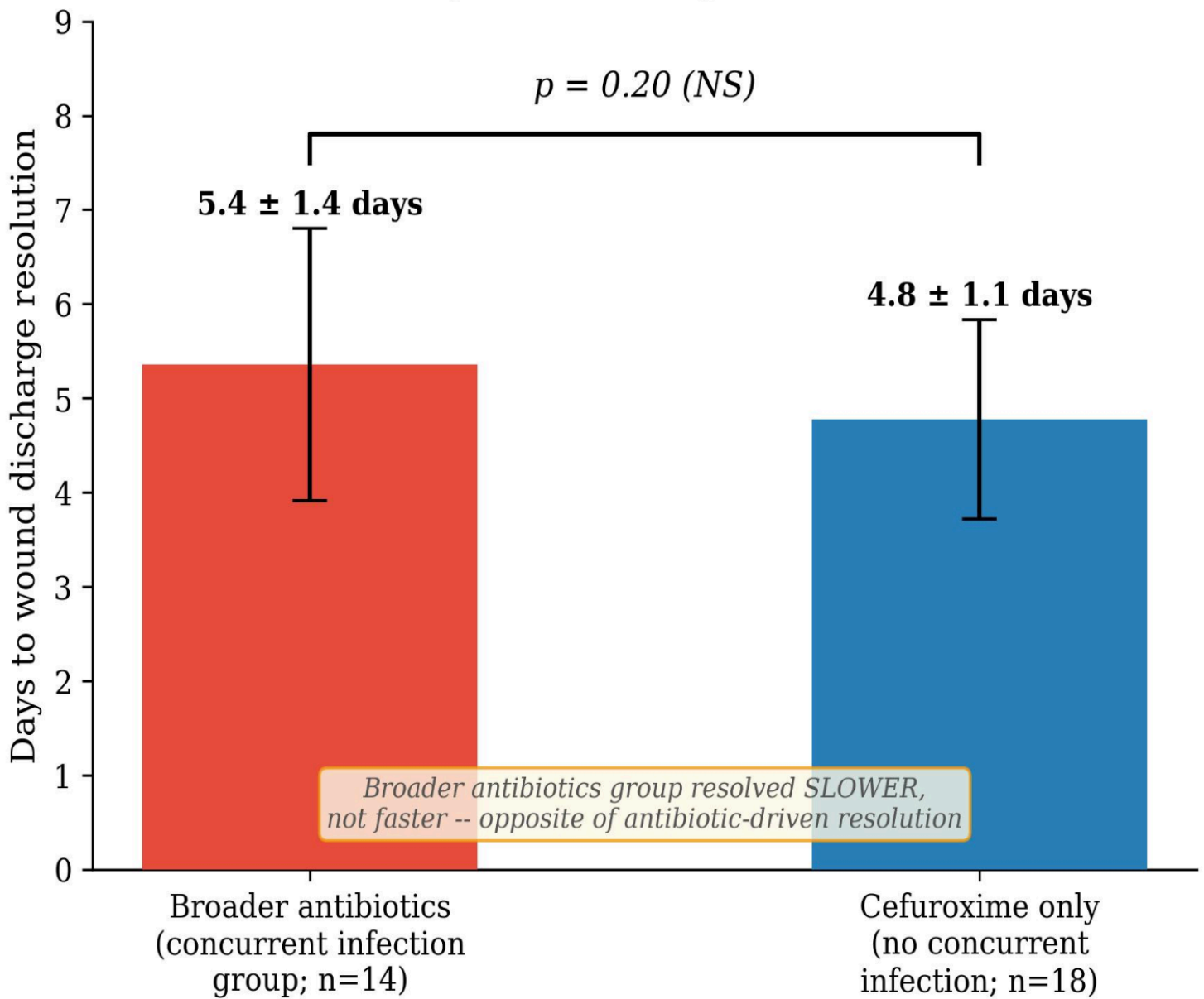


Figure 7

Antibiotic confound test. Broader antibiotic group ($n = 14$): mean 5.4 ± 1.4 days. Cefuroxime-only group ($n = 18$): mean 4.8 ± 1.1 days. $p = 0.20$ (NS). The broader antibiotics group resolved more slowly -- the reverse of antibiotic-driven resolution. Error bars = 1 SD.

Fig. 8 Hospital length of stay analysis

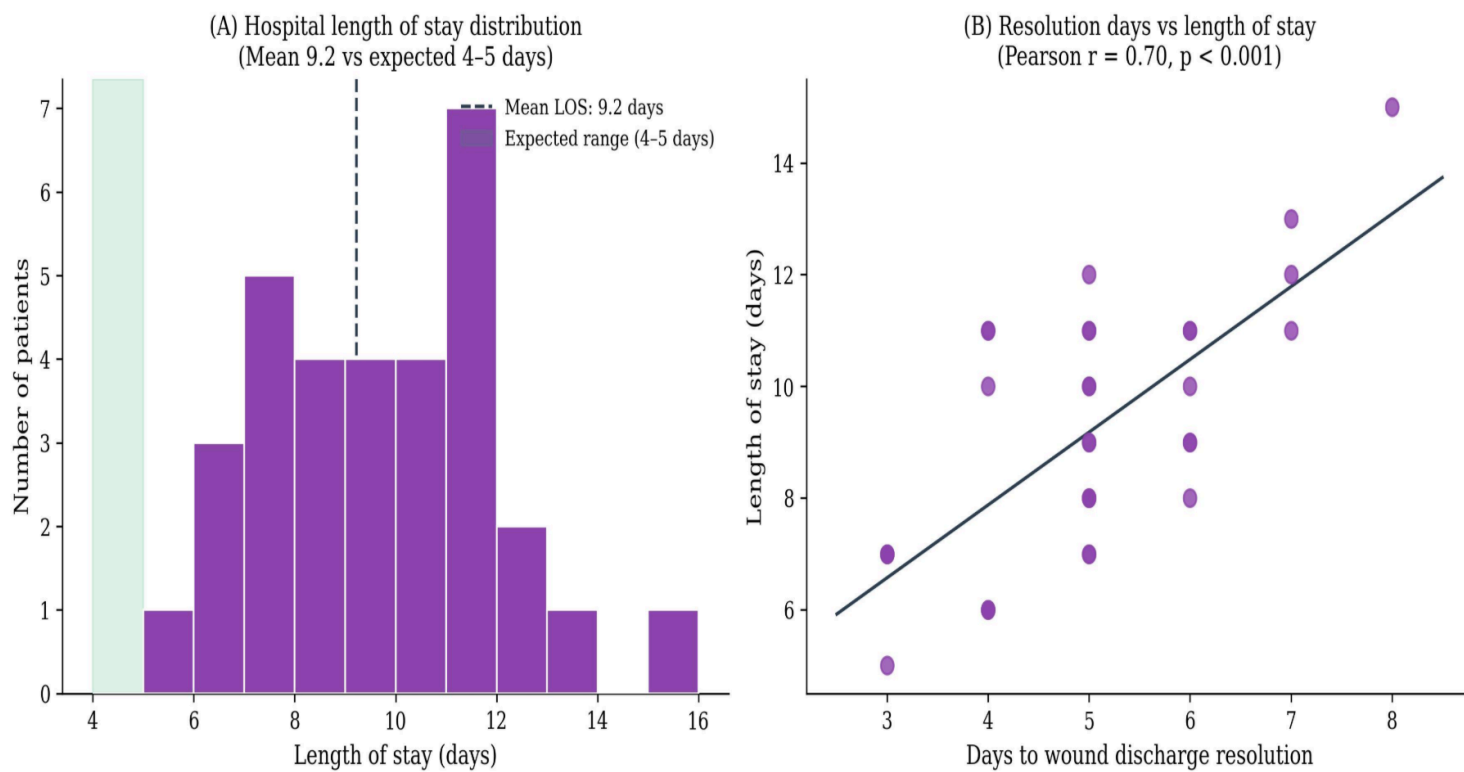


Figure 8

(A) LOS distribution: mean 9.2 +/- 2.3 days (range 5-15). Green shaded area = expected 4-5 days for uncomplicated arthroplasty; approximately 4.7 excess days per patient. (B) Resolution days vs LOS scatter plot (Pearson $r = 0.70$, $p < 0.001$).